Papers on Anthropology

XIV

PAPERS ON ANTHROPOLOGY
XIV

UNIVERSITY OF TARTU
CENTRE FOR PHYSICAL ANTHROPOLOGY

PAPERS ON ANTHROPOLOGY

XIV

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PREFACE

On September 23–25, 2005, a conference will be held in Tartu, which is dedicated to the bicentennial of the Old Anatomical Theatre. The present collection is also dedicated to this jubilee. Maie Toomsalu's article describes the history of the building, and Jaan Kasmel provides an overview of teaching of anthropology at the University of Tartu throughout two centuries.

Not long ago (in 2002), the Centre for Physical Anthropology published a book by Maie Toomsalu in Estonian, which contains short biographies of 79 professors who have worked at the Old Anatomical Theatre. An English version of the book is going to come out soon.

The publishers of *Papers on Anthropology XIV* and its international editorial board commemorate with deep sadness one of our board members, the late Prof. Otto Eiben from Hungary.

We thank all the contributors to this collection and look forward to fruitful cooperation with you in the future.

Helje Kaarma

Prof. Helje Kaarma

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Papers on Anthropology XIV, 2005, pp. 11–23

ABOUT THE HISTORY OF BUILDING THE OLD ANATOMICAL THEATRE

M. Toomsalu

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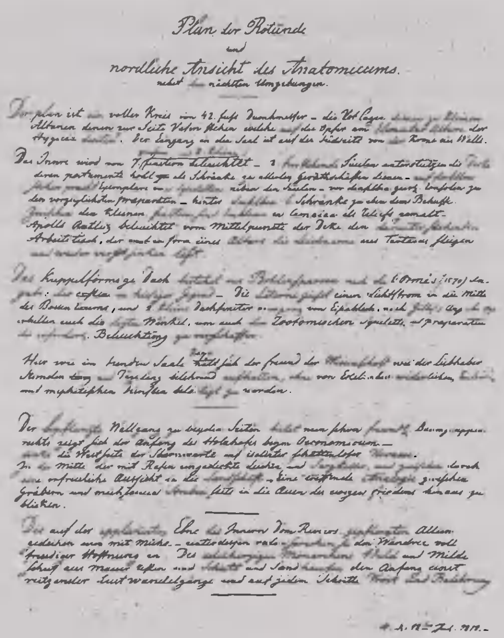
With his Ukase (decree) as of 12 April 1801 the Russian Emperor Alexander I ruled the new university of the Empire be established in Tartu (History of Tartu University II, 1982, page 34). With his Ukase as of 5 January 1802 he confirmed the property of land given to the University of Tartu: the Dome Hill and the land at the foot of the hill where St. Mary`s Church built in the 14th century (in ruins since 1704) had been located. The area was unfortunately covered with buildings not suitable for university instruction. It was prescribed that the university should have a library, an astronomical observatory, an anatomical theatre, a hospital, a botanic garden and other institutions (History of Tartu University II, 1982, page 34). The annual budget of the university had to amount to 56,050 roubles. When the university had already started its activities, it was allocated with respective sums generated by the economy of Livonia (Petukhov, 1906, pp. 96–97). The Statutes of 1803 provided that the Faculty of Medicine should have six professorships or chairs: Professors Ordinary in anatomy, physiology and forensic medicine; pathology, therapy, clinical medicine and semiotics; dietetics, study of medicines, history of medicine and medical literature; surgery and obstetrics; Professor Extraordinary in veterinary science, also a post for a prosector in the capacity of a Professor Extraordinary. At the Faculty of Medicine students could also study chemistry and pharmacy beside medical subjects (History of Tartu University II, 1982, page 43). The Statutes also provided that the anatomical theatre and specialized clinics for internal diseases, surgery and obstetrics be established,the library, the manège, the dancing hall and the bathing establishment had to service the whole university. The university started its work in the rented rooms which were located far from each other and were mainly not suitable for studies. The first new building was completed in the autumn of 1802 being a wooden manège for teaching horse riding. On

8 June 1803 a construction committee was set up (J. W. Krause, W. F. Hezel, M. E. Styx and G. F. Parrot, in the second term D. G. Balk acted as Rector). The committee was headed by Johann Wilhelm Krause, professor of economics, technology and civil engineering (architecture), who became the designer of university buildings and the leader of construction. The construction could immediately start because 120,000 roubles were allocated to the university from the state budget and additional sums were repeatedly transferred. The first buildings to be designed and constructed were the Anatomical Theatre, the Library and the Main Building of the University. The Anatomical Theatre and the Library were planned to be built on the Dome Hill.

Photos 1. View of Tartu in 1803

At that time Tartu looked pitiful, there were few imposing buildings there (Photo 1). The ruins of the Dome Church, barracks for 150 soldiers, a hay barn and a cellar of the regiment's smithery were on the Dome Hill. The townspeople had piled their wastes there, they had dug out sand and good soil for their gardens. The hill was also used as a pasture land. It was an unkempt area near the centre of the town.

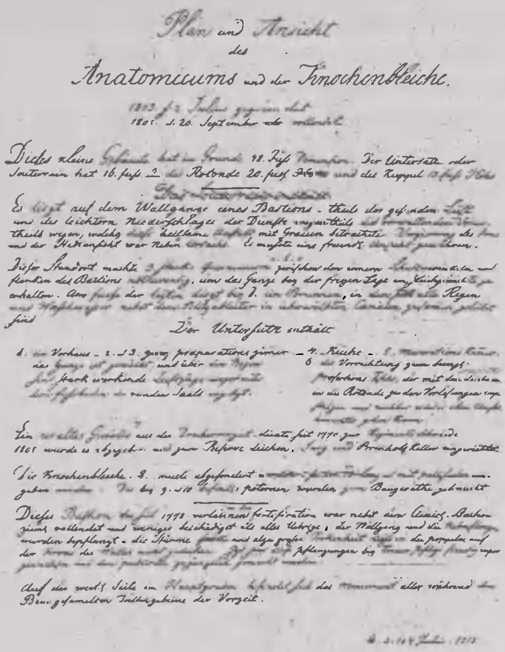
By the order of professors Balk and Styx the construction of the rotunda of the Old Anatomical Theatre started on 8 June 1803(Die erste Jahrzehnt, 1902, page 246). Thanks to his knowledge of the local language the Kreis (Region) Commissar Petersen was appointed construction commissar, Kranhals and Lange were responsible for


Plan der Rotünde

und

nordliche Ansicht des Anatomicums.

nebst den nächsten Umgebungen.


Plan und Ansicht

des

Anatomicums und der Knochenbleiche.

Photos 3, 4. The descriptions of construction plan of the rotunda of the Old Anatomical Theatre purchasing stones, Königmann for timber, Bachmann was the secretary for construction workers, supervisors and warehouses. Tartu was a poor town and this is why there was a constant lack of building materials. Almost all the timber had to be sailed from Russia across Lake Peipsi, ironware came from St. Petersburg. Instead of helping to build the university, the nobility in town and rural areas, craftsmen and even peasants tried to make maximal profits from the construction (Das erste Jahrzehnt, 1902, page 244). In the end of August 1803 Dr. Heinrich Friedrich Isenflamm (with a nickname Tall Heinrich) arrived in Tartu to occupy the post of a professor of anatomy, physiology and forensic medicine. He found that the Anatomical Theatre was on a wrong place and too small a building. After observing it, he decided: "Zum Zaig, ollewail, ischt halter nischt!" (Das erste Jahrzehnt, 1902, page 93). He thought about the foundation of the Anatomical Theatre which was erected in a nice place but on a bad construction soil with great efforts: "Nischt, zu klain, a Hundeluch" (Das erste Jahrzehnt, 1902, page 93). In 1804 the Anatomical Theatre was roofed. On 16 May 1804 the Emperor Alexander I paid a visit to Tartu and inspected all the construction sites expressing his satisfaction (Das erste Jahrzehnt, 1902, page 250). In September 1805 the Anatomical Theatre was officially handed over to professor Isenflamm and people moved in. Professor Isenflamm thought that the rooms were dark, uncomfortable. The building was located far from the centre and it was hard and tiresome to reach it. He thought that everything was made in a wrong manner to fool him personally. When the architect Krause heard about it from his construction workers, he sent Isenflamm or Ingrimm ("a fit of pique" – as Krause called him) a message with his workers that he would give a good trashing if such "lovely" expressions were repeated (Das erste Jahrzehnt, 1902, page 94). As Isenflamm was not participating in the liquidation of chaos, his angry words were no more taken into consideration. The Curator of the University Friedrich Maximillian Klinger, who visited the building, found that the Anatomical Theatre was full of light, friendly and so clean that the representatives of the higher society could enjoy drinking tea in a small round hall (Das erste Jahrzehnt, 1902, page 94).The first building of the Faculty of Medicine was the smallest among other university buildings of the period and it was a rotunda with a cupola on a quadrangular foundation (according to principles of art history, a rotunda is a temple with a circular ground plan surrounded by a colonnade, the modifications have often been used in the manorial architecture as decorations of parks). The exterior walls of the socle were rusticated. On four sides pylons were projected as porticos. The four risalites, each with two Doric-Tuscan style pilasters, and a gable and eight windows, topped with mezzanine windows, decorated the building. Triangular pediments in the cupola zone made a functional building look like a mauseoleom. Wrought-iron balconies were embellished with decorative urns so much liked in the period of classical architecture (Photo 4).

Photo 4. The rotunda of the Old Anatomical Theatre

The lower part of the circular hall of 102 square meters (Preem, 2002, page 4) contained, beside two preparation rooms, a kitchen and an infusion chamber in the middle of which there was a mechanism for hoisting corpses to the altar-like operation table in the hall and after the demonstration the corpses were lowered to remove everything unpleasant and nauseating for keeping everything clean and having healthy air. There were special devices to preserve corpses and clean bones. There was also a room for keeping the collection of anatomical preparations. The cupola hall was designed as an amphitheatre. The Anatomical Theatres of the amphitheatre type were used in teaching medicine already in ancient times. It is known that already in 1497 Alexander Benedictus built an Anatomical Theatre in the form of an amphitheatre in Padua. Carolus Stephanus built a similar structure in Paris in 1564 (Schumacher, 2002, page 221). In Tartu the ceiling of the cupola hall was painted *en Camayeu* (The former head of the Institute of Anatomy H. Tapfer said that blue-coloured pieces had fallen from the ceiling). Apollo's face, surrounded by a halo, was

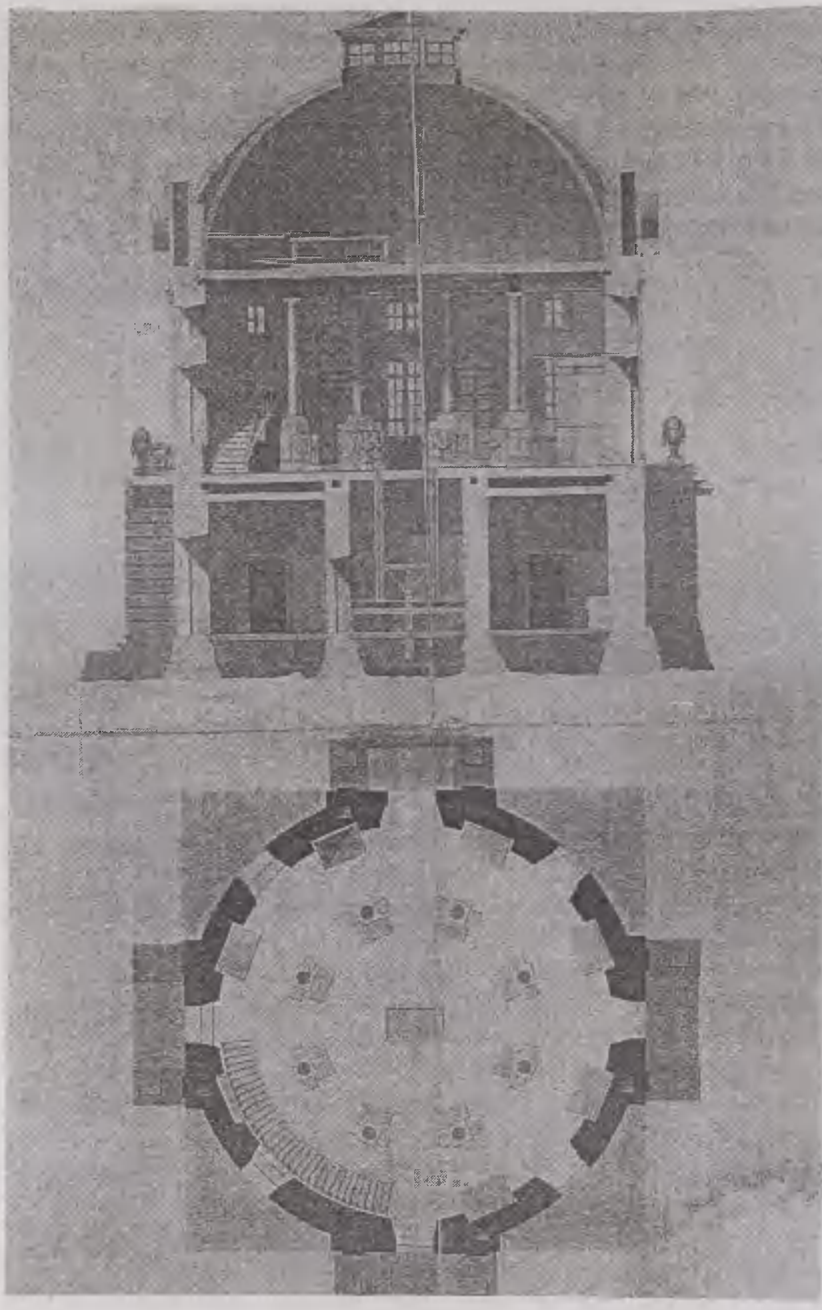


Photo 5. The Cross-section of interior of the rotunda of the Old Anatomical Theatre

approvingly looking at the work done for the benefit of human well-being, learning from death to preserve life. (Die erste Jahrzehnt, 1902, page 95). The first teacher of drawing at the university K.A. Senff had painted emblems in *grisaille* – technique. The ceiling of the hall was supported by eight Doric columns, the pedestals of which were designed as drawers and cupboards. The pedestals were decorated with wreaths – again a beloved motif of classical architecture (Vaga, 1928, pp 20–21). Four stoves had to heat the hall sufficiently in the coldest winter (Die Kaiserliche Universität, 1827, page 30). (Photo 6).

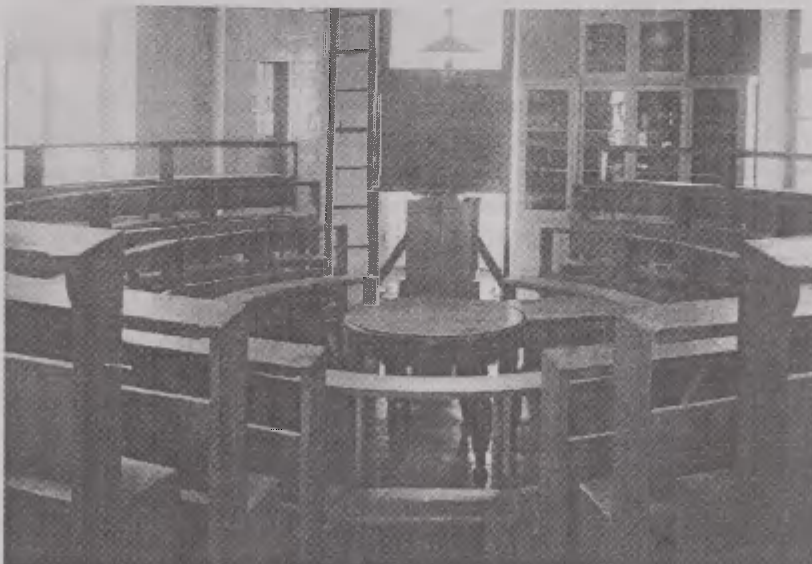


Photo 6. The amphitheatre of the rotunda of the Old Anatomical Theatre

According to his taste, Isenflamm ordered a strong iron hook to be fixed to the middle of the beautiful ceiling piece for hanging up a chandelier. Some months later eight large windows were covered with curtains because the incoming light was dazzling. After a year Isenflamm felt that the passage leading to the circular hall was steep and dangerous and he demanded that stairs should be built. It was a difficult task – spoiling the construction and the image of the rotunda. The architect Krause ordered wooden stairs to be made and installed but did not dare to change the upper northern window and make a door instead. The stairs disappeared (Das erste Jahrzehnt, 1902, page 95).

Photo 7.

At first Krause had planned to connect the Anatomical Theatre with a hospital but later it was decided to build the two separately because the smell of corpses in the hospitals was not acceptable. On the same place, where the Anatomical Theatre is located at present, it was possible to use the cellars of an old fortification structure for storing corpses.

As the number of students was constantly growing each year, the building became too small. Already in 1820 the extension was discussed and in May the same year Krause made respective drawings and the calculation of building costs. Two wings were planned to the rotunda but as the building site was too narrow, it was not possible to put them on one line. According to the initial plan, the wings should have been built at the right angle. Later the design was changed so that the wings might have been added as segments to the rotunda. The construction was completed only in 1825–1827 (K.A.Ü.M. Acta betr.). Both wings had two storeys which were separated from each other by a flat cornice. The ground floor is rusticated as the rotunda. Professor V. Vaga thinks (Vaga,1928, page 21) that thanks to the semicircular wings the rotunda gains in importance becoming more festive. V. Vaga also says that Krause's old age tells in the design of the wings (in 1825 he was 68 years old) and there are traces of giving up the classical style (Vaga, 1928, page 21). On top of the tower there was a glass structure to bring light into the upper part of the cupola (Photo 8). In the first floor – there were (Photos 9, 10)

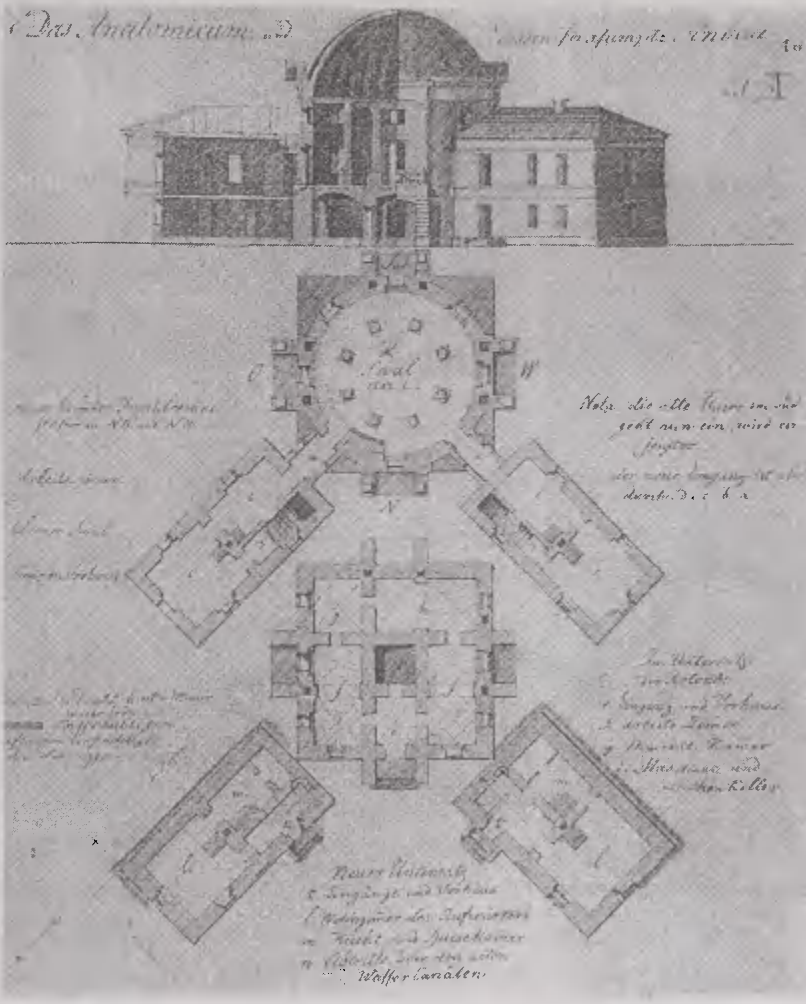


Photo 8. The Plan of extension of the Old Anatomical Theatre

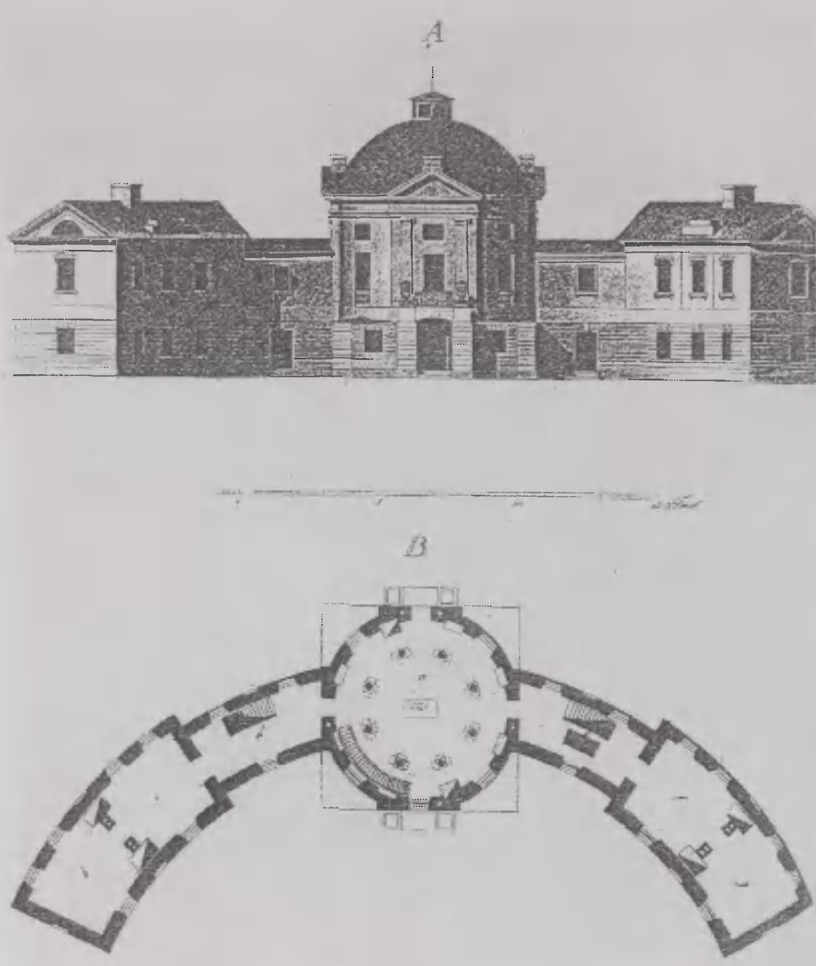


Photo 9. The first floor of the Old Anatomical Theatre

a) a circular lecture room for teaching anatomy with a table for autopsy which could be lowered with a special device to the cold room in the ground floor;
b) a room for storing the pathological – anatomical collection;
c) a lecture room for lectures of pathological anatomy;
d) a staircase leading to the ground floor;
e) a staircase leading to the ground floor and the hatched ice cellars;
f,g) rooms for the collection of anatomical preparations (Die Kaiserliche Universität zu Dorpat. Fünfundzwanzig Jahre nach ihrer Gründung, pp. 30–31);

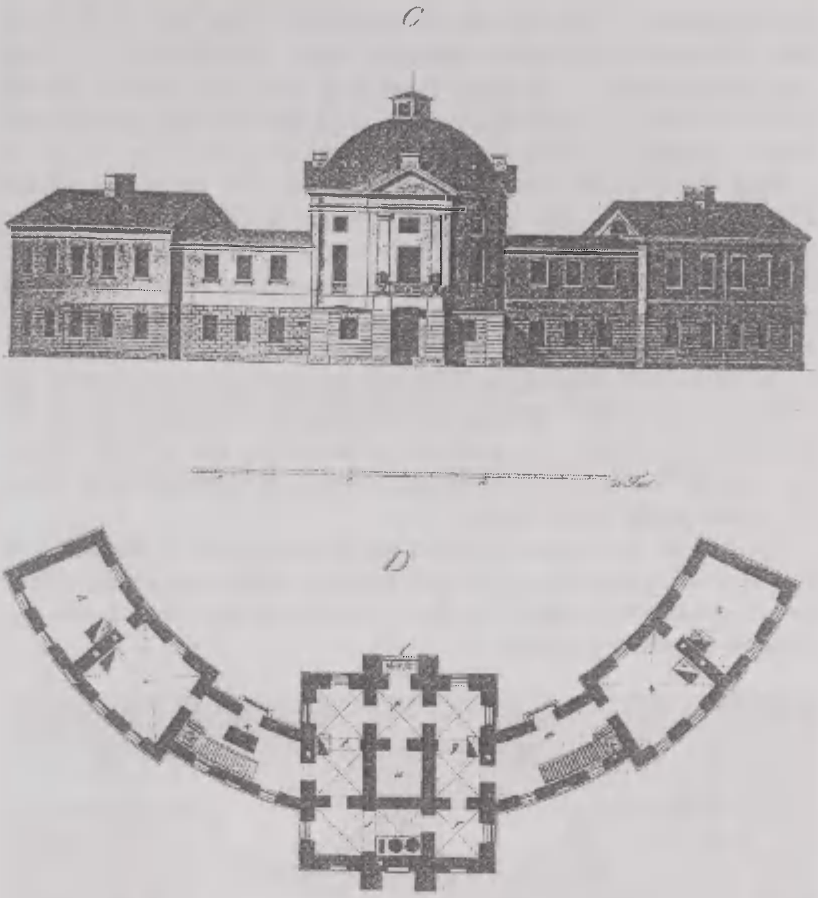


Photo 10. The ground floor of the Old Anatomical Theatre

In the ground floor there were:

h) a room for comparative anatomy;
i) entrance to the central part of the building;
j) entrance to the wing with a staircase from the northeast;
k) entrance with a staircase to the wing from the northeast;
l,m) rooms for anatomical autopsy and surgical practice;
n) the vestibule;
o,p) living quarters for a servant in anatomy classes;
q) the kitchen with waste water piping;
r) the room for students to practise autopsy;
s) the cold room for corpses lowered from the lecture room (for maceration there was a room next to the cellar).

At the distance of 12 steps in the southwest at the foot of the wall there was a roofless bleeching place for bones (length – 18 feet, width – 12 feet, height – 12 feet), supplied with windows covered with an iron net to let in the wind and sunrays (Die Kaiserliche Universität zu Dorpat. Fünfunddzwanzig Jahre nach Gründung, page 31).

In 1856–1860 the wings were lengthened after the design of the architect K. Rathaus (the university architect in 1851–1869). Rathaus tried to harmonize his design with Krause's style. Professor V.Vaga finds that it was unsuccessful because the treatment of the details was narrow–minded, shy and dry and spoilt Krause's building (Vaga, 1928, page 33). (Photo 8).

In 1874–1878 Maximilian Rötscher was an acting architect of the university but he did not have the necessary documents to prove his qualifications. Under his guidance a house for the servant in the Anatomical Theatre was built in 1874 (K.A.Ü.M. Acta betr.d. B. eines Gebäudes für die Versuchstiere…).

In 1911 by the request of Professor Extraordinary N. Burdenko, a professor of operative surgery, the northern wing was added a new wooden structure, designed by Pavel Fjodorovitš Nikitin, to house the Chair of Operative Surgery.

Photo 11. The Old Anatomical Theatre on 1902

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ON ANTHROPOLOGY AT THE UNIVERSITY OF TARTU THROUGHOUT TWO CENTURIES

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The plan of the restoration of the University of Dorpat (present Tartu), adopted in 1799, and its first statutes (1802, 1803) did not envisage the teaching of anthropology. At the same time, however, the curriculum of the university reveals that during the autumn semester of 1802 Daniel Georg Balk (1764–1826), full-time professor of pathology, semiotics, therapy and clinic, taught a course in medico-philosophical anthropology for medical students, four hours per week. He used the textbook *Medizinisch-Philosophische Anthropologie für Aerzte und Nichtaerzte* published in Leipzig in 1790 by J. D. Metzger, professor of the University of Königsberg. In the following years Prof. Balk taught physical-, historical- and physiological-philosophical anthropology during five semesters, using specimens from his anatomical-pathological collection to illustrate his lectures.

Actually, some other professors of the medical faculty took an interest in the teaching of the subject as well. Thus, in 1805 four professors of the medical faculty (D. G. Balk, H. F. Isenflamm, M. E. Styx, L. E. Cichorius) out of six were involved in teaching anthropology, which could have been facilitated by the completion of the *Theatrum Anatomicum* (the first stage of the present Old Anatomical Theatre).

That year can be regarded as the peak of teaching this academic subject at the University of Tartu throughout its history. At that time there were still only plans to introduce the teaching of anthropology at Moscow University, which is one of the oldest universities in Russia, founded in 1755.

Thereafter the number of lectures of anthropology delivered by graduates of German universities dwindled, and after the Patriotic War of 1812, in the period of political reaction in Russia, they ended.

Teaching of anthropology was resumed in the autumn term of 1822 by full professor of physiology, pathology and semiotics J. J. F. W.

Parrot. In the following three quarters of the century it was continued by *Privatdozent* H. J. Köhler and full professor of anatomy and forensic medicine A. F. Hueck. All three of them were already graduates of the Imperial University of Dorpat. The two latter used for their lectures on anthropology the first part of the textbook of anthropology that their fellow student K.E. von Baer, professor of zoology at Königsberg University, had published in 1824 [4].

From the beginning of the second half of the 19th century other research centres in Russia began to develop considerably more rapidly than before. The well-known naturalist A. Keyserling, after having become the curator of Dorpat educational district in 1862, spared no effort to preserve the earlier position of the university of this place among the research centres of international significance.

Encouraged by him, the well-known German naturalist, Prof. M. J. Schleiden moved to Dorpat (Tartu), where in the autumn of 1863 the university established a professorship of plant physiology and anthropology for him. During two terms Schleiden lectured only on anthropology and, because of disagreements, left the university of his own accord in a year.

One might suppose that, influenced by Schleiden's lectures, full professor of state medicine G. H. von Himmelstiern included in the spring term of 1864 a section on forensic anthropology in his lectures of forensic medicine that he delivered to the students of the law faculty [8].

From the same year C. H. L. Stieda MD started working as prosector's assistant at the anatomical theatre (later he became full professor of anatomy in Dorpat and thereafter at Königsberg Univer-ity). He was appointed to systematize K. E. von Baer's legacy, and, influenced by the works of the well-known naturalist, he became interested in anthropology. Although in Dorpat (Tartu) Prof. Stieda did not lecture on anthropology, he laid the foundation to systematic anthropological research at the university. Under his supervision doctoral dissertations were defended on Estonians', Latvians', Livonians', Jews', Lithuanians' and Ukrainians' anthropology [9].

In 1864 the famous French anthropologist and surgeon P. Broca published his manual of anthropometric research, which gave essential impetus to the development of anthropology.

Using Broca's manual, graduate of the Imperial University of Dorpat (Tartu) B. E. O. Körber MD, while working as a naval surgeon in Kronstadt, conducted anthropological research on large groups of sailors. In these studies Körber tried to find correlations between the development of different characteristics of physical development. After becoming full professor of state medicine in Dorpat (Tartu), he lectured on anthropometry in his course of hygiene during many years [3].

To improve the teaching of anthropology and anthropological research at the University of Yuryev (Tartu), Director of the Institute of Anatomy Prof. A. Rauber submitted in 1901 an application to open a department of anthropology and in 1909 an institute of anthropology at the Old Anatomical Theatre, but, unfortunately, the university rejected these applications.

During the 25 years of work at the University of Dorpat/Yuryev (Tartu), Prof. A. Rauber himself did not lecture on anthropology, but two of his students did: *Privatdozent* R. J. Weinberg MD from 1903–1905 and *Privatdozent* A. E. Landau MD from 1909–1912. The latter also became the first curator of the anthropological collection opened at the university in 1911; before that he had donated to the university the entire collection he had amassed for his own money. In 1912 he also published in Yuryev (Tartu) a small handbook of anthropology in Russian. Unfortunately the successful anthropological work at the Institute of Anatomy was severed on the eve of World War I [7].

After an interval of almost ten years, lectures of anthropology at the University of Tartu of the Republic of Estonia resumed in the autumn of 1922. The respective proposal had come from the former merited professor of Harkov University, doctor of medicine and zoology, 78-year-old Alexander Brandt, who had settled in Yuryev (Tartu) as early as 1911. During the following eight terms, he taught several anthropological courses as a *Privatdozent* [5].

Thereafter, lectures on anthropology were delivered by *Privatdozent* of criminal anthropology and criminalistics H. Madisson MD and *Privatdozent* of internal diseases A. Arrak MD [1].

The founder of the Estonian school of anthropology professor of zoology J. Aul (1897–1994), became interested in anthropology as early as in his student days. After taking a doctor's degree in 1938, a study trip to Western Europe and a habilitation lecture, Tartu University Council awarded him in October 1939 the qualification of associate professor in anthropology. He delivered lectures on anthropological subjects for more than forty years.

It should be added that Prof. J. Aul made an enormous contribution to anthropology, measuring more than 40,000 Estonians (men, women, schoolchildren) within ten years. Thus, by 1938, the Estonians could be considered the nation that had undergone the most extensive anthropological measurements in the world. Unfortunately, one of his wishes, opening an anthropology laboratory at the university, never came true [6].

Only after the restoration of Estonia's independence (1991), in the course of reforms at the University of Tartu, the Centre for Physical Anthropology was founded (on 18 July 1993) at the Faculty of Medicine on the initiative of Professor of Obstetrics and Gynecology H. Kaarma and with the support of Prof. P. Tulviste, the then Rector of the University.

The aim of the Centre is to teach anthropology and carry out research at the university and to coordinate respective activities in Estonia. The Centre's responsibilities also include graduate studies and in-service training for students and experts in different specialities.

The Centre unites lecturers, researchers and students from several faculties of the university, and experts in several areas, who are interested in anthropology. The Centre works in close cooperation with the Ministry of Social Affairs, Bureau of Medical Statistics, Estonian Anthropometric Register, Estonian Naturalists' Society, Institute of Mathematical Statistics at the university and a number of well-known anthropologists from the whole world [2].

During its twelve years of existence, the Centre for Anthropology headed by Prof. H. Kaarma has given its contribution to teaching and research of this subject at the University of Tartu with its 11 faculties and over 17,000 students.

Today the Centre for Physical Anthropology is continuing and expanding its activities in the historic Old Anatomical Theatre, in the rooms that once belonged to the Institute of Anatomy.

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LAB OR GYM? DILEMMA ON CHOOSING A RESEARCH BATTLEFIELD IN FIGHTING AGAINST OBESITY IN YOUTH

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ABSTRACT

The decreasing level of physical activity and fitness is a cause of serious health problems (cardiovascular, endocrine, orthopedic, psychosocial) even in the youngest population, where growing obesity becomes more and more visible reality. Sedentary life style reduces muscle mass and more fat tissue in body composition became a "norm". In the case of overweight and obesity, public costs of medical treatment and clinical testing are enormous. Therefore reliable, valid and easy in use testing tools are required for the population-wide prevention strategies and intervention programs. In the paper we have verified laboratory and field testing methods in two most important determinants of obesity prevention, showing scientifically proven dependence, namely: fat and endurance measuring. It was concluded that the field methods tested in the work turned to be valuable and reliable tools at the level sufficient for health educators and professionals.

Key words: body fat, endurance testing, obesity prevention, youth

INTRODUCTION

According to WHO [41] obesity is a serious health problem that reduces life expectancy by increasing one's risk of developing coronary artery and pulmonary disease, hypertension or diabetes of a II type. Numerous studies have proven connection between the level of activity and body fat [4, 15, 25, 27, 30] as well as with an occurrence of heart disease, metabolic problems, insulin of a II type [1, 16, 20] also genetically dependent. The prevalence of obesity in young age groups appears to be increasing in most of the industrialized countries. Recent research into this problem concerns relations of physical activity with motor and cardiovascular fitness, fatness, body mass, BMI (body mass index) and other body components at various developmental stages but without any educational interventions [2, 4, 7, 8, 13, 28, 35, 40]. In the research carried out in the USA, on more than 10 thousand pupils, the connection between the level of activity and BMI has been observed. Increasing BMI has been influenced by decreasing physical activity [2].

The prevention of weight gaining requires a consideration of several influencing determinants. Some of them, like genetic or somatic determinations, are very often beyond our control (except these of medical intervention). Others, like oxygen consumption during physical exercises, can be reasonably easily controlled and used in a health training prescription. It becomes one of the main predictors in prevention of any abnormal weight (fat) gaining.

Most recently numerous researchers report evident connections between VO_2max (maximal oxygen consumption) and BMI. Ekelund et al. [9] have found that body fat was significantly and negatively related to VO_2max both for boys ($r=-0.48$) and girls ($r=-0.43$). Interestingly, Kropej et al. [23] have found in their research that more girls than boys reach a plateau in VO_2, and fat mass (FM) is more frequently in the plateau achievers than non-achievers. This finding has agreed with the results of Kemper and van Zundert [20] who have also found that more girls (73%) than boys (53%) could reach the VO_2 plateau. In this case it is connected to a larger leg muscle mass and the difference between genders grew along the rowing paths. It is also worth mentioning here that Fawkner and Armstrong in their research [10] found that there are no gender differences among pubertal boys and girls in the oxygen consumption (VO_2) kinetic response to moderate intensity exercise. However, gender differences are apparent even in the prepubertal years in the response to maximal exercise. It seems to be important for the exercise loads prescription. However, Sumiński [34] found that the weight status of the child does not significantly influence the correlation between VO_2max as a result of a maximal, graded treadmill test according to the Bruce protocol and the field-based aerobic fitness test consisted of the 20m shuttle run (20-MST).

Van Praagh et al. [36] measured VO_2max in 12-year-old boys in the laboratory tests and estimated VO_2max in the 20-MST. He found a significant correlation between both tests. Grant et al. [12] compared seven commonly used indirect VO_2max tests (namely: the max Bruce and the 85% Bruce treadmill tests, the Astrand-Ryhming test, the HR exploration cycle ergometer test, the Leger shuttle run, the 15m-run and the Canadian Fitness Test – ab. CAFT step test) with the direct laboratory VO_2max tests. His findings helped him conclude that all the tests had a validity of 0.80 for females (except for CAFT) and a very low validity for males (for the procedure description see: Grant et al. [12]). Also, De Oliveira et al. [26] found a comparison between the results of the 20-MST and the VO_2max on a treadmill in the laboratory ($r=0.72$) and therefore, the findings of the former one are more suitable results for field games researching.

Kemper [18] in his report from the Amsterdam Growth and Health Longitudinal study proved a significantly higher VO_2max values of relatively physically active boys and girls than achieved by their inactive counterparts (during the teenage period 12–21 years). However, an increase in the physical activity level of 30% over an extended period of time (25 years old) resulted in a relatively small increase in VO_2max – 3%. Kemper concluded that genetic determinants were more important for aerobic fitness than environmental ones (such the as amount of daily physical activity).

In the prevention of obesity prevalence it is important to detect the problem and the possible reasons of its occurrence quite early. It is known that some genes are responsible for muscle mass control (GF – 1 or PPAR Delta). Others, like EPO, help in increasing endurance abilities. Establishing of DNA structures and the types of genes, responsible for various health abilities as well as some diseases, is certainly necessary, when used in a proper and an ethical way to save human life but if it is misused, hangs a dangerous threat over a mankind. And probably "early" genetic intervention (excluding the one during pregnancy) would be the easiest way to shift the problem of obesity away, once and for "good". However, whether this would be really for good? It remains unknown.

Since the relation between the body-size and the maturation stage related to exercise performance level is well-known and documented, any comparison between boys and girls at the age of puberty should employ special techniques for interpreting the size-related results [37]. However, it has not been of our intention to go into details of gender comparison between pubertal girls and boys and we are aware of dimorphic differences starting to differentiate girls from boys around this age [38]. The clear aim of this paper is to validate field and lab testing methods, and therefore we have decided to connect boys and girls together, while analyzing various methods of testing.

The aim of the research was to find possible tools, easy in use, to help reduce obesity through the early stage of prevention. It would be the most practical and within the reach of an "average" health professional for whom a sport gym rather than a physiological laboratory should be the first choice in developing intervention strategies. Clinical laboratory exercise testing may be useful in small groups of children or adults, but does not work in exercise testing of children or nation-wide research. Therefore, the purpose of this study was to validate fitness and fatness testing as useful tools for exercise prescription in natural field conditions.

SUBJECTS AND METHODS

The amount of body fat is usually quantified by assessing the fat mass (FM) and fat-free mass (FFM) of the individual. Among most commonly used methods of body fat measurement one should notice: anthropometrical measurements (including body height, body mass and several circumferences of various body segments), skinfold thickness measurements, dual X-ray absorptiometry (DXA), magnetic resonance imaging (MRI), underwater weighting or Bioelectrical Impedance Analysis (BIA). The present trends point towards a new method of body fat estimation – the BOD POD Body Composition System based on the principle of air displacement (opposite to underwater weighing based on the principle of water displacement). In the BOD POD system subjects sit in an egg-shaped fiberglass chamber that contains a weighing device and a computer used to determine body density. Only a couple of studies have been conducted so far, but this new method seems promising as it is relatively quick (takes three to five minutes), simple and requires little effort by the subject (for more see:[14, 24, 29, 32]).

In the research carried out at the beginning of the 2004/05 school year in Poznań there was a sample of 32 randomly selected 13-year-old pupils (14 boys and 18 girls) from two gymnasium schools. The body fat estimation was done by skinfold thickness measurement using a Lange caliper. Skinfold mean values were obtained by measurement done in five sites: subscapular, suprailiac, triceps, biceps and calf. There was also an examination of the body fat of all the subjects by BIA with by Bodystat (see the description of the testing procedure in Heyward et al. [14]). The level of endurance in every subject was determined both by the 20-MST and the PWC_{170} test (accordingly to the Eurofit test battery procedure). The mean and standard deviation values of the examined groups are presented in Tables. 1 and 2. Statistical methods (including the Spearman's correlation coefficients) were employed to establish significance of correlations between the measured variables.

Table 1. Mean, median and standard deviation values in a group of examined 13-year-old boys (N=14)

	$\bar{X}$ Mean	Median	Min	Max	SD
Cardiorespiratory endurance					
PWC [W/kg]	1.93	2.03	1.00	2.50	0.36
PWC [W]	98.36	104.05	61.30	121.40	17.33
Endurance shuttle run [cycle's number]	7.00	8.00	3.00	9.50	2.05
Body composition					
Weight [cm]	51.64	54.50	35.00	64.00	8.53
Height [kg]	165.17	165.00	146.00	176.00	9.30
Fat mass [kg]	8.60	8.40	5.00	14.70	3.07
Fat free mass [kg]	39.32	40.45	31.10	46.80	5.46
BMI [kg/m^2]	17.67	17.35	14.50	21.10	2.02
Skinfolds					
Triceps [mm]	8.00	8.00	5.00	15.00	2.71
Biceps [mm]	5.92	5.00	3.00	11.00	2.20
Subscapular [mm]	7.57	8.00	3.00	12.00	2.37
Suprailiac [mm]	12.50	14.50	5.00	17.00	3.77
Calf [mm]	12.14	11.50	5.00	21.00	4.73

Table 2. Mean, median and standard deviation values in a group of examined 13-year-old girls (N=18)

	$\bar{X}$ Mean	Median	Min	Max	SD
Cardiorespiratory endurance					
PWC [W/kg]	1.91	1.86	1.40	2.69	0.32
PWC [W]	93.52	98.60	60.20	129.10	20.65
Endurance shuttle ran [cycle's number]	6.27	6.50	4.00	9.00	1.73
Body composition					
Weight [cm]	49.27	46.50	36.00	72.00	10.32
Height [kg]	162.72	162.00	151.00	187.00	9.29
Fat mass [kg]	9.72	9.25	4.10	21.00	4.02
Fat free mass [kg]	37.51	38.15	29.10	46.00	5.07
BMI [kg/m^2]	18.53	18.55	14.10	24.00	2.39
Skinfolds					
Triceps [mm	11.00	10.50	5.00	21.00	3.72
Biceps [mm]	7.38	7.00	3.00	16.00	2.95
Subscapular [mm]	9.88	9.00	5.00	24.00	4.60
Suprailiac [mm]	15.77	15.50	5.00	26.00	6.40
Calf [mm]	12.16	11.50	5.00	21.00	4.28

RESULTS

The comparison of the results obtained by the field and laboratory estimation methods of the selected health-related fitness components (endurance, body composition), and connected with obesity is presented in Table 3. The measurement of cardio-respiratory fitness done by the 20-MST proved a strong and statistically significant correlation of the 20-MST with the PWC_{170} test while the PWC_{170} results were expressed in values per kg of body mass ($r=0.70$; $p\leq0.01$). No significant correlation between the 20-MST and the PWC_{170} test for calculation of the overall PWC results in W was found. The endurance run is dependent on body mass and, of course, on all the muscle mass engaged in this kind of an exercise. In the PWC_{170} test only the muscle mass of the lower part of the body is engaged in cycling. So, the final physical capacity, obtained as a result of this test, is generated not by the whole body. Probably, the PWC_{170} test results, calculated per kg of body mass, reflect the correlation between endurance run and cycling in a better way.

As it was noticed, a comparison of body skinfolds, measured with a Lange caliper, indicated a significant correlation of the body mass components obtained by a bioelectrical impedance analysis (BIA). A sum of five skinfolds has shown a strong statistically significant correlation to fat mass (FM) in both: body mass expressed in kg ($r=0.408$; $p\leq0.01$) and percentage of the total body mass ($r=0.391$; $p\leq0.01$).

Table 3. The Spearman's correlation of field and laboratory tests results in examined 13-year-old pupils (boys and girls together)

	R Spearman	t(N-2)	p level
Cardio-respiratory endurance			
20-MST & PWC [W/kg]	0.701	5.397	0.000
20-MST & PWC [W]	0.327	1.895	0.067
Body composition			
Triceps & fat mass [kg]	0.208	1.166	0.252
Triceps & fat mass [%]	0.191	1.068	0.293
Biceps & fat mass [kg]	0.316	1.828	0.077
Biceps & fat mass [%]	0.347	2.027	0.051
Subscapular & fat mass [kg]	0.504	3.199	0.003
Subscapular & fat mass [%]	0.435	2.646	0.012
Suprailiac & fat mass [kg]	0.232	1.309	0.200
Suprailiac & fat mass [%]	0.181	1.012	0.319
Calf & fat mass [kg]	0.340	1.982	0.056
Calf & fat mass [%]	0.440	2.689	0.011
Sum of skinfolds & fat mass [kg]	0.408	2.449	0.020
Sum of skinfolds & fat mass [%]	0.391	2.328	0.026
BMI & fat mass [kg]	0.705	5.449	0.000
BMI & fat mass [%]	0.514	3.285	0.002

However, a correlation analysis of the selected skinfolds (by caliper) with a total body fat (by BIA) has shown some differences. A statistically significant correlation with the percentage of body fat was found only for subscapular and calf skinfolds. Thickness of other skinfolds proved no direct relation to the total body fat.

DISCUSSION

The relations between the level of fitness and body fat contents have been proven in the numerous studies mentioned earlier. For the aim of our research it was important to estimate a significance of correlation between the selected methods of body fat and endurance abilities assessment in the group of 13-year-old boys and girls. It was our belief that at this age there was still a chance to modify habitual behaviours in accordance with health-related fitness theories [5], and therefore any possibility should not be squandered. Szmodis et al. [33] have found a correlation between the parental body linearity and skinfolds in the off-springs. It has proven the strongest relation between 10–13 years of chronological age. The period of puberty has brought rapid changes both to the mind and body. It has seemed to be associated with more marked organism's responses to slight modifications of the natural surrounding and environment, particularly in boys, who have been found as more eco-sensitive [6, 33, 39].

In this comparison study of field and laboratory tests it was our aim to estimate a correlation and reliability of the selected tests. The results of the 20-MST have strongly correlated with the PWC_{170} test (Table. 3) noticed as a time and money consuming laboratory test – expensive as regards time and necessary means. Some attempts to find an easier way to estimate the selected health-related fitness parameters were undertaken earlier [3, 38]. These authors have compared modern and traditional body composition assessment methods. However, our findings have provided a very important and easy in use a tool to assess the teenagers' characterized by a low level of physical fitness. There was no need to employ an expensive laboratory procedure to the predict subject's oxygen consumption. Endurance could be estimated in quite a simple way otherwise. Therefore, the 20-MST would be useful for both school and training (health-related) settings – easy to control, easy to implement and reasonably valuable to estimate an improvement of health levels.

Similarly, a comparison of body fat measurements – BIA and skinfolds – has revealed that these two methods could be used interchangeably with a statistically justified correlation and validation. However, a more detailed analysis has indicated that to minimize possible estimation errors there was a need to measure several skinfolds. This might be due to individual differences in body fat distribution, especially among teenagers incoming the stage of puberty. Saczuk et al. [31], also Kemper et al. [17] in their research have found it possible to distinguish four subgroups of biological development (according to Tanner's scale) in the same age category of 13-year-old pupils. It would also obviously influence the distribution and spreading of the body fat. It was proven in our research that a sum of five skinfolds, namely: biceps, triceps, subscapular, suprailiac and calf have significantly correlated to the estimation of body fat assessment by BIA ($p \leq 0.01$), and therefore might also be used interchangeably.

A monitoring of changes in FM and FFM or endurance capacity could improve our understanding on energy metabolism and allow avoiding various diseases causing body composition changes. An accurate assessment of the body health level has been equally important in the case of professional athletes as well as any other member of society to understand Kemper's [19] consideration: "Are we fit because we are active? or "Are we active because we are fit?". Health consequences related to obesity in youth concerned many risk determinants, such as: cardiovascular (dislipidemia, elevated systolic and diastolic blood pressure), endocrine (insulin resistance, abnormal metabolism), life style (low fitness, low physical activity level, low movement competence), orthopedic (accelerated, abnormal growth) psychosocial (low self-esteem and socio-economic status). There are also strong indications of transferring the problem of obesity from youth into later stages of adulthood and elderly life [18, 22].

Additionally, we have to remember that psychosocial consequences of lowered fitness level and obesity problems in children and youth might range from learning and behavioral difficulties through negative self-esteem and self-confidence to acceptation of cultural preferences for thinness. In future it could be transferred to the next generation in the family. So the problem requires a considerable attention. Therefore, methods of health assessment, easy in application and reliable at the same level, such as: skin thickness measurement or the 20-MST should be recommended to become widely used tools for all the professionals of health science, especially in the field of natural environment. It would allow us to avoid many problems with all these getting the lab ready for "the research" and perhaps help diminish the level of people's obesity.

CONCLUSIONS

1. Skinfold field methods of body composition assessment are reliable and useful tools for identifying health risks, determining the health and fitness profiles and monitoring growth as well as the evaluation of nutrition and exercise intervention changes.

2. For an accurate assessment of body fat by the use of skinfold method, it seems necessary to measure and sum up several skinfolds giving more statistically justified correlation.
3. Results of 20m shuttle run test (20-MTS) can be used as a reliable indirect method to predict accurately VO_2max and endurance abilities (capacity) in young children.
4. The field and laboratory body fat and endurance testing methods examined in the paper can be used interchangeably with statistically similar significance.

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MORPHOLOGICAL AND PHYSIOLOGICAL PARAMETERS IN RELATION TO PLAYING POSITION OF HIGH LEVEL MALE BASKETBALL PLAYERS

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ABSTRACT

When establishing morphological and functional indices for basketball players, researchers have analysed the data of the members of a team as belonging to one and the same sample. We think that it is necessary to differentiate analysis on the basis of the playing position of the player.

We examined 36 high-class basketball players: 15 guards, 13 forwards and 8 centre players. Testing included collection of anthropometric data and a cardiopulmonary test with stepwise increasing loads.

In all investigated subjects the following variables were sampled: oxygen uptake expressed per kilo of the subject's weight at rest (VO_{2rest}), at anaerobic threshold (VO_{2AT}), and at peak of exercise (VO_{2max}), the ratio of oxygen uptake at anaerobic threshold to oxygen uptake at the peak of exercise (ratio VO_{2AT}/VO_{2max}), work rate at anaerobic threshold (W_{AT}), work rate at the peak of exercise (W_{max}) and relative power expressed as peak of work rate per kilo of the subject's weight (W_{relat}), heart rate at anaerobic threshold (HR_{AT}), heart rate at the peak of exercise (HR_{max}), pulmonary ventilation at anaerobic threshold (VE_{AT}), pulmonary ventilation at the peak of exercise (VE_{max}) and respiratory exchange ratio (RER) at the peak of exercise.

We found significant differences in height ($F=38.027$) and body mass ($F=37.899$) between the athletes in different playing positions, using analysis of variance. Despite significant differences in body height and weight, we were not able to confirm existence of a similar consistent pattern for body mass index.

We also found significant differences in peak oxygen consumption (F=4.234) and relative power (F=8.313) between the athletes in different playing positions, using analysis of variance.

The results of the study show that there are significant differences in the morphological and functional indices between the guards, forwards and centre players, arising during regular sport-specific exercise. Therefore, we are of the opinion that it is necessary to use morphological and physiological data, collected during cardiopulmonary exercise testing (CPET) in selection of players, for management of the training process, as well as for evaluation of the testing results on the basis of the person's playing position.

Key words: anthropometry, exercise testing, basketball, playing positions, oxygen uptake

INTRODUCTION

Fitness of players is an important characteristic that may directly influence the effectiveness of the team in sport games. A reliable measure of a subject's physical capacity is necessary to plan training programmes and to define some aspects of performance. Despite the similarity of performance indicators in invasion sport games [8] and selection, different exercise loads and functions fulfilled during training and competition introduce specific physiological features of the involved subjects. For the above reasons and owing to early specialization in sport schools, participants develop morphological and functional properties differing among different fields of sport as well as within one and the same field.

While research into soccer and tennis has been well advanced, considerably less attention has been given to other sport games like handball or basketball [6, 7]. Basketball is a typical invasion game with repartition of participants according to playing position. Despite specific research focused on physiological response to physical stress, inherent in basketball [7, 10], relatively little information is available about comparison of morphological and functional properties in relation to particular playing positions. The mean values for the investigated groups are used as a generic fitness standard, while playing position-related differences are overlooked or ignored [9]. The improved quality of practice but not its increased amount can ensure success for professional athletes in the future. The best possibilities for improving the quality of conditioning are associated with individualization of exercise tasks and intensities. However, the first step in individualization of conditioning is determination of current typical morphological and functional indices. The relationship between morphological and functional indices and playing positions is not yet established for male elite basketball.

The purpose of this study was to evaluate the differences in individual anthropometric and physiological parameters obtained during cardiopulmonary exercise testing in professional high-level basketball guards, forwards and centre players.

MATERIAL AND METHODS

We studied 36 healthy men: 32 Caucasians and 4 blacks. All 36 subjects were professional athletes with international experience (European Cups for club teams as a minimum). The study cohort consisted of 15 guards, 8 centre players, and 13 forwards. Written informed consent for participation in the study was obtained from each athlete in accordance with the Code of Ethics.

Height (to the nearest cm) and weight (to the nearest 0.1 kg) were recorded with the subjects dressed in exercise clothing and without shoes. Standing height and weight were used to calculate BMI (weight, kg) / (height, m^2).

Each subject was well rested before the test and had not done hard physical work during the preceding 24 hours. All tests were carried out under laboratory conditions complying with the regulations of the American Thoracic Society (ATS) [1]. Each subject performed the exercise test on an electrically braked cycle ergometer ERGO-METRICS 800 (Ergoline, Bitz, Germany). Power output was increased by 25 or 30 Watts (W) every minute and pedalling cadence was kept constant at 60–70 revolutions per minute (rpm). The exercise tests were terminated upon exhaustion or when the criteria established for test termination were met. Termination of the test was associated with the following criteria: respiratory exchange ratio being 1.10 or more, heart rate attaining a plateau with the increasing workload, oxygen consumption attaining a plateau with the increasing workload [1, 4, 11].

Gas exchange data were collected continuously using the automated breath by breath system VMAX229C (Sensormedics Corps. Yorba Linda, CA, USA). Calibration of the flow/volume sensor was achieved immediately before each test by manually pumping a 3-litre syringe through the flow-meter at a rate similar to that achieved during the exercise test. Samples were formed for each 20-second interval for the evaluation of the lung ventilation indicators, heart activity and oxygen uptake. Anaerobic threshold was identified by the conventional criteria using the V-slope method [1, 11]. In all investigated subjects the following variables were sampled: oxygen uptake expressed per kilo of the subject's weight at rest (VO_{2rest}), at anaerobic threshold (VO_{2AT}), at the peak of exercise (VO_{2max}), the ratio of oxygen uptake at anaerobic threshold to oxygen uptake at the peak of exercise (ratio $VO_{2\,AT}/ VO_{2max}$), work rate at anaerobic threshold (W_{AT}), work rate at the peak of exercise (W_{max}) and relative power expressed as the peak of work rate per kilo of the subject's weight (W_{relat}), heart rate at anaerobic threshold (HR_{AT}), heart rate at the peak of exercise (HR_{max}), pulmonary ventilation at anaerobic threshold (VE_{AT}), pulmonary ventilation at the peak of exercise (VE_{max}) and respiratory exchange ratio (RER) at the peak of exercise.

The statistical Package for Social Sciences software (SPSS 11.0) was used for all statistical analyses. Descriptive statistics were calculated as the means, standard deviations, range and medians. The data was analysed using ANOVA for the repeated measures. The critical value of Fisher's distribution was $F>3.3158$ for analysis of variance [3]. The differences detected by ANOVA were determined with the Tukey HSD and Bonferroni post hoc tests. Statistical significance was accepted for the $p<0.05$ levels.

RESULTS

The comparative data of the anthropometric parameters for the guards, forwards and centres are presented in Table 1.

We found significant differences in height ($F=38.027$) and body mass ($F=37.899$) between the athletes in different playing positions, using analysis of variance. However, despite significant differences in body height and weight we cannot confirm existence of a similar consistent pattern for body mass index.

Table 1. Anthropometric indices of the study subjects.

Parameter	Position	Mean±SD	Median	Mini-mum	Maxi-mum
Age (years)	Guards	24.13±3.796	24	19	30
	Forwards	26.23±3.898	26	20	32
	Centres	25±3.891	25.5	19	30
Height (cm) *	Guards	188.8±6.27	190	179	201
	Forwards	201.54±4.96	203	192	208
	Centres	207.75±3.845	207.5	203	215
Body mass (kg) *	Guards	85.47±6.297	85	69.0	95.5
	Forwards	101±7.876	101	88.5	113.0
	Centres	111.31±7.294	109.25	104.0	127.0
Body mass index (kg/m^2)	Guards	24.02±2.051	24.78	19.52	26.58
	Forwards	24.88±3.851	24.73	22.57	28.31
	Centres	25.77±1.282	25.22	24.27	27.63

* Fisher's distribution between the groups > 3.31.

We confirmed statistically significant differences in height and body mass between the guards, forwards and centres using the post hoc criteria. Differences in body mass and height in the case of different playing positions are presented in Table 2.

Strong correlation ($r=0.817$, $p<0.0001$) was established between the weight and height of the investigated athletes using the Spearmen range test. As shown in Fig. 1, this relationship can be described as *Mass (kg) = –111.72 + 1.06 x height (cm).*

The values of the physiological variables estimated or calculated during cardiopulmonary exercise testing are presented in Table 3.

Table 2. Multiple comparison of the morphological indices.

Parameter	Post hoc criterion	Compared playing positions	Mean difference	Standard error	p
Height (cm)	Tukey HSD	G-F	−12.7385	2.0322	0.000*
		G-C	−18.95	2.3479	0.000*
		F-C	−6.21154	2.4099	0.037*
	Bonferroni	G-F	−12.7385	2.0322	0.000*
		G-C	−18.95	2.3479	0.000*
		F-C	−6.21154	2.4099	0.043*
Weight (kg)	Tukey HSD	G-F	−15.5333	2.6974	0.000*
		G-C	−25.8458	3.1164	0.000*
		F-C	−10.3125	3.1987	0.007*
	Bonferroni	G-F	−15.5333	2.6974	0.000*
		G-C	−25.8458	3.1164	0.000*
		F-C	−10.3125	3.1987	0.008*

* Difference statistically significant, p<0.05.

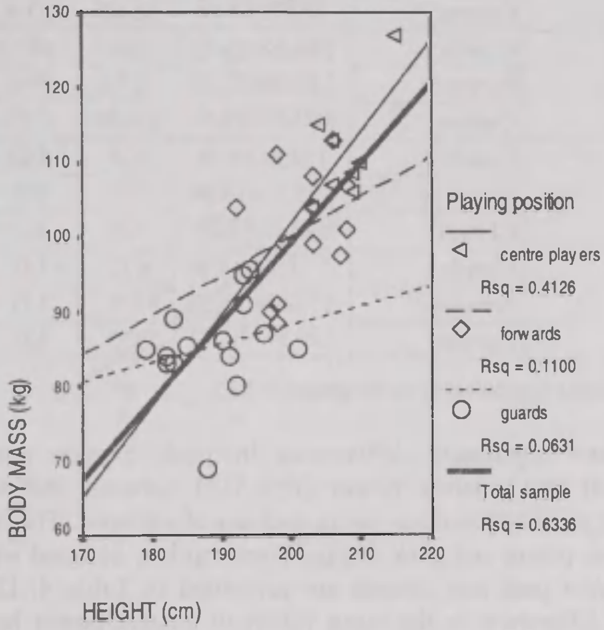

Figure 1. The relationship of body mass and height in male basketball players.

Table 3. Main results of cardiopulmonary exercise testing of the study subjects.

Parameter	Position	Mean±SD	Median	Minimum	Maximum
VO_{2AT} (ml/min/kg)	Guards	26.09±5.97	25.6	18.1	40.8
	Forwards	23.28±2.91	23	18.5	30.1
	Centres	22.43±3.78	22.7	15.6	27.5
VO_{2max} * (ml/min/kg)	Guards	52.85±8.84	52.7	35.6	66.3
	Forwards	46.17±5.95	47.6	36.2	55.1
	Centres	45.75±3.38	46.45	40.5	50.0
Ratio VO_{2AT}/VO_{2max}	Guards	49.62±8.88	48.1	36.3	66.4
	Forwards	50.85±6.05	50.2	43.2	62.4
	Centres	48.99±7.04	50.4	38	60.3
W_{relat} * (W/kg)	Guards	3.93±0.48	3.99	3.26	4.82
	Forwards	3.36±0.5	3.28	2.74	4.63
	Centres	3.19±0.38	3.075	2.75	3.78
VE_{AT} (l/min)	Guards	53.66±14.06	50.3	35.8	83.4
	Forwards	56.25±11.56	55	37.3	75.2
	Centres	53.95±13.13	55.65	33.4	73.1
VE_{max} (l/min)	Guards	134.49±25.72	126.7	100.3	182.3
	Forwards	133.06±31.56	127.8	89.0	193.4
	Centres	139.69±19.69	139.05	113.2	168.9
HR_{AT} (bpm)	Guards	124.4±15.79	121	102	154
	Forwards	123.23±13.06	121	101	143
	Centres	123.12±7.29	122	115	134
HR_{max} (bpm)	Guards	172.67±14.8	172	141	194
	Forwards	171.69±12.57	175	151	190
	Centres	170.87±12.02	173	151	190

* Fisher's distribution between the groups > 3.31.

We found significant differences in peak oxygen consumption (F=4.234) and relative power (F=8.313) between the athletes in different playing positions, using analysis of variance. The differences in relative power and peak oxygen consumption, detected with the use of different post hoc criteria are presented in Table 4. Despite the marked differences in the mean values of relative power between the

Table 4. Multiple comparison of the functional indices.

Parameter	Post hoc criterion	Compared playing positions	Mean Difference	Standard Error	p
VO_{2max} (ml/min/kg)	Tukey HSD	G-F	6.6774	2.6364	0.042*
		G-C	7.0966	3.0459	0.065
		F-C	0.4192	3.1264	0.99
	Bonferroni	G-F	6.6774	2.6364	0.049*
		G-C	7.0966	3.0459	0.078
		F-C	0.4192	3.1264	1
W_{relat} (W/kg)	Tukey HSD	G-F	0.5711	0.1784	0.008*
		G-C	0.7417	0.2061	0.003*
		F-C	0.1707	0.2115	0.702
	Bonferroni	G-F	0.5711	0.1784	0.009*
		G-C	0.7417	0.2061	0.003*
		F-C	0.1707	0.2115	1

G- guards, F- forwards, C- centres. * Difference statistically significant, $p<0.05$.

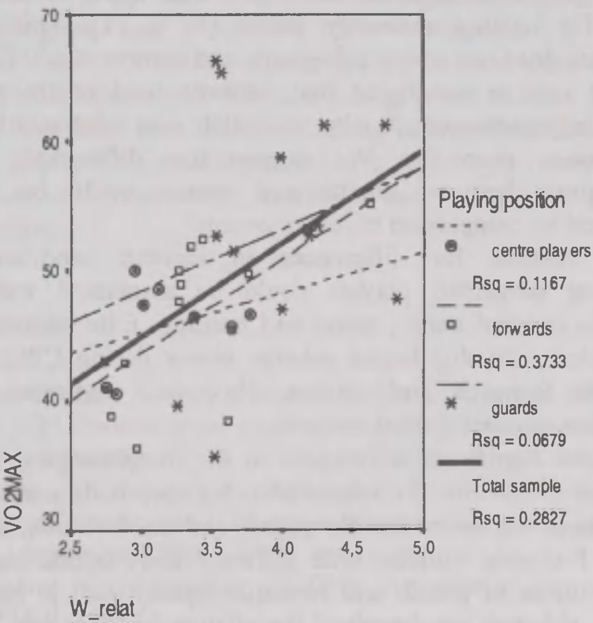

Figure 2. Scatterplot of oxygen consumption to relative power of the subjects of the study.

guards and the centre players, we cannot confirm that these differences were significant. We only succeeded in establishing statistically significant differences for individual basketball playing positions in peak oxygen consumption and relative power. Fig. 2 is an attempt to develop a scatterplot of these variables.

DISCUSSION

The main result of this study is the establishment of significant differences not only in the morphological but also in the physiological properties of elite basketball players in relation to their playing positions. Although typical anthropometric and physiological parameters of basketball players have been reported in the literature [2, 5, 7, 10], the data have not been analysed regarding the playing positions of the subjects.

We found evidence that guards are aerobically better prepared. Hoffman (2003) made the same suggestion but the results of the study were not statistically confirmed [7]. Peak oxygen consumption values of elite guards in basketball are higher than upper border normative values for healthy sedentary adults [1, 4, 11]. This categorical difference does not concern forwards and centres at all. On the other hand, it can be concluded that forwards and centre players can successfully participate in elite basketball with relatively low oxygen consumption properties. We suggest that differences in oxygen consumption between guards and centres could be statistically confirmed by comparison of larger groups.

The reasons for differences in aerobic condition between individual basketball players could be associated with different distances covered during game and training. Elite basketball guards were able to develop higher relative power during CPET compared with the forwards and centres. However, confirmation of this suggestion requires further research.

Despite significant differences in the morphological parameters, we failed to describe the relationship between body mass and height using linear regression for the guards and the forwards, as shown in Fig. 1. Probably, athletes with different body builds can fulfil the playing duties of guards and forwards equally well in basketball. In general, although we described the relationship between VO_{2max} and W_{relat} as linear (r-square >0.25), some problems arose with linearity when we attempted to construct this relationship in relation to playing positions. Yet we can suggest at least two links: the results revealed the need to study more sensitive indices of functional capacity. On the other hand, the results of cardiopulmonary exercise testing might be associated with the intensity of exertion, as has been shown in soccer [6]. We suggest that division of basketball players according to their playing time could explain some unclear issues in similar studies.

Use of two post hoc criteria (Bonferroni and Tukey HSD) is due to the different properties of these criteria [3]. Similarities between the results obtained with the use of different post hoc criteria could be accessory indirect confirmation of the presented differences.

The established values of anthropometric and physiological parameters for individual playing positions could be useful in selection and evaluation of athletes in high-level basketball. The differences found should be taken into account when designing conditioning programmes for high-level basketball teams.

CONCLUSION

The results of the study show that there exist significant differences in the morphological and functional indices between the guards, forwards and centre players, arising during regular sport-specific exercise. We therefore think that it is necessary to use the morphological and functional data, collected during cardiopulmonary testing, in selection of players, for management of the training process, as well as for evaluation of the testing results on the basis of the person's playing position.

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DEPENDENCE OF FINNO-UGRIC PEOPLES' HEAD AND FACE MEASUREMENTS ON STATURE

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ABSTRACT

The paper presents a short overview of the variability of stature, head and face measurements in Finno-Ugric and their neighbouring peoples on the basis of Karin Mark studies (22 ethnic groups, consisting of 133 local ethnic groups, over 12,000 individuals in total) [6, 7, 8]. The article describes the dependence of head and face measurements on stature.

The studied peoples are characterised by considerable anthropological variety. The mean stature of these peoples varies between 157.7–174.7 cm, head length between 186.3–195.9 mm, head breadth between 150.8–159.8 mm, etc.

Dependence of head measurements on stature is rather great. The correlation coefficient is the highest between the head module and stature (r=0.80), followed by head length (r=0.74) and head breadth (r=0.55). It is also high between forehead breadth and stature (r=0.61). Among the face measurements, the most greatly dependent on stature is physiognomic facial height (r=0.60), followed by morphological facial height (r=0.44). The breadth measurements of the face are less dependent on stature: bizygomathic breadth (r=0.30) and bigonial breadth (r=0.24).

Key words: Finno-Ugric peoples, stature, head and face measurements, correlations

INTRODUCTION

Correlations between particular parts of the body are significant from the viewpoint of the body as a whole as well as for comparing the morphological characteristics of different nations. In Estonia, only a few papers have been dealing with these correlations [1, 2, 3, 4].

The well-known Estonian anthropologist K. Mark (1922–1999), who could, with full justification, be called a Finno-Ugric anthropologist, has assembled an extensive and valuable body of material concerning the morphological characteristics of all the Finno-Ugric peoples and, for comparison, their neighbouring peoples. The results of her studies have been published in monographs as well as in many other solid sources [6, 7 and others]. In her extensive manuscript study on the anthropology of Finno-Ugric peoples and their neighbouring peoples, K. Mark has also presented correlations between characteristics.

The current article introduces a part from the forthcoming monograph *Physical Anthropology of the Finno-Ugric Peoples*, which is based on K. Mark's material [8]. It will deal with the variability of stature and head and face measurements, and the correlations between these measurements and stature.

MATERIAL AND METHODS

Data on the mean stature, head and face measurements of 22 ethnic groups (consisting of 133 local ethnic groups), studied by K. Mark (among them 17 Finno-Ugric, 2 Indo-European and 3 Turkic groups, a total of more than 12,000 individuals) were used [6, 7, 8]. The arithmetical means and variation range of the traits of the studied peoples are given in the Table 1. Here, the ethnic groups are arranged in ascending order of their mean stature.

To establish the dependence of head and face measurements on stature, K. Mark used the correlation coefficient. It was calculated between the head and face features and stature using the arithmetic averages of Finno-Ugric groups. The main statistics of the respective traits are given in full in the monograph *Physical anthropology of the Finno-Ugric peoples* (after K. Mark's manuscript; compiled, completed and edited by L. Heapost) [8].

In this article, the classification of traits used by K. Mark is unchanged.

RESULTS AND DISCUSSION

The average stature, head and face measurements are presented in Table 1.

The average **stature** of the studied ethnic groups varies greatly – from 157.7 cm to 174.7 cm. Observing the ethnic groups in ascending order of their average stature, we get a number of groupings of peoples within which there are no significant differences.

1. Khants have the shortest stature among all the peoples studied (157.7 cm); they differ significantly from all the other peoples. 2. Mansi, Sami and Bessermen are of short stature (160.5–161.6 cm). 3. Mari, Udmurts and Komi-Permyaks (162.3–162.9 cm). 4. Bashkirs and Vepsians (163.5–163.9 cm) are peoples of relatively short stature. 5. Komi-Zyrians, Chuvash and Tatars (164.7–165.2 cm) are already of medium growth for Finno-Ugrians, 6. Karelians, Russians of the Volga area, Izhorians and Moksha (165.7–166.3 cm). 7. Erza, whose growth is above the average (167.7 cm), differ significantly from all the other peoples studied. 8. Transcarpathian Hungarians and northeastern Finns have relatively tall stature (168.7–169.3 cm). They differ significantly from the other peoples. 9. Finns (without northeastern Finns) and Estonians have rather tall stature (172.9–173.2 cm). They differ significantly from the others. 10. Finnish Swedes (174.7 cm) are the tallest among the peoples studied and differ significantly from all the others.

The average **head length** of (summative) ethnic groups varies from 186.3 mm to 195.9 mm. The ethnic groups form a number of groupings according to their mean head length, within which significant differences are almost nonexistent.

1. Izhorians, Transcarpathian Hungarians, Komi-Permyaks and Udmurts with the smallest head length (186.3–187.3 mm). 2. Mari, Sami and Vepsians (187.7–188.2 mm). 3. Bessermen and Karelians (188.5–188.6 mm). The same grouping also includes Chuvash, Komi-Zyrians and Russians of the Volga area, whose head length (188.7–189.2 mm) is also medium for Finno-Ugrians. 4. Mansi, Khants, northeastern Finns and Bashkirs, whose head length is medium (190.1–190.8 mm). 5. Tatars together with Erza and Moksha (191.4–191.8 mm). 6. Finns (without northeastern Finns) and Estonians have considerably longer heads (193.4–194.0 mm). 7. Longest head (195.9 mm) is characteristic of Finnish Swedes.

Table 1. Stature, head and face measurements of Finno-Ugric and comparative ethnic groups

	Stature			N	Head length		Head breadth		Head module	
	N	M	var		M	var	M	var	M	var
Khants	90	157.7	–	92	190.2	–	151.9	–	342.1	–
Mansi	71	160.5	158.4–164.5	75	190.1	189.9–190.5	152.8	152.3–153.7	342.9	342.2–344.2
Sami	197	160.8	158.2–163.6	201	187.8	187.0–189.0	156.0	153.7–158.4	343.8	340.7–347.4
Bessermen	134	161.6	160.6–162.6	138	188.5	186.3–190.2	151.6	150.7–152.3	340.1	337.0–342.5
Mari	925	162.3	160.9–164.8	982	187.7	186.4–189.5	152.3	150.6–153.7	340.0	337.8–342.0
Udmurts	1324	162.5	161.4–163.6	1359	187.3	183.6–190.4	151.1	149.3–152.5	338.4	335.0–342.9
Komi-Permiaks	286	162.9	162.1–163.5	291	187.0	186.6–187.7	151.9	151.3–152.7	338.9	337.9–339.5
Bashkirs	394	163.5	162.5–165.2	403	190.8	188.9–192.0	152.4	150.4–155.4	343.2	342.4–344.3
Vepsians	105	163.9	163.4–164.7	108	188.2	187.5–189.4	153.1	152.6–153.8	341.3	340.1–343.2
Komi-Zyrians	796	164.7	162.2–167.1	809	189.0	187.0–190.7	154.1	152.0–156.5	343.1	340.6–346.6
Chuvash	270	165.1	164.5–166.0	275	188.7	188.0–189.5	153.0	152.6–153.8	341.7	340.6–342.3
Tatars	489	165.2	164.6–166.4	500	191.4	189.0–193.3	153.2	150.4–154.6	344.6	343.1–347.3
Karelians	329	165.7	164.3–166.5	334	188.6	187.2–190.2	153.0	152.4–153.4	341.6	340.1–342.9
Russians	603	166.0	164.4–167.7	612	189.2	186.2–191.1	152.6	151.6–153.5	341.8	338.2–344.6
Izhorians	156	166.3	164.8–167.2	163	186.3	185.5–186.8	154.1	153.3–154.5	340.4	338.8–341.3
Moksha	1195	166.3	164.5–168.7	1259	191.8	190.1–193.2	150.8	149.0–152.4	342.6	340.6–345.2
Erza	1458	167.7	165.6–170.5	1505	191.6	189.3–193.4	152.2	150.6–154.1	343.8	341.2–346.5
Hungarians	198	168.7	168.6–168.8	199	186.6	186.6–187.2	159.8	158.5–161.2	346.4	344.5–348.4
NE Finns	367	169.3	168.5–169.6	371	190.4	188.4–192.0	157.9	155.9–160.0	348.3	347.2–348.9
Finns	1089	172.9	171.3–176.6	1104	193.4	190.7–195.8	154.9	152.2–156.6	348.3	345.4–352.4
Estonians	1280	173.2	169.8–175.7	1282	194.0	191.9–197.5	156.9	155.8–158.4	350.9	348.0–355.7
Finnish Swedes	408	174.7	172.7–176.9	410	195.9	194.8–197.8	154.6	154.2–154.9	350.5	349.4–352.0

Table 1. Continuation

	Forehead breadth		Bizygomathic breadth		Bigonial breadth		Morphological facial height		Physiognomical facial height	
Khants	108.7	–	141.7	–	110.1	–	125.7	–	186.1	–
Mansi	109.4	107.9–110.3	143.3	142.2–143.9	112.2	111.0–112.9	125.5	125.1–126.5	186.9	185.7–189.1
Sami	108.7	106.2–110.0	141.5	139.8–142.8	109.2	107.0–111.0	118.8	118.0–120.8	180.4	178.3–182.3
Bessermen	105.5	104.4–106.3	139.9	139.5–140.2	110.8	109.2–111.4	126.9	126.4–127.3	188.1	187.2–188.6
Mari	105.8	104.1–107.3	139.5	137.9–141.4	109.5	107.2–110.8	126.2	124.2–127.4	187.1	184.3–190.0
Udmurts	105.7	104.4–107.0	140.2	138.9–141.8	109.4	107.9–110.0	125.9	123.9–128.1	185.4	183.0–187.6
Komi-Permiaks	106.8	106.6–107.2	139.8	139.2–140.7	109.6	109.1–110.3	125.6	124.6–126.3	186.6	185.3–187.9
Bashkirs	107.2	106.5–108.6	141.5	140.7–143.7	109.5	108.4–111.4	128.8	127.5–130.1	187.2	186.1–189.7
Vepsians	108.7	108.6–108.8	141.2	141.1–141.4	109.8	109.6–110.0	125.0	124.2–126.4	187.1	186.8–187.8
Komi-Zyrians	108.6	105.5–110.0	141.3	139.4–143.5	110.2	107.3–112.2	126.3	125.3–128.5	187.8	185.8–189.8
Chuvash	107.1	106.5–107.6	140.6	140.4–140.7	110.6	110.0–111.1	128.5	127.3–129.1	190.2	189.4–191.3
Tatars	106.9	105.2–107.8	141.3	140.8–142.1	109.7	108.0–110.3	126.9	124.5–128.3	185.5	183.6–188.5
Karelians	108.7	107.3–109.5	140.3	139.7–140.9	109.8	107.8–111.1	125.0	122.8–126.0	186.6	185.2–189.5
Russians	106.7	105.3–108.5	139.3	138.6–141.0	108.3	107.2–109.4	125.8	124.4–127.2	184.8	183.8–186.3
Izhorians	107.3	107.1–107.5	141.2	140.5–141.6	110.3	109.3–110.9	127.7	127.5–127.8	189.0	188.5–189.4
Moksha	105.3	104.3–106.8	139.1	138.2–140.1	108.3	107.1–110.3	125.8	124.6–127.6	183.8	182.0–187.2
Erza	107.2	105.5–109.4	139.8	138.0–141.2	109.2	106.2–111.4	126.5	123.4–128.5	184.8	182.2–186.6
Hungarians	111.9	111.7–112.1	143.7	142.8–144.7	111.1	110.7–111.6	125.6	125.4–125.9	187.2	186.6–187.8
NE Finns	112.4	112.0–112.7	143.0	141.8–144.1	111.8	110.0–112.0	121.9	121.0–122.9	187.2	185.7–188.6
Finns	110.2	109.1–111.3	141.1	138.3–142.8	109.3	107.7–111.1	127.6	125.4–130.8	191.5	188.0–195.0
Estonians	111.1	107.6–112.6	143.3	142.2–144.4	110.8	109.4–112.1	127.4	125.4–129.4	190.4	186.9–192.8
Finnish Swedes	110.8	109.5–111.3	141.6	141.2–142.2	109.9	109.2–110.0	129.4	128.5–130.6	192.6	191.4–193.7

One should take into account that to a certain extent head length depends on stature. To express this dependence more precisely, correlation coefficient (r) was calculated between both features using the arithmetic averages of Finno-Ugrians' groups. The correlation coefficient proved rather high (r=0.74), the value of the regression coefficient (Ry/x) was 0.47. In most peoples studied, head length proved to be concordant with stature. Thus, Finns and Estonians, who have tall stature, also have great head length, although it is medium for their stature. Tall Finnish Swedes, however, have great head length even for their stature. Great head length for their stature is also characteristic of Moksha, Tatars, Bashkirs and Mansi. Even greater, on the borderline between large and very large, is the head length of Khants, who are the shortest among all the peoples studied. Among the peoples of short stature, the head length of Komi-Permyaks is below average. Small head length for their stature is also typical of Izhorians and very small of Hungarians.

The average **head breadth** ranges in the studied ethnic groups from 150.8 mm to 159.8 mm. The narrowest heads belong to Moksha (150.8 mm) and Udmurts (151.1 mm). Head breadth somewhat below the average is also characteristic of Bessermen (151.6 mm). Most of the peoples studied have heads of medium breadth. Head breadth above the average (154–155 mm) is typical of Komi-Zyrians, Izhorians, Finnish Swedes and Finns. Broad head is typical of Sami (156.0 mm), even broader – of Estonians (156.9 mm) and northeastern Finns (157.9 mm). Transcarpathian Hungarians with their particularly great head breadth (159.8 mm) stand apart from all the other peoples studied.

Head breadth is not as dependent on stature as head length (r=0.55; Ry/x=0.31). Among the narrow-headed peoples, Moksha have rather narrow heads for their stature, which is medium. The other narrow-headed peoples – Udmurts, Bessermen and Komi-Permyaks – are of short stature, and their head breadth can be regarded as medium for their stature. Khants also have comparatively narrow heads, but as their stature is still shorter, their heads are even broad for their stature.

Most peoples studied have medium head breadth, which is also medium for their stature. Only Erza, who are of medium stature, have relatively small head breadth for their stature, and short-statured Mansi have large head breadth.

Among the broad-headed peoples, the heads of tall-statured Finns are of medium breadth for their stature; Finnish Swedes have narrowish heads and Estonians really broad ones. The heads of Sami, northeastern Finns and, in particular, Hungarians should be regarded very broad for their stature.

The head module or the sum of head length and head breadth characterises the size of the head. In studied ethnic groups this characteristic varies from 338.4 mm to 350.9 mm. The smallest average head module (338.4 mm) among the studied ethnic groups is characteristic of Udmurts and Komi-Permyaks. It is also small in Mari and Bessermen, and, among the Baltic-Finnic peoples, in Izhorians. The head module of most peoples studied belongs to the medium category. Great head module is typical of Hungarians and Finns, very great – of Finnish Swedes and Estonians.

Dependence of the head module on stature is rather great (r=0.80; Ry/x=0.78).

Most of the peoples studied are characterised by medium head module for their stature.

Small head module for their stature is characteristic only of Izhorians, below the average – of Udmurts. Among the peoples with medium head modules, Khants, Mansi and Sami have great head modules for their stature; the head modules of Bashkirs and Tatars are also rather great.

Among the peoples whose head module is large or very large for their stature, only Estonians and northeastern Finns have head modules above the average.

The average **forehead breadth** varies in the studied ethnic groups from 105.3 mm to 112.4 mm. Like other head dimensions, forehead breadth depends on stature (r=0.61, Ry/x=0.34). Thus, if stature increases by 1 cm, forehead breadth increases by 0.34 mm. Narrow forehead for their stature was characteristic only of Moksha; broad, however, of Komi-Zyrians, Vepsians, Sami, Mansi and Hungarians, very broad – of Khants.

Bizygomatic breadth varies in the studied ethnic groups from 139.1 mm to 143.7 mm. Bizygomatic breadth below 138.1 mm should be considered very small, 138.2–138.8 small, 138.9–141.6 medium, 141.7–143.2 large and above 143.3 very large.

Dependence of bizygomatic breadth on stature is not particularly great (r=0.30, Ry/x=0.12). Nonetheless, this dependence influences the assessment who should be considered broad- or narrow-faced. Among the narrow-faced peoples, Moksha, Erza and Russians have really narrow faces, but the bizygomatic breadth of Mari, Komi-Permyaks and Bessermen is medium for their stature. Broad face for their stature is typical of Bashkirs, Sami and Khants, also of northeastern Finns and Estonians. Mansi and Hungarians have very broad faces for their stature.

Bigonial breadth varies in summarised ethnic groups from 108.3 mm to 112.2 mm. It is classified as follows: below 107.5 mm very small, 107.6–108.8 mm small, 108.9–110.3 mm medium, 110.4–111.6 mm large and above that very large.

Bigonial breadth depends even less on stature than bizygomatic breadth (r=0.24, Ry/x=0.08). Bigonial breadth of Russians and Finns is small for their stature, that of Komi-Zyrians, Chuvash, Bessermen, Hungarians, Khants and northeastern Finns – large, and of Mansi – very large. Estonians and Izhorians are on the borderline between large and medium.

Morphological facial height varies in summarised ethnic groups from 118.8 mm to 129.4 mm. Its classes are the following: below 123.0 mm very small, 123.0–125.0 mm small, 125.0–127.0 mm medium, 127.0–129.0 mm large and above 129.0 mm very large.

Morphological facial height is more dependent on stature than face breadth measurements (r=0.44, Ry/x=0.20). Sami and northeastern Finns with their very low faces also have very low faces for their stature. Among the peoples with medium facial height, morphological facial height is still relatively large for their stature in Mari and Tatars, and even larger in Khants and Bessermen.

Among the high-faced peoples, Estonians' and Finns' facial height is medium for their height, and in Finnish Swedes it is even high for their stature. The highest face in this respect is typical of Chuvash and Bashkirs.

Physiognomical facial height varies in summarised ethnic groups from 180.4 mm to 192.6 mm. It is classified as follows: below 182.0 mm very small, 182.0–185.1 mm small, 185.1–188.2 mm medium, 188.2–191.3 mm large and above that – very large.

In general, the regional distribution of physiognomical facial height is similar to that of morphological facial height. Differences between both facial heights depend on forehead height.

Physiognomical facial height depends relatively greatly on stature (r=0.60, Ry/x=0.42). In relation to stature, physiognomical facial height is small in Sami, Moksha, Erza and Russians; medium in Udmurts, Tatars, Karelians and Hungarians; medium but tending towards large in Komi-Permyaks and Vepsians. In relation to stature, facial height is large in Khants, Mansi, Mari, Bessermen, Bashkirs, Komi-Zyrians, Izhorians, Finns, Finnish Swedes and, particularly, in Chuvash.

Thus, the dependence of the head measurements on stature appeared to be rather great. The correlation coefficient is the highest between the head module and stature (r=0.80), followed by head length (r=0.74) and head breadth (r=0.55). It is also high between forehead breadth and stature (r=0.61). Among the face measurements, the dependence of the physiognomic facial height on stature is the greatest (r=0.60), followed by the morphological facial height on stature (r=0.44). The face breadth measurements are less dependent on stature: bizygomathic breadth (r=0.30) and bigonial breadth (r=0.24).

These data show the great variability of morphological data of Finno-Ugric peoples, regardless of their linguistic kinship.

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RARE CALCANEUS ANOMALIES

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ABSTRACT

The Sever's disease, or apophysitis of the calcaneus, is a common anomaly in children between 10 and 14 years of age. Calcaneal apophysis is the secondary ossification centre that serves as the site of insertion for the Achilles tendon and the origin of the plantar aponeurosis (fascia). Excessive use of these structures in young adolescents may also result in calcaneal apophysitis. There are no known long term complications associated with the Sever's disease, because this condition is thought to be self limiting – it will disappear when the two parts of the bony growth join together.

Although it is a relatively common problem in growing children nowadays, there are no descriptions of this anomaly in the palaeopathological literature. In this study we present four examples of the supposed Sever's disease in skeletal materials coming from Avar period (7–9th c. AD) of Hungary.

Key words: paleopathology, the Sever's disease, calcaneal apophysis, long term complications

INTRODUCTION

When the heel starts to develop bone, there is generally one large area of development that starts in the center of the cartilage heel. This area of bone spreads to 'fill up' the cartilage. Another area of ossification occurs at the back of the heel bone. These two areas of the developing bone will have an area of cartilage between them – this is how the bone grows in size. At around the age of 16, when growth is nearly complete, these two bony areas fuse together. The Sever's disease or calcaneal apophysitis is usually considered to be due to damage or a disturbance in this area of growth. Since the first report on The

Sever's disease (1912) [16], several authors have described this defect in the clinical and radiological literature in children and in adolescents, too [4, 6, 11, 14, 17]. The disease was reported as an inflammation of the calcaneal apophysis resulting in the clinical symptoms of pain at the posterior heel, mild swelling, and difficulty with walking. The direct pressure, side to side on the medial and lateral walls of the heel, is most symptomatic. This anomaly occurs in the heel, and the insertion of the Achilles tendon. The calcaneal apophysitis is a condition that affects children between the ages of 10 and 14 years, because this is the phase of life, when growth of bone is taking place at a faster rate than the tendons'. Incidence is higher in boys than girls. Micheli and Ireland reported on 85 patients, 64% of whom were male [12].

In the Sever's disease one or both heels may be affected. Bilateral forms of this aseptic necrosis in an adult were described by Jorgensen and Petersen 1960 [8]; Allen and Andrews 1983 [1].

The cause of the Sever's disease is not entirely clear. It is most likely due to overuse or repeated minor trauma that happens in a lot of sporting activities.

There are no known long term complications associated with the Sever's disease, because this condition is thought to be self limiting – it will disappear when the two parts of bony growth join together [13].

Sometimes this disease occurs with other anomalies such as Tae Kwon Do injuries [18] or brucellosis [15].

No paleopathological reports of this condition have appeared [2].

MATERIALS AND METHODS

Three cemeteries (765 specimens) dated to 7–9th c. AD (Avar Period) were studied from the common anthropological and paleopathological points of views in the skeletal collection of the Department of Anthropology, University of Szeged, Hungary. The investigation has been carried out using the gross morphology and radiographical analysis. The paleopathological analysis revealed four cases with similar calcaneal abnormalities. In this study these anomalies are presented.

RESULTS

Case reports
Site: Szarvas – Grexa téglagyár (Grave No. 224)
Age at death: adult
Sex: male
Pathological description:

In the first case the right calcaneus of a poorly preserved adult male revealed severe pathological alterations: the calcaneal tuberosity was shorter by about 1.5 cm and larger by 2–3 mm compared to the opposite side. The calcaneal sulcus was also wider (Figure.1). A deep insertion of the calcaneal tuberosity at the site

Figure 1. Shortening and widening of the right calcaneus – proximal aspect (Grave No. 224, Adultus, male)

of the Achilles tendon could be observed (Figure. 2). Other anomalies of this area could also be seen: although the posterior talar articular surface had been damaged post-mortem, a transformated, knobby and abnormal area was detectable on this surface. The deformation of the joint contour of the middle talar articular surface and marginal osteophytosis were seen. The lateral process of talus was scalloped. The radiographical analysis of these bones did not show any abnormalities. On the distal epiphysis of tibia, fibula or tarso-metatarsal area no pathological changes were found.

Figure 2. Deep insertion of the calcaneal tuberosity – posterior aspect (Grave No. 224, Adultus, male)

Site: Szarvas – Grexa téglagyár (Grave No. 342)
Age at death: adult
Sex: female
Pathological description:

The second case is very similar to the above described pathological bone. The left calcaneus of a fairly well preserved adult female was affected by the anomalies. The calcaneal tuberosity was also shorter by about 1.5 cm and larger by 2–3 mm compared to the opposite side (Figure. 3) and we also found the deep insertion of the calcaneal tuberosity at the site of the Achilles tendon (Figure. 4). On the basis of the x-ray analysis of the affected bone, no anomalies were detectable. This individual did not show any other pathological changes or morphological anomalies on calcaneus or phalanges.

Figure 3. Shortening of the left calcaneus – proximal aspect (Grave No. 342, Adultus, female)

Figure 4. Deep insertion of the calcaneal tuberosity – posterior aspect (Grave No. 342, Adultus, female)

Site: Hajós-Cifrahegy (Grave No. 113)
Age at death: adult
Sex: female

Pathological description:

The tarsal bones of a well preserved adult female showed severe pathological changes. On the right side the calcaneal tuberosity was shorter by 1.5 cm and larger by 0.5 cm (Figure. 5). On the lateral process of the calcaneal tuberosity, 2-cm-long groove could be seen, approximately 0.3cm wide (Figure. 6). Similarly to the first case (Szarvas No. 224), the calcaneal sulcus was broadened. Instead of the convex posterior talar articular surface, a concave talar articular surface with an abnormal circular necrotic area was found. The corresponding surface of talus was also abnormal in shape with irregular bone. The distal joint surface of both medial cuneiforms showed pea-size osteonecrosis. No other pathological alterations on the distal epiphyses of the tibia or the fibula were found. According to the radiographical analysis, the examined bones were normal.

Figure 5. Shortening and widening of the right calcaneus – proximal aspect (Grave No. 113, Adultus, female)

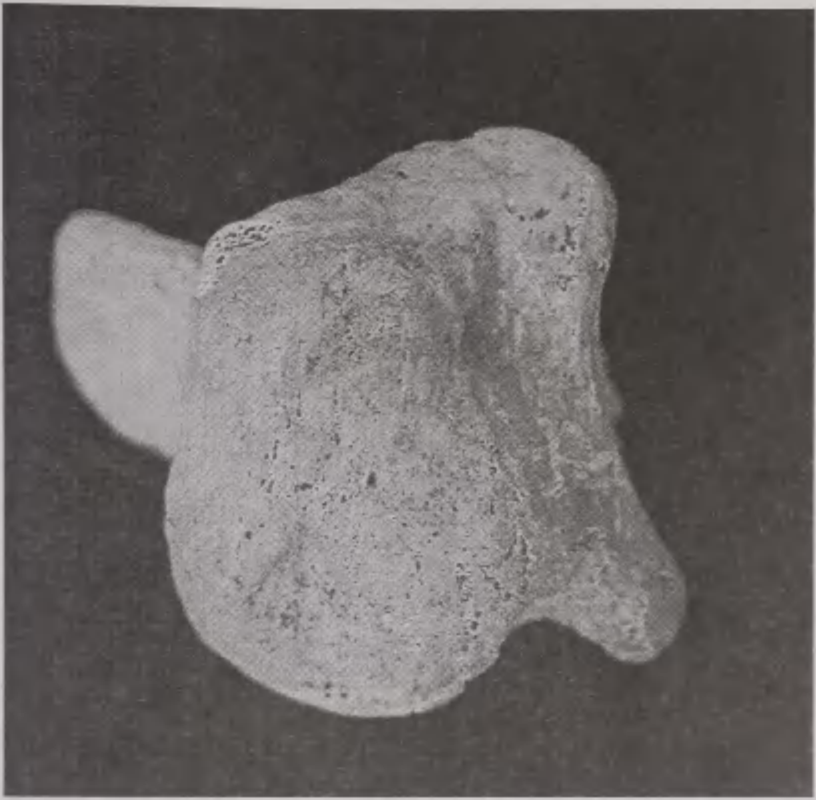

Figure 6. Deep insertion of the calcaneal tuberosity – posterior aspect (Grave No. 113, Adultus, female)

Site: Orosháza-Bónum téglagyár (Grave No. unknown)
Age at death: adult
Sex: female
Pathological description:

Pathological alterations were present on the left calcaneus and talus of a well preserved adult female. These anomalies were similar to the cases described above. The left calcaneal tuberosity was shorter by 1 cm and larger by 3 mm compared to the right side (Figure. 7). The articular surfaces of the calcaneus were normal. On the lateral process of calcaneal tuberosity pathological changes were found: a 2-cm-long and 0.5–0.7-cm-wide ovoid depression could be seen parallel with the edge of the bone (Figure. 8).

Figure 7. Shortening and widening of the left calcaneus – proximal aspect (Grave No. unknown, Adultus, female)

Figure 8. Ovoid depression on the calcaneal tuberosity – posterior aspect (Grave No. unknown, Adultus, female)

DISCUSSION

The Sever's disease (calcaneal apophysitis) is an inflammation in the area between the sections of the bone that make up the heel. This problem occurs in young people, whose bones have not yet fused and fully matured.

The cause of the Sever's disease is not entirely clear. It is most likely due to overuse or repeated minor trauma that happens in a lot of sporting activities – the cartilage join between the two parts of the bone can not take all the shear stress of the activities. Some children seem to be just more prone to it for an unknown reason – combine this with sport (especially if it is on a hard surface) the risk of getting the disease increases.

Although it is a relatively common problem in growing children nowadays, there are no descriptions of this anomaly in the paleopathological literature.

The paleopathological investigation of 4 adult individuals (3 females and 1 male) revealed similar pathological alterations: unilateral shortening and broadening of the calcaneus and a deep insertion on the tuber calcanei at the site of the Achilles tendon's attachment were seen in all the cases. Some individual differences could be observed between these cases but the overall morphological appearance of the affected bones was very similar.

Concerning the differential diagnosis of the observed lesions, the following diseases can be taken into account: clubfoot, Chopart fracture, or other fractures of the calcaneal tuberosity.

Clubfoot (talipes equinovarus) is a complex childhood deformity that is marked primarily by a deformed talus and calcaneus. The heel is turned inward and the rest of the foot is bent downward and inward, the arch of the foot is higher than normal. The trochlear surface of the talus is smaller, the talar neck is underdeveloped, the talar head and the medial and posterior tubercles are underdeveloped, and the fibula is thinner than normal. The navicular and the cuboid bones are also adducted and inverted. The navicular tuberosity is close to the medial malleolus, and the metatarsals are also adducted [3, 10, 5].

The Chopart fracture involves the talus and the calcaneus proximally, the navicular and the cuboid bones distally [9], and the midtarsal area is much more affected than the tarsal bones.

Concerning the characteristic lesions of the above mentioned diseases the clubfoot and the Chopart fracture can be excluded, because in the presented cases the metatarsal bones, phalanges and the position of calcaneus or talus were normal.

Fractures of the calcaneal tuberosity are rare injuries [7]. However, all the fractures seem to be different from the presented cases.

The most probable diagnosis of these anomalies is a severe calcaneal apophysitis.

According to the medical literature data the incidence of the Sever's disease is higher in boys than in girls and there are no data regarding the adult populations. In the paleopathological literature we have not found any data referring to the occurrence of the disease.

In contrast with modern medical data in this study, the age at death of the presented specimens were adults. This fact can be related to the existence of the Sever's anomaly in the adults, which could be attributed to the severe degree of the disease developed in the childhood.

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GLYCOSAMINOGLYCANS, HYALURONAN AND TYPE II AND X COLLAGENS IN RAT BONE REPAIR AFTER THE PERFORATION OF THE TIBIA. EFFECTS OF TRAINING AND IMMOBILIZATION

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ABSTRACT

Introduction of a new model, elaborated previously [19], the bicortical perforation model, the study of the cellular and extracellular events during tissue repair by histologic, histochemical, and immunohistochemical techniques and the study of the effects of physical training and immobilization on the healing process have been performed. An investigation of posttraumatic bone repair histology and immunochemistry after bicortical perforation in 72 young adult male Wistar rats has been performed. The repair was studied in normal and affected (training, immobilization) animals at 1–42 days after operation.

The posttraumatic bone repair is an ordinary process of osteohisto- and organogenesis, and dependent on the environment factors. Training did not influence significantly the cell proliferation of chodrocyte and their ECM synthesis (HA, collagen II-type and X-type) and therefore did not accelerate their skeletal repairs, whereas the immobilization of animals depressed these processes and bone repair was inhibited. After perforation, contrary to “classic” repair (primar desmal periosteal and secondary endosteal chondrous)., the repair picture is inverted (a primary endosteal desmal and secondary periosteal chondral and desmal repair have been seen). This periosteal condral ossification is similar to the endochondral ossification of the metaphyseal (growth) plate (similar histology, similar HA distribution, similar collagen II-type and collagen X-type express). The study of histology and the immunohistochemistry of bone repair after perforation gave important new, more detailed results about the reparative histogenesis of the bone tissues: the repair dynamics of the callus areas, the dynamics of cell proliferation, compared with the extracellular matrix (ECM) protein synthesis, the effects of training and immobilization, similarities and peculiarities of post-traumatic osteohistogenesis and embryohistogenesis on the metaphyseal plate.

Key words: Posttraumatic wound healing of the perforated bone; repair histology, histogenesis and immunohistochemistry, ossification; callus, periost, extraperiosteal tissue; growth plate

INTRODUCTION AND REVIEW OF LITERATURE

Traumatology and ortopaedics is based on the use of knowledge about the repair morphology of the skeletal hard (osseus, chondrous) tissues. The problems of post-traumatic bone repair morphology after trauma are (opposite to other mesenchymal tissues): the formation of the external and internal callus as a special material for repair process, and two different bone formation pathways – desmal (intramembraneous) and (endo)chondral ossification. Also, the post-traumatic periosteal secondary cartilage formation in skeletal reparationis, is not clear and its similarity to the primar cartilage of postnatal endochondral osteohistogenesis, or fetal skeletal development – embryohistogenesis [8].

Different experimental models were made (external and internal bone fracture, scrap, incision-slit-cutting-fissura, the standard defect of osteotomy etc.) for the qualitative and quantitative study of the bone repair after surgical injuries [11]. A lot of methods for the enhancement of fracture healing were used [6]. Physical activity (swimming) may accelerate the repair process of the osteotomized tibia in Wistar rats [13]. In such kind of experiments (Wistar rats, the segment osteotomy of tibia) the recanalization of tibia has been seen on the 35th days after injury. However, the total callus area, as well as tissue relations (hard callus, soft callus), did not differ compared with control [19]. Thus, the effects of training on fracture healing have not been carefully described. After the immobilization of animals, the post-traumatic bone repair has always been inhibited [7, 19, 24, 25, 33, 34].

The aim of the present work is to introduce a new highly reproducible exact model, the bicortical perforation model, to study the cellular and extracellular events by histologic, histochemical, and immunohistochemical techniques during tissue repair and to study the effects of physical training and immobilization on the healing process. The similarity and the pecualirities of post-traumatic secondary cartilage compared with the primary cartilage in postnatal bone endochondral histogenesis will be described.

MATERIAL AND METHODS

Experimental animals and the fracture model

Male Wistar rats, weighing approximately 200–220 g each, were used in this study. The animals were investigated for the 1st to 42nd days (Table 1).

Table 1. Distribution of animals for experiments in control (I), training (II) and immobilization groups (III).

Days after perforation	I	II	III
1	1	–	–
4	4	1	2
7	5	1	2
10	7	1	1
14	13	2	1
21	5	4	4
28	5	3	3
35	3	2	1
42	1	–	–
	44	14	14

The guidelines for the care and the use of the animals were approved by the Ethical Committee of the University of Tartu.

The training was performed in a special swimming-pool with the size of 40 cm x 40 cm x 70 cm at the water temperature 22±2°C. In the immobilized subcroups rats were separated into narrow boxes (cages), one animal in each box; so their ability to move was significantly reduced. In experiments both the right and the left limb were employed. The bilateral limb has been used as described by other authors (3, 21, 31, 36).

Anaesthesia was induced with the intramuscular injection of ketamine 50 mg/kg b.w. and diazepam 5 mg/kg. The profylaxis of infection was carried out with ampicillin of 7.5 mg/kg i.m. It was started 2 hours before the operation and continued during 3 days. The operations were performed under strictly aseptic conditions.

Operative technique. On the anterior surface of tibia, a perforation hole with the diameter of 1.5 mm was bored through the bone cortex between the diaphysis and proximal epiphysis, 1 mm below to the tibial tubercle. The medial and the lateral cortex were intact. Such kind of experiments permit: 1)to standardize the amount and localization of the injury and 2)to give a possibility to separate the periosteal and the endosteal zones of callus and their compartments, especially the areas of angiogenesis. The isolation of periost from the endosteal tissues was performed previously by covering the perforation opening with medical wax at the temperature of 37–40°C (19).

Postoperative management. The rats were maintained for the postoperative period in a special box, 3 animals in each (except the immobilization group of rats). Special rat food ("Dimela" – Finland R-70 or R-34 during early postoperative period) and water in abundance were given.

Tissue preparation

The sacrification of rats was performed by the decapitation of animals anaesthesized with the ketamine and diazepam. The average size of the material collected for histological evaluation was 0.5–1.0 cm. The perforated tibia were dissected and fixed with 10% formalin at 4°C for 24 h, and then decalcified with 20% aqueous solution of EDTA (4).

Histology and computerized histomorphometry

Paraffin embedded slices with a thickness of 7 μm were stained with hematoxylin and eosin, Heidenhain iron hematoxylin, by van Gieson, alcian blue and safranin-O (specific for glycosaminoglycans – GAG, 23). Inflammatory cells (mostly degenerative cells), mast cells (tissue basophils), lymphocytes and plasma cells were observed in slices stained with azure-2-eosin. The mitotic division of chondroblasts and their apoptosis were observed by magnification: objective 40x ocular 10x. The standard ocular network with the area of 40.000 μm was used. The percentage of chondrocytes in mitotic division and in apoptosis was counted. This methology is based on the cell image analyses (mitosis, apoptosis – programmed cell death) of haemato-xylin-eosin stained slices, which permits the calculation of the mitosis index (MI), i.e. the percentage of cells in the mitosis from the average number of cells, as well as the calculation of the apoptosis index (AI). Both these processes are in normal conditions correlated: the greater proliferation of cells correlated with a greater rate of cell death [1]. The quantitation of apoptotic index by common light microscopy as a routine method is available to provide preliminary information of apoptotic cell death [29, 30, 35]. Mayer´s hematoxylin-eosin staining shows apoptotic cells with a condensed pycnotic nucleus and shrunken cytoplasm [9].

The microanatomical pictures of callus tissues were photographed by the light-microscope Olympus BX-50 and saved electronically. Further, the process was performed with the computer program Adobe Photoshop 5.0 under simultaneous visual control of light-microscopy. The total area of callus, as well as the areas of hard (osseus and chondrous tissues), and soft callus (connective tissue, degenerative inflammatory tissues) were measured. The painted areas of different colours were summarized in pixels and calculated in percentage [19].

Histochemistry and immunohistochemistry

Hyaluronan staining. The endogenous peroxidase activity of the sections was blocked with 3% H2O2. After 3x10 min washes with 0.1 M phosphate buffer, pH 7.4, non-specific binding was blocked by incubating the sections in 1% bovine serum albumin (Sigma, St Louis, MO, USA) in phosphate buffer at 37°C for 30 min. Incubation with the biotinylated hyaluronan binding complex probe (bHABC 3–5 μg/ml in phosphate buffer containing 1% bovine serum albumin) was performed overnight at 4°C (32). The slides were washed with phosphate buffer. The avidin-biotin-peroxidase complex (Vector Laboratories, Burlingame, CA, USA) was added on the sections for 1 h. The slides were washed and incubated in 0.05% 3.3'–diamino-benzidine dihydro-chloride (Sigma) and 0.03% H2O2 in phosphate buffer for 2–3 min before mounting.

Immunohistochemical type II and type X collagen stainings. Endogenous peroxidase activity in the sections was blocked with 3% H2O2. The sections were pretreated with testicular hyaluronidase (2 mg/ml in PBS, pH 5, for 1 h at 37°C) and pronase (1 mg/ml in PBS, pH 7.3, for 30 min at 37°C) and stained with the Histo-Stain-Plus kit (Zymed, San Francisco, CA, USA) according to the manufacturer's instructions. Antibodies recognizing collagen type II and type X [10] were used. The antibodies were kind gifts to Dr. Mikko Lammi from Prof. Klaus von der Mark (Erlangen, Germany). Biotinylated secondary antibody and streptavidin-conjugated peroxidase were used for detection using 3.3'-diaminobenzidine dihydrochloride as chromogen. Nuclei were counterstained with haematoxylin. As negative control the primary antibody was replaced with PBS or non-immune hybridoma cell culture medium.

Statistical analysis

Statistical analysis was performed using one sample t test and the unpaired t-test (GraphPad Quick Calcs: Analyze continuous data) at the level of significance p less than 0.05 ($p<0.05$) with the Newman-Keuls multiple comparison test.

RESULTS

Morphological characteristics of the post-traumatic repair of the perforated tibia

The post-traumatic bone repair and the continous remodelling of callus is an ordinary process of tissues (acute inflammation, development of fibrous, chondrofibrous, chondrous and osseous callus, remodelling). Endosteal ossification follows directly without the chondrous stage, but the periosteal – through the chondrous callus (Fig. 1A, B; 2A-D).

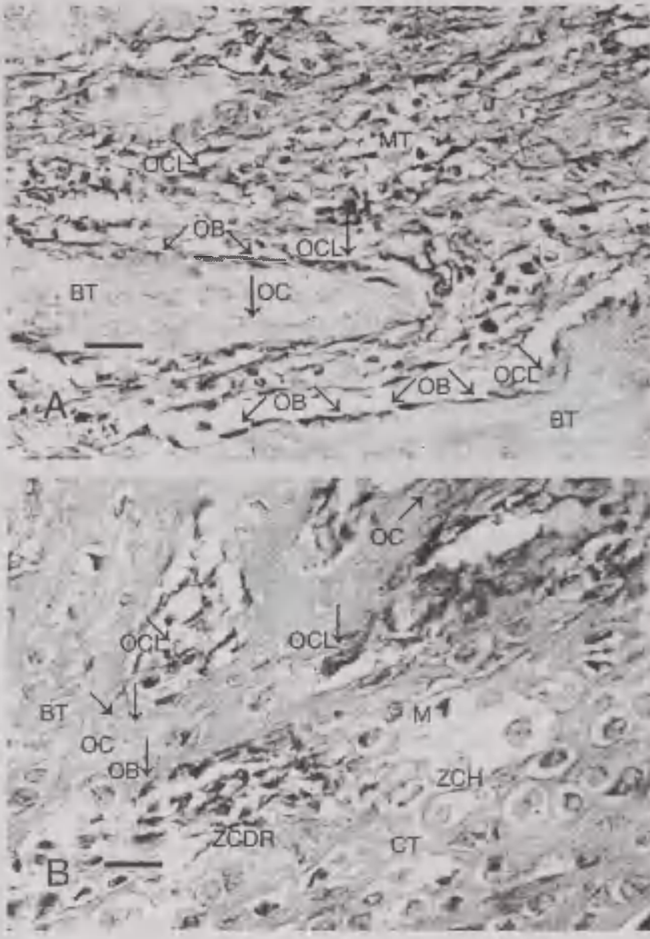

Figure 1. Histological findings in the perforation callus of rat tibia. Desmal (intramembranous) bone formation in endosteal callus (A) and chondral bone formation in the periosteal callus (B) on the 21st day after perforation.
A: Newly formed bone tissue (BT) islets surrounded by the osteoblastic (OB) layer. MT- mesenchymal tissue. OCL-osteoclasts. OC-osteocytes. B: Actively proliferating chondrous tissue (CT) with mitoses (M) replaced by forming bone tissue (BT) osteoid. Certain lacunes containing the capillary sprouts with precursor cells. Cartilage zones have been noticed (ZCH-zone of chondrocyte hypertrophy; ZCDR-zone of cartilage degeneration and removal). Arrows indicate OC, OB and OCL localization.
Hematoxylin and eosin. Bar= 50μm

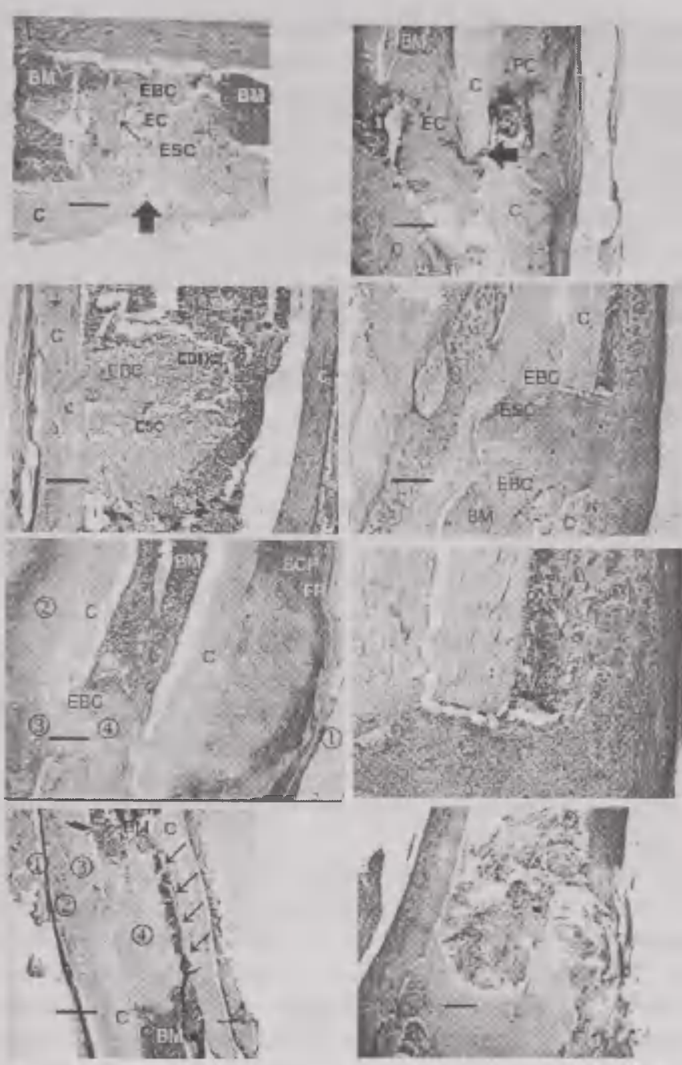

Figure 2. The post-traumatic bone repair in rat tibia 14th (A), 21st (B), 28th (C) and 35th (D) days after bicortical perforation of the cortex of tibia; 14th (E) and 28th (F,G,H) days after the perforation of tibia and the immobilization of animals, i.e. the left-side panels (A-D) show the perforation calluses of the control group and the right-side panels (E-H) those of the immobilized animals.

Callus development dynamics: on the 14th day one half of the endosteal callus and one quarter of the periosteal callus are bony (A), on the 21st–28th almost all of the callus is bony (B,C). Endosteal bone callus

appears in the periphery of the wound (B). The zones of callus are 1-extraperiosteal, 2-periosteal; 3-interfragmental cortical and 4-endosteal with bone marrow. The recanalization of the callus on the 35th day has occured (D). After the immobilization of the animals the bone callus formation is inhibited (E-H).On the 28th day endosteal bone callus is weak (H) and the periosteal bone callus is mixed with the chondrous tissue (G) as a " mosaic" callus.1,2,3,4- zones of callus (Figure 1). C-cortex, cortical bone; BM-bone marrow; EC-endosteal callus; FP-fibrous periost; EBC- endosteal bone callus; SCP-soft (cellular) periost. Fine arrows: (A)-bone trabecles, (D)-direction to the marrow cavity. Thick arrows- perforation hole.
Hematoxylin-eosin (A), HA (B-G), safranin-O (H). Bar in A-E and H= 500μm.

Repair callus is localized in four well-known placements:
1) external soft tissue;
2) periost;
3) interfragmental cortex;
4) endost and bone marrow (Fig. 2C, D).

The perforation of the bone causes hemorrhage and tissue destruction as well as reparative changes on the 1st–7th day (proliferating fibroblasts and chondroblasts, the appearance of capillary network, the degranulation of tissue basophils, the appearance of macrophages and osteoclasts, lymphocytes).

One half of the endosteal callus and a quarter of the periosteal callus on the 14th day after perforation is bony (Figure 2A). The endosteal callus is mostly bony on the 21st–28th days after perforation (Figure 2 B, C). The recanalization of the bone cavity occured on the 35th–42nd days after injury (Figure 2 D). Thus posttraumatic osteohistogenese is mainly finished by the 21st day, but organo-morphogenese (bone formation) and remodelling continue up to the 28th–42nd days.

Similar repair histology has occured after the perforation of the trained rats (Data not shown). After the perforation and immobilization of animals the post-traumatic repair process is inhibited. Both periosteal and endosteal ossification is weak on the 14th days (Figure 2E) mixed with chondrogenesis until 28th–35th days (Figure 2 F, G, H).

Quantification of the callus areas of the perforated tibia in repair dynamics

The total callus area (Table 2) is 20,1± 1,1; at the same time the hard callus area (15.8± 0.8) is significantly higher compared to soft callus area (4.3± 0.5) ($p < 0.05$). Similar values have been seen in the trained group. In the immobilized group, on the contrary, the soft callus area (14.6±1.7) is significantly higher compared to the hard callus area (6.6 ±0.7) ($p < 0.05$). The total callus area did not differ from the control and the trained animal groups.

Table 2. The areas of callus tissues 28 days after the perforation in the control (I), the training (II) and the immobilization group (III) (percentage of the callus area ± SD). Computer field in use: 17.6%; 120, 000 pixels (100%).

Group	Total callus	Hard callus +	Soft callus +
I	20.1± 1.1	15.8 ± 0.8 *	4.3 ± 0.5 *
II	25.7 ± 3.2	19.5 ± 2.1 *	6.2 ± 0.9 *
III	21.2 ±2.8	6.6 ± 0.7 *	14.6 ± 1.7 *

+ the hard callus is bone and cartilage, the soft callus is the inflammatory area with the adjacent cells and mixed connective tissue
* differences between the values of this group are significant ($p < 0.05$)

The hard callus formation is more intensive in the endosteal callus compared to the periosteal callus (Table 3). 14 days after perforation the osseous callus is 71.3± 12.1 and 24.7± 4.3, on the 28th day 85.7 ± 6.6 and 57.9 ± 8.7 respectively.

Table 3. Areas of endosteal(I) and periosteal callus tissues(II) 4–28 days after the perforation (percentage of the total callus area ± SD).
I

Days	Osseus tissue	Chondrous tissue	Fibrous connec- tive tissue	Soft tissue
4	0	0	58.5± 6.9	41.5± 6.9 *
7	6.9	0	44.3	48.8
14	71.3± 12.1 *	0	27.4± 9.8 *	1.3± 2.3
21	90.1± 2.2 *	0	9.9± 2.2	0
28	85.7 ±6.6	0	14.2± 6.6 *	0.1± 0.1

II

Days	Osseus tissue	Chondrous tissue	Fibrous connective tissue	Soft tissue
4	0	0	62.4±11.5	37.6±12.2
7	15.2	16.7	32.5	35.6
14	24.7± 4.3	20.4±3.6	46.0±13.3	8.9±2.2
21	48.4± 9.2 *	15.8±2.3	31.5±8.5	4.3±1.3
28	57.9±8.7 *	5.3±1.2 *	34.3±6.8	2.5±0.9

* differences between the values of this group are significant ($p < 0.05$)

Localization and quantification of mitotic and apoptotic cells of the periosteal chondrous callus of the perforated tibia

The mitotic and apoptotic chondrocytes are localized mostly in the proliferation zone of the periosteal chondrous callus (Table 4, Fig. 3 C-G).

Table 4. The mitotic index (MI) and apoptotic index (AI) of chondrous callus cells in the zone of proliferation 7th, 14th and 28th days after perforation of rats tibia.

Days	MI (%)	AI (%)
7	57	14
14	32	8
28	15	2

In the trained rats the similar localization and the quantity of mitoses and apoptotic cells has occured, whereas in immobilized animals the quantity of mitoses fell, the quantity of apoptotic cells decreased and there was a significant difference in the scores between these groups (Data not shown).

Contribution of HA and GAG in the wound healing of perforated tibia

HA stain is the most intensive in the bone marrow (progenitor cells) and the extraperiosteal mesenchymal tissue (Figure 2 C, F, G; 3 A, B). Periosteal fibrous callus and cartilage are clearly marked (Figure 2 C; 3A, B, F, H). HA-positive are: nucleus, cytoplasm, ECM; non-stained is capsula of chondrocytes (Figure 3D, F-H).

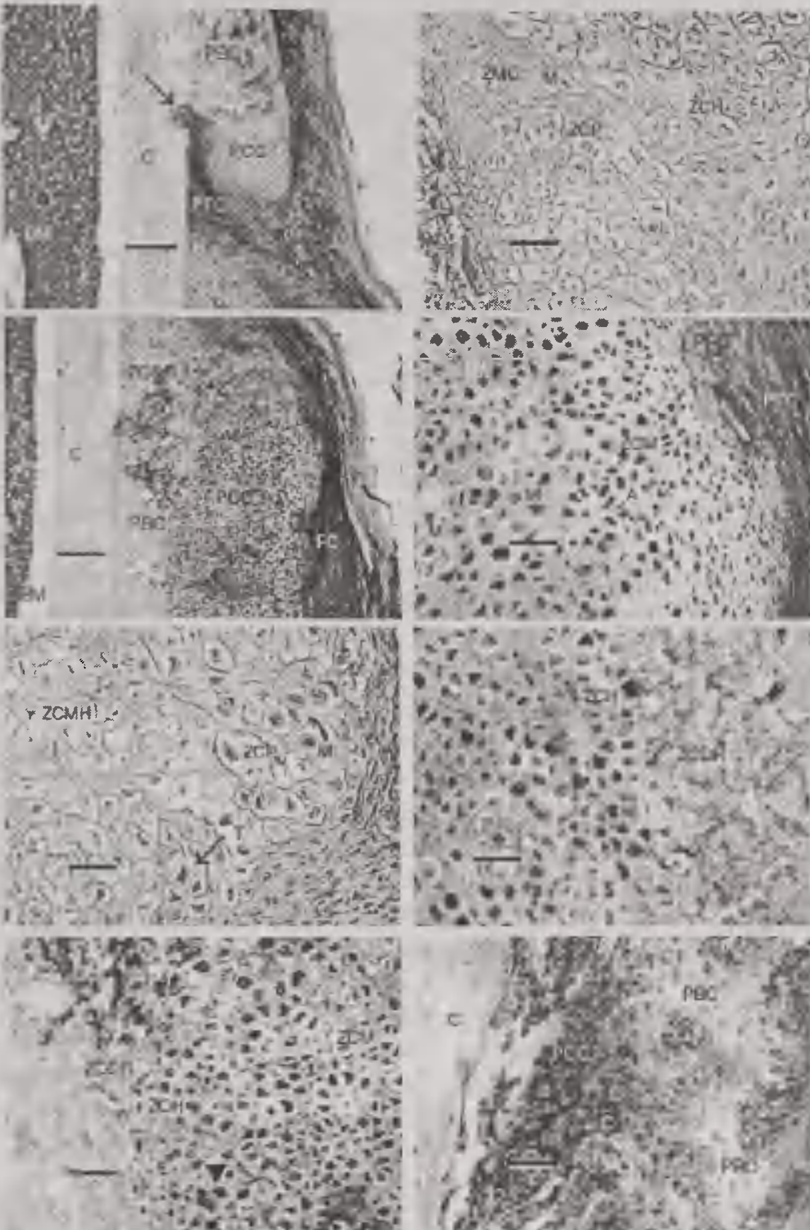

Figure 3.
Left panel (from up to down) - A,B,C.D. Right panel - E,F,G,H

Figure 3. The post-traumatic bone repair in rat tibia 10th (A), 14th(B), 21st(C-G) and 28th days(H) after perforation. The left-side panels (A-D) show the perforation callus of the control group and the right-side panels (E-H) those of the immobilized animals.
The periosteal chondrous callus(PCC) and fibrous callus (PFC) on the 10th day after perforation (A). The fibrous callus penetrated the superficial layers of the cortex (C). The periosteal bone callus (PBC), the chondrous and the fibrous callus on the14th day after perforation(B).The zonal differentation of the periosteal chondrous callus 21 days after perforation (C,D). The chondrocyte mitotic division is intensive and numerous apoptotic cells are noted in the zone of chondrocyte proliferation (ZCP) (C). The zone of chondrocyte hypertrophy (ZCH) and chondrocyte degeneration and removal (ZCDR) are lacking of mitoses and apoptotic cells (D). In ZCH and ZCDR a lot of bi- and multinucleated chondrocytes have been seen (D). HA staining is strong in chondrocyte and ECM but lacks in chondrocytes capsula (D,F,G). In immobilized rats the zonal differentation is not clear (E-G) and in some cases has disappeared with the formation of bone-chondrous mixed callus or "mosaic"(H). Mitotic activity is inhibited and the number of apoptotic cells is decreased (E-G). Arrows: A- fibrous callus, penetrated to cortex and C- apoptotic cells. Dark triangle: binucleated chondrocyte (D).
Hematoxylin-eosin (C,E), HA-(A,B,D,F-H). Bars in A,B= 500μm; in D,F-H=200μm; in C,E=50μm.

Strong hyaluronan staining is present in the periosteal callus around chondrocytes near the fracture (Figure 2 G) and often forming a "mosaic" with the bone callus (Figure 3H) whereas no hyaluronan staining is seen in the endosteal callus . The hyaluronan staining is the most intensive in the subperiosteal zone adjacent primary cortex (Figure 3A). In the trained rat tibia the hyaluronan staining is similar to the control group (left panel) whereas in the immobilized group (right panel) hyaluronan staining is decreased (Figure 3 E-H).

In this group the number of binucleated chondrocytes of degeneration zone is decreased (Figure 3G) compared to control (Figure 3D). Zonal distribution of HA in chondrous callus (Figure 3 D, F, G) is similar as compared to the regional proximal metaphyseal plate.

Glycosaminoglycans (GAG) were concentrated mainly in the bone tissue of callus. After the training on the 28th day and immobilization on the 35th day the GAG concentration was increased in the region of the cortex/ adjacent to callus (but not in the callus), and after immobilization decreased in both the periosteal and the endosteal callus (Data not shown).

Type II and X coilagens in rat bone repair after the perforation of the tibia

Collagen II-type is clearly detected 7th–14th days after injury in the chondrocytes of the periosteal callus .The internal callus is not marked with collagen II-or minor collagen type-X (Figure 4 E, G). The capsula of chondrocytes is strongly marked (Figure 4 A, F).

The zonal distribution of collagen (the zone of cartilage maturation and proliferation, the zone of chondrocyte hypertrophy, the zone of cartilage destruction and removal; Figure 4A, C) is similar compared to the regional (proximal) metaphyseal plate (Figure 5 C, D, F-H).

In trained rat immunostaining for collagen type-II and X is similar compared with the control group. In the immobilized animals the collagen staining is significantly weaker compared with the controls (Fig. 4A-H).

Proximal metaphyseal plate histology, histochemistry and immunohistochemistry in rat bone repair after the perforation of the proximal tibia

The external (periosteal) chondro- and osteogenesis is similar to the endochondral ossification of the metaphyseal plate (Figure 5 A-H). HA stain of the hypertrophic chondrocytes (Figure 5A,B) and collagen type-II (Figure 5 C, D) were intensive. HA did not stain in the capsule of chondrocytes (Figure 5 B), whereas collagen type-II was stained in this capsule intensively (Figure 5D).

In the immobilized rats the hypertrophic cell zone is narrow and HA occurs weakly (Figure 5E) as well as collagen type-II (Figure 5 F-H) compared to control.

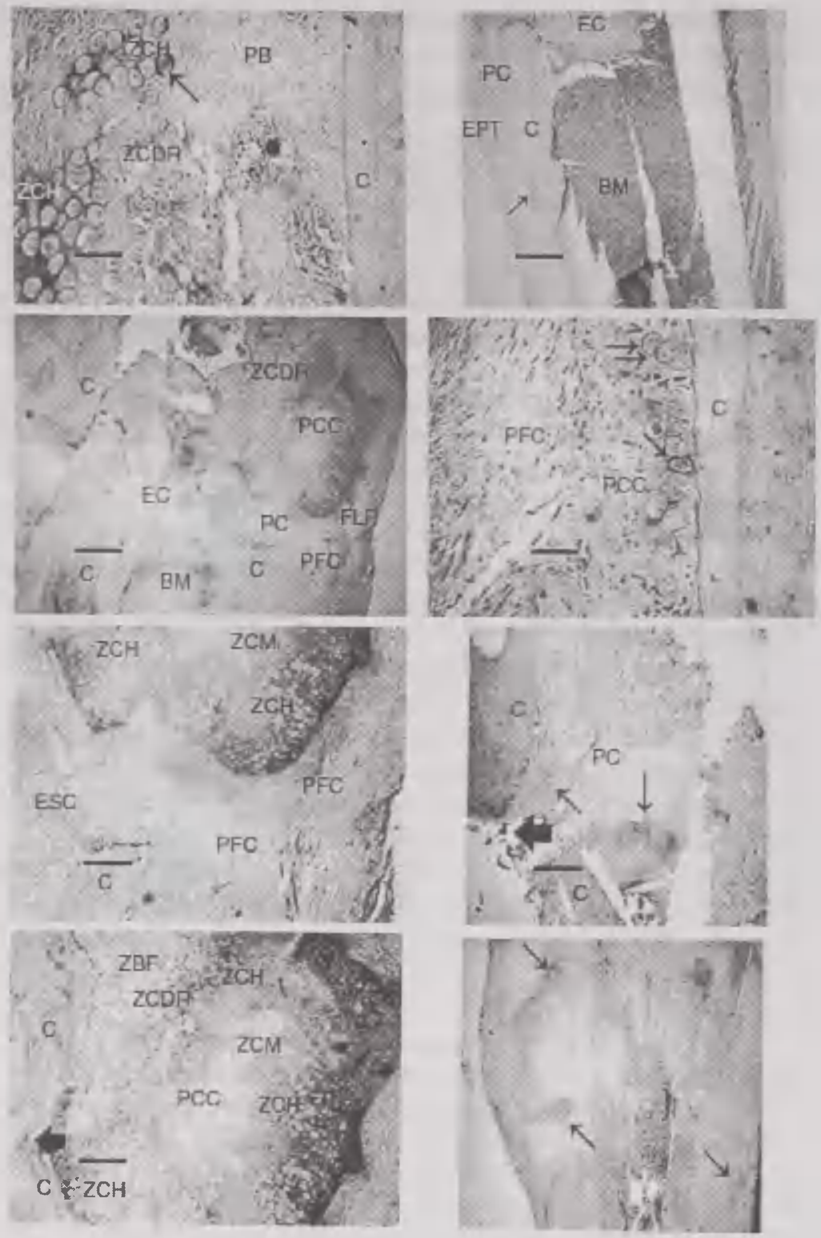
ZCH
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Figure 4.

Figure 4. The post-traumatic bone in rat tibia 10th (A,E-G) and 28 days (B-D, H) after perforation. The left-side panels (A-D) show the perforation calluses of the control group and the right-side panels (E-H) those of the immobilized animals.
Collagen type-II localizes mainly in the zone of the hypertrophic chondrocytes (ZCH) (A-C, F, H) and lacks in the zone of maturation (ZCM) and degeneration (ZCDR). Collagen type-II concentrated in the chondrocytes capsula (A,F). After the immobilization of animals the collagen type-II synthesis is inhibited. Arrows: A,F-collagen in the capsula of chondrocytes; E,G,H - little islets of chondrocytes, capable of collagen synthesis in immobilized animals. Thick arrow (D,G) – perforation hole.
Immunochemistry for collagen type-II detection .Bars: B,E,G,H= 1000μm; C=500μm; A,E=200μm.

Figure 5. The regional (proximal) metaphyseal plate changes in rats after the perforation of tibia 28 days(A-E) and 35 days after injury(F-H). The left-side panels (A-D) show the metaphyseal plate of control animals and the right-side panels (E-H) those of the immobilized animals.
HA (A,B,E) and collagen type-II (C,D,F-H) localizes mainly in the well developed zone of hypertrophic chondrocytes. The high concentration of collagen type-II has been noted in the capsula of chondrocytes (D). After the immobilization of animals the HA and collagen synthesis is inhibited (E-H). Arrows: A,E- HA stain in the hypertrophic chondrocytes of the growth plate. MP- metaphyseal plate; CT-chondrous tissue.
Histochemistry for HA. Immunohistochemistry for collagen. Bars: A, E= 1000μm; C,F= 500μm; B=200μm; D,G,H= 50μm.

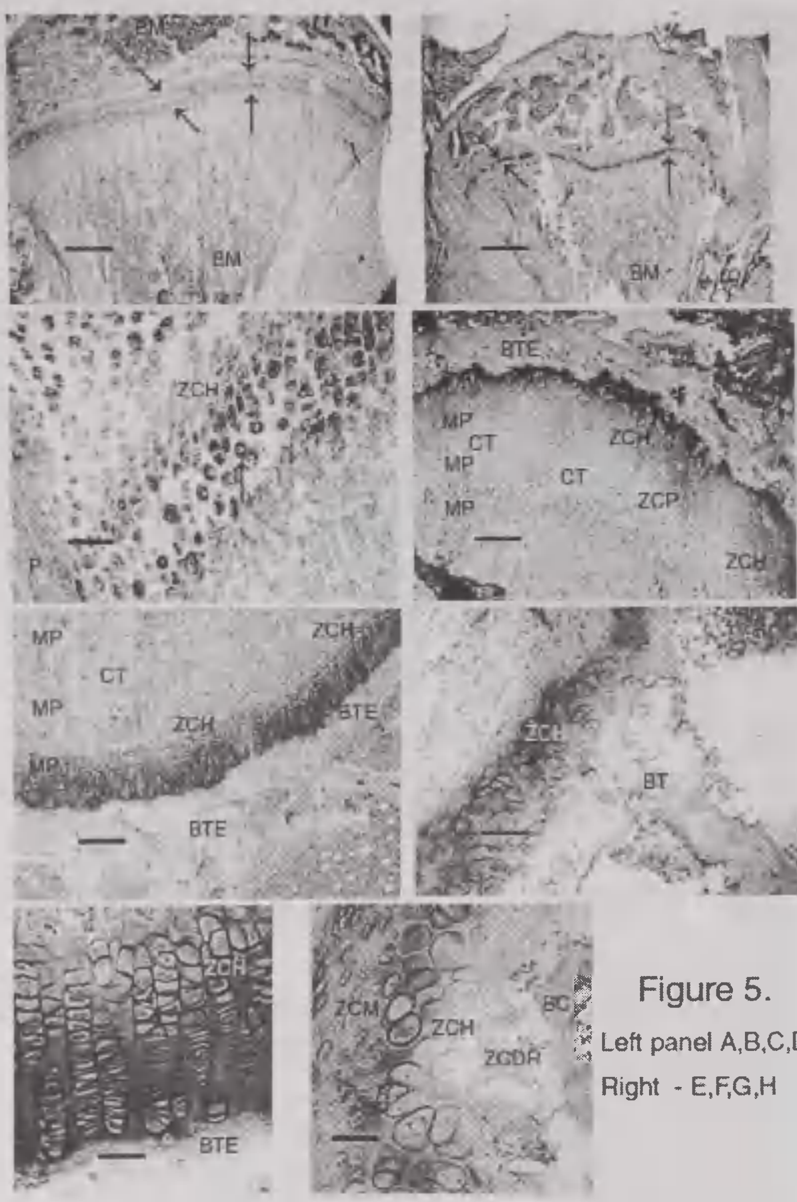

Figure 5.
Left panel A,B,C,D
Right - E,F,G,H

Figure 5.

DISCUSSION

Our data suggest, resembling to that of other authors [5, 6, 11, 18, 20] that the osseus and chondrous callus formation is dependent on the mode and degree of injury: the more “strong” trauma (closed fracture of tibia) causes the markable inhibition of the bone callus development whereas a “smaller” trauma (segment osteotomy) causes a large development of the bone tissue callus [19]. Our results suggest a dependence on the callus formation at least from the point of view of functional requirements to the regenerat in the repair process (necessity of consolidation etc.) and not so much on blood supply (posttraumatic angiogenese, etc).

Physical activity (swimming) may accelerate the repair process of the osteotomized tibia in Wistar rats [13]. The physical activity for a successful bone tissue repair after osteotomy may be achieved even by normal weight bearing, whereas the tenotomized rat tibia repair is inhibited [12]. The submicroscopic studies of traumatized chondrous and bone tissue in the dog tubular bone show the stimulation of the repair process following physical loading, and inhibition following hypokinese, and especially following the hypokinese after training [7, 16]. Similar results are received in rat tibia after immobilization in a plaster cast and following remobilization with exercises [33, 34]. The immobilization also causes the matrix changes in the joint cartilage [22]. However, the problem is not so clear. It is possible that the effect of training is trauma-dependent. In a moderate trauma after segment osteotomy the post-traumatic bone repair is stimulated (organotypic repair about 35–42 days after osteotomy, increased mitotic activity of chondrocytes) [19]. As the effect of training after perforation is not so clear yet more detailed analyses were carried out during the present work. It occured that in the trained groups of rats the general morphological characteristics of the post-traumatic repair of the perforated tibia, the total callus area, as well as the selected areas of different tissues of callus (bone, cartilage, soft tissues), the mitotic and the apoptotic activity of the chondrocytes of chondrous callus, the contribution of HA, as well as collagens type-II and type -X and their stain, are similar compared to the controls. Training does not effect remarkably the wound healing after the bicortical perforation of tibia. In the immobilization group of rats the post-traumatic bone repair is inhibited in all the groups (internal fracture, segment osteotomy, bicortical perforation).

The ossification type is also trauma-dependent. Post-traumatic osteohistogenesis is in the internal fracture mainly secondary (indirect, replacing cartilage); in segment-osteotomy primary periosteal and secondary endosteal [19]. After bicortical perforation the bone repair is "inverted", i.e. primary endosteal desmal and secondary indirect periosteal chondrous.

Glycosaminoglycans (GAG) concentration was measured by microspectrophotometry after staining histological sections with safranin-O [14]. It was noticed that 11-week immobilization of canine knee causes a significant softening (fall of the GAG concentration) of lateral femoral and tibial cartilages. After the remobilization period of 50 weeks the alterations of cartilage biomechanical properties disappeared. Immobilization causes the reversible changes in cartilage markers and synovium metabolism including HA in young beagles. Increased weight bearing did not change the concentration of markers [15].

In our experiments the GAG concentration was higher on the 28th day after osteotomy and low after the perforation of tibia. In the training group the GAG content did not change compared with normal weight bearing. In both immobilization groups (osteotomy and perforation) the periosteal and endosteal GAG content is decreased.

On the 28th day of osteotomy the callus total area and the GAG concentration is higher compared to perforation. After physical loading (training) the total callus area is increased but the GAG concentration is falling without any correlation between them. After immobilization the callus area, as well as the GAG content, are decreased.

In normal calluses in a rat model the collagen type-II was detected in proliferative chondrocytes on the 4th day after injury and the collagen tyoe-X in hypertrophic chondrocytes on the 7th days after injury. On the 14th day collagen-expressing cells were widely distributed [27]. By the same way of experiments the appearence of first chondrocytes is observed on the 5th day after injury in the subperiosteal layer, which is derived from the periost by cell differentiation [28]. Collagen-X is expressed in the hypertrophic zone of calcifying cartilage [2]. In the rat pseudoarthrosis model collagen type-II staining of the interfragmental area without any bridging chondral or bony elements in the fracture gap has been shown [17]. Collagen type-II is a marker of the chondroid differentiation and calcification [26]. The same results were given in our experiments.

The regional metaphyseal plate in the perforated rats tibia in control animals as well as after training and immobilization had the same histological picture as in the callus repair site.

Training did not influence the HA and collagen type-II and type-X concentration and zonal distribution; immobilization inhibited this ECM protein synthesis.

Our results affirmed the oppinion about the similarity of the post-traumatic periosteal chondrogenesis and osteogenesis with embryohistogenesis [8] or postnatal endochondral osteohistogenesis of the metaphyseal plate.

For clinical practice we can conclude that:

1) a repair process in small traumas (i.e perforation) is successful without mechanical stimulation (physical training);
2) post-traumatic bone tissue repair is trauma-dependent and highly specific, having a lot of repair types (from "classic" up to "inverted");
3) the immobilization of animals always causes the inhibition of the repair process in the repair site, as well as in the regional metaphyseal plate.

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THE CONTRIBUTION OF DRINKING WATER TOWARDS DENTAL FLUOROSIS: A CASE STUDY IN TARTU

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ABSTRACT

The aim of the study was to investigate the influence of fluoride in drinking water on the prevalence of dental fluorosis among schoolchildren in Tartu (Estonia). The subjects of the current study were 12 years old, living in six zones of Tartu with different fluoride content in drinking water. In total, 368 children were investigated. The prevalence of dental fluorosis among schoolchildren was on average 30.2%, the highest percentage (53.3%) was in the Veeriku zone and the lowest (8.8%) was in the Staadioni zone. The association between the prevalence of dental fluorosis and the fluoride content in drinking water was observed which made it possible to assess the relative risk of fluorosis. Conclusion: the relationship between the prevalence of dental fluorosis among children and the fluoride content in drinking water was determined and the relative risk of fluorosis was calculated.

INTRODUCTION

Fluoride is a natural element found at varying concentrations in water as well as in soil. It is considered a beneficial nutrient for the integrity of teeth and bone. When consumed in optimal amounts, fluoride increases tooth mineralisation and bone density, reduces the risk of dental caries and helps promote enamel remineralisation throughout life for individuals of all ages [4, 7].

Excessive fluoride intake has been found to cause irreversible toxic effects on teeth and the skeleton including dental fluorosis, bone fractures [2]. Chronic intake of high levels of fluoride can lead to other serious health problems, as joint deformities, cancer, etc [1, 11]. It may also affect human intelligence, especially in children, who are most susceptible to early fluoride toxicity [21, 42].

Fluorosis is the hypomineralisation of tooth enamel which results from excessive systemic fluoride ingestion during enamel development prior to tooth eruption [4]. Fluorosis can range from very mild to severe. Mildly fluorosed enamel is fully functional and may present as barely detectable whitish surface striations, whereas severely fluorosed enamel is more prone to wear and fracture and may present as pitted, stained and porous enamel. Severe fluorosis can result in teeth with brown discoloration. It makes teeth more susceptible to dental caries [39]. Fluorosis may occur in either the primary or permanent dentition. No specific period of enamel formation could be singled out as being the most critical for the development of dental fluorosis [5].

The fluoride amount in drinking water is commonly the main source of human daily fluoride intake [20, 40, 41]. The Finnish study showed that the estimated fluoride intake through food is only about 0.5 mg/day [18].

The association between the fluoride level in drinking water and the degree of dental caries and fluorosis has been documented worldwide [6, 13, 23, 40]. An optimal fluoride level in water (the concentration which provides the maximum protection against caries with the least clinically observable fluorosis) is estimated at 0.7–1.2 mg/l depending on the regional temperature. The maximum health-based fluoride limit in drinking water suggested by the WHO [38] and established by both the European Union [12] and Estonian legislation [16] is 1.5 mg/l.

The aim of the current study was to assess the prevalence of dental fluorosis among the schoolchildren who were born and living in Tartu where the content of fluoride in drinking water was different by regions.

MATERIAL AND METHODS

Study area

The study area – the town of Tartu – is the second largest town in Estonia located in the southern part of Estonia and covers an area of 39 km^2 with the population of 100,000 inhabitants. The groundwater without any treatment is used to supply drinking water. Over 100 deep tube wells are connected to the public water supply network. They rely on various hydrogeological aquifers with the different quality of water. The data on fluoride concentration in water were obtained from the water quality database of tube wells in 1986–1997 compiled for the Tartu Agenda 21 [32].

Since the municipal drinking water distribution system combines water from several tube wells, the fluoride concentration in tap water at consumer varies depending on the zone of the influence of the tube well. For the study we took care to select only the zones that were supplied by definite tube wells of the known fluoride concentration. The advice of leading hydrogeologists was considered. As a result six zones were defined on purpose for the current study (Figure 1).These zones are of approximately the same eco-environmental and ethnic conditions as well as socioeconomic standards.

The wells in the Staadioni and the Karlova zones rely on the aquifer from Quaternary deposits with a fluoride concentration in the range of 0.2–0.3 mg/l and are, in this paper, called the low-fluoride zones. The water sources of the Annelinn and the Aardla zones are the aquifers in Devonian and Silurian deposits with a fluoride concentration in the range of 1.0–1.8 mg/l. The wells in the Raatuse and the Veeriku zones rely on local anomalous hydrogeological areas with the elevated (over 2 mg/l) fluoride concentration in water. Therefore these zones are called the high-fluoride ones. At present the tube wells giving high-fluoride water are closed.

Study population

The study population is a part of the over-Estonian survey of dental health of schoolchildren conducted in 1999–2000 according to the uniformed methodology of the World Health Organisation [37]. The 12-year-old children served as a target group. Consent from the children, as well as from local authorities, was obtained prior to the examination.

Figure 1. Study zones in Tartu

The children were asked about the duration of their residence at the present address.

Schoolchildren were localized according to their current home address and their correspondence to drinking water zones was determined. Only those schoolchildren who had reported the continuous residence since birth in the corresponding zones were included in the study. As a result, the total sample size was 368 children.

Clinical examination

Intra-oral examination was conducted at the schools in Tartu by a trained examiner with an assistant recording the observations. After the initial cleaning of teeth by the use of gauze, the dentition was inspected using disposable dental mirrors and probes. Illumination was by indirect sunlight and a local lamp. All partly or fully erupted teeth were examined. Caries experience was assessed in accordance with the DMFT indices as described by the WHO Oral Health Surveys [37].

Dental fluorosis was assessed on vestibular, occlusal and lingual surfaces. The white flecks, fine white and brown lines in the enamel were registered as a mild degree of fluorosis. Very chalky, opaque enamel, mottling and the loss of the portions of the outer enamel was diagnosed as severe fluorosis [8].

Data processing

Data were computerised using the Excel program and the statistical analysis was performed with SPSS for Windows program. The prevalence of dental fluorosis was calculated as frequency of occurrence among the studied population (%). The difference between indicators was evaluated by t-test. The difference was considered significant if $p<0.05$. The association between the prevalence of dental florosis and the fluoride content of drinking water was characterised by a relative risk (RR) and its confidence interval [27].

RESULTS AND DISCUSSION

Fluoride content in drinking water

Table 1 gives the mean value, standard deviation and the range of fluoride content in drinking water sources (tube wells) by the study zones in 1986–1997. It is the period when the study population was born and grew up.

The content of fluoride in the water supply system varied between the studied zones to a large scale depending on the water source from which the supply system feeds on. The lowest fluoride concentration (on average 0.18 mg/l) was detected in Zone I (Staadioni) where the water system intakes the water from Quaternary deposits. Zone II (Karlova) had the average fluoride content 0.29 mg/l. In Zones V and

VI (Raatuse and Veeriku) the fluoride content in drinking water was anomalously high (on average 2.41 and 3.89 mg/l, respectively). This exceeds the national limit 1.5 mg/l about two times. Zones III and IV (Aardla and Annelinn) intake the water from different groundwater layers and the actual fluoride concentration depends on the water consumption and water pressure balance between different wells, on average it was 1.19 and 1.59 mg/l, respectively.

Table 1. Fluoride content (mg/l) of drinking water sources in Tartu, 1986–1997

Zone		No of samples	*Mean*	SD	Min	Max
No	Name					
I	Staadioni	25	0.18	0.05	0.10	0.30
II	Karlova	20	0.29	0.16	0.10	0.70
III	Aardla	28	1.19	0.18	0.80	1.50
IV	Annelinn	35	1.59	0.18	1.30	1.90
V	Raatuse	24	2.41	0.34	1.85	3.2
VI	Veeriku	8	3.89	0.35	3.35	4.40
I–VI	**Total**	**140**	**1.34**	**1.02**	**0.10**	**4.40**

Prevalence of dental fluorosis

The distribution of 12-year-old schoolchildren according to gender and the residence in six zones and the prevalence of dental fluorosis is shown in Table 2.

The number of children was different by zones. Boys and girls were equally represented in the total sample (47% and 53%, respectively). However, they were unevenly represented between zones. In Raatuse zone the boys constituted 76.5% of sample, while in other zones the girls prevailed (over 50%), but the differences were not significant.

The prevalence of dental fluorosis among Tartu schoolchildren was 30.2%, being 26.3% among boys and 33.7% among girls. The difference between boys and girls was not significant.

In Zone I (Staadioni) with the lowest average fluoride concentration 91.2% the study group did not exhibit dental damage and the remaining 8.8% had only a mild degree of dental fluorosis. The results obtained from Zones II, III, IV (Karlova, Aardla, Annelinn) showed that the percentage of children with dental fluorosis (15.8; 21.0 and 38.3%, respectively) increased with the increase in fluoride content in the drinking water source (Figure 2). Results from the high-fluoride Zones V and VI (Raatuse and Veeriku) showed that about half of the study group had dental fluorosis (47.1 and 53.3%, respectively).

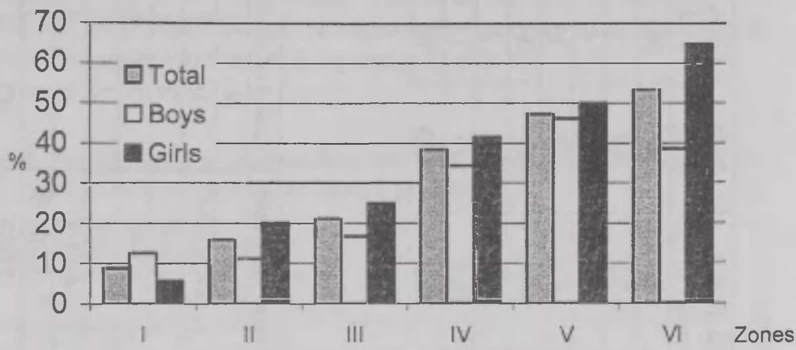

Figure 2. Prevalence of dental fluorosis (%) among schoolchildren in different zones in Tartu

In most cases (89%) the mild degree of fluorosis was diagnosed (Table 3). Only twelve children (3 boys and 9 girls) had severe fluorosis. Half of them lived in the high-fluoride Zone VI (Veeriku) where the severe form among the diseased group reached 38%. The high occurrence of severe fluorosis was found in the low-fluoride Zone II (Karlova) as well. In Zone I (Staadioni) and Zone V (Raatuse) a severe form of fluorosis was not detected. Due to a small number of cases the differences between boys and girls as well as between zones, were not significant.

Tabel 2. Prevalence of dental fluorosis among 12-year-old schoolchildren in Tartu

Zone		No of children	Children with dental fluorosis		Boys	Boys with dental fluorosis		Girls	Girls with dental fluorosis	
No	*Name*		No	%	No	No	%	No	No	%
I	Staadioni	34	3	8.8	16	2	12.5	18	1	5.6
II	Karlova	38	6	15.8	18	2	11.1	20	4	20.0
III	Aardla	100	21	21.0	48	8	16.7	52	13	25.0
IV	Annelinn	149	57	38.3	67	23	34.3	82	34	41.5
V	Raatuse	17	8	47.1	13	6	46.2	4	2	50.0
VI	Veeriku	30	16	53.3	13	5	38.5	17	11	64.7
I–VI	**Total**	**368**	**111**	**30.2**	**175**	**46**	**26.3**	**193**	**65**	**33.7**

Table 3. Distribution of schoolchildren by the severity of fluorosis

Zones		No of school-children	Cases of dental fluorosis		Cases of mild fluorosis		Cases of severe fluorosis	
No	*Name*		No	%	No	%	No	%
I	Staadioni	34	3	8.8	3	9*/100**	0	0*/0**
II	Karlova	38	6	15.8	4	11/67	2	5/33
III	Aardla	100	21	21.0	19	19/90	2	2/10
IV	Annelinn	149	57	38.3	55	37/96	2	1/4
V	Raatuse	17	8	47.1	8	47/100	0	0/0
VI	Veeriku	30	16	53.3	10	33/62	6	20/38
I–VI	**Total**	**368**	**111**	**30.2**	**99**	**27/89**	**12**	**3/11**

* % from all the studied children, ** % from all the cases of fluorosis

Relationship between the water fluoride level and the prevalence of fluorosis

A strong association between the water fluoride level and the prevalence of fluorosis was found. The data allowed to calculate the relative risk of dental fluorosis in relation to the zone of residence and the fluoride content in the drinking water (Table 4).

Table 4. Relative risk of dental fluorosis among schoolchildren in different zones of Tartu (compared to Zone I Staadioni).

Region		Content of fluoride in water (mg/l)	Relative risk (RR)	Confidence interval (CI 95%)
No	Name			
I	Staadioni	0.2	1.00	
II	Karlova	0.3	1.79	0.41–7.71
III	Aardla	1.2	2.38	0.67–8.48
IV	Annelinn	1.6	4.33*	1.28–14.67
V	Raatuse	2.4	5.33*	1.25–22.71
VI	Veeriku	3.9	6.04*	1.60–22.80

* statistically significant

The risk of dental fluorosis was over 4 times higher among the children of Zone IV (Annelinn) where the average fluoride content exceeded slightly the permissible level as compared to Zone I (Staadioni). In Zones V and VI the risk was even higher. Currently, these wells are excluded from the public water supply system. In Zones II and III where the fluoride content in water was below the limit, there was no significant risk of dental fluorosis as compared to Zone I where the fluoride content in water was the lowest.

DISCUSSION

The prevalence of dental fluorosis among schoolchildren was studied in the town of Tartu where the fluoride content in drinking water varied between zones significantly. Other conditions (climate, the quality of outdoor air, living conditions, dietary habits and oral hygiene) were considered to be distributed evenly inside the town.

There were some limitations in this study. First, the selection of the children was not randomised as it was a convenient sample from the national oral health survey. Secondly, the zones included in the study are characterised by the average fluoride concentration in drinking water only.

Although the study population was not randomised, it was considered reasonably representative of the 12-year-old children of Tartu in the similar ethnic and socioeconomic class. The results of this study may be extrapolated to the school-going 12-year-old children of Tartu.

The research approach of this study was designed to evaluate the exposure to fluoride via drinking water only and this has limited the capacity of the study to comment on other factors such as fluoride toothpaste and other dietary exposure to fluoride which can serve as risk factors for fluorosis [22]. It should be mentioned that fluoride toothpaste was available on the Estonian market since the early 1990s (i.e. after the tooth eruption of the studied population) and no additional fluoride supplements such as fluoride tablets, mouth rinses, fluoride gel applications were used regularly.

This study assumed that the fluoride exposure of each child in the zone corresponded to the average fluoride level in the drinking water of that zone. The use of the average fluoride level of the zone water to determine the child's fluoride exposure status was perhaps not the best approach, as the fluoride content inside the zone varies to some degree and in the course of time. Because of the lack of resources it was not possible to determine the individual exposure of subjects via drinking water.

Our results, showing the 30.2% of prevalence of dental fluorosis among Tartu schoolchildren, does not differ significantly from the data of scientific literature from other countries. Stephen *et al* [30] have reported the prevalence of the clinical form of dental fluorosis in Scotland in 30% of schoolchildren. Splieth *et al* [29] found that the prevalence of very mild fluorosis among 10–17-year-old schoolchildren in Germany was 32% and the questionable form of dental fluorosis was even 64%. Frang *et al* [15] found that the prevalence of the moderate form of dental fluorosis was 20.7% in 7–10-year-old schoolchildren in Hungary.

In the UK the prevalence of diffuse enamel opacities among 12-year-old children was 20%, ranging from 8% in Northern Ireland to 22% in England [36]. A study by Carvalho *et al* [9] in Belgium, assessing the apparent decline in dental caries among 12-year-old children between 1983 and 1998, showed early signs of fluorosis in 5% of subjects in 1983 and 30% of the subjects in 1998. In Denmark the prevalence of fluorosis among 11-year-old children was 15% [19]. A national survey of the US schoolchildren found that 22.3% of children surveyed had some fluorosis. Of these cases, 94% were very mild or mild. Only 6% of fluorosis cases were considered moderate or severe [1]. So far, the highest prevalence of dental fluorosis has been reported in China: among 9–15-year-old schoolchildren the prevalence of fluorosis was 84–98%, but this was found in the regions with a very high fluoride content (7.2–8.3 mg/l) in drinking water [10]. The direct comparison of these fluorosis data from various countries is difficult because of inherent differences in water consumption, climate, nutrition, living standards and the availability of other fluoride sources within the countries.

The association between fluoride in drinking water and the degree of dental fluorosis has been documented worldwide [6, 13, 25]. In Italy 95% of 12-year-old children in the low-fluoride area (0.3 mg/l) had no evidence of fluorosis compared with 55% in high-fluoride (2.5 mg/l) area [3]. The similar data have also been reported in previous studies in Estonia [17, 34]. The association between the fluoride content of water in different regions in Estonia and the prevalence of fluorosis demonstrate the same results detected among schoolchildren in Tartu. According to the data by Kiik [17], the prevalence of dental fluorosis among 7–12-year-old schoolchildren, living in low-fluoride areas, was 7.8%, but in high-fluoride areas (2.2–2.8 mg/l) the prevalence was even 53.6%. The high prevalence of fluorosis was also detected by Vihm [34] in the town of Virtsu where the prevalence reached 41.2%. This is also the region with a very high natural fluoride content in drinking water (4.8–5.0 mg/l).

In the study by van der Hoek *et al* [33] the fluoride level in drinking water remained a very strong independent risk factor for fluorosis in the multivariate analysis. The students drinking water with a fluoride level of 1 mg/l or higher had an almost five times higher risk for dental fluorosis than the students drinking water with a fluoride content of 0.3 mg/l or less. No clear effects could be found for using the fluoridated toothpaste, the occupation of the father, and the socio-economic status.

In recent years there has been an increase in the prevalence of mild fluorosis. The use of the fluoride toothpaste by young children has been reported as a potential risk factor for fluorosis in a number of studies [24, 28, 31, 35]. Other factors, associated with fluorosis in nonfluoridated areas, were fluoride-supplement use [26, 35] and the higher socioeconomic status [31]. The review of studies evaluating risk factors or indicators and quantifying the risk for dental fluorosis from the 1980s through the 1990s time period showed that four major risk factors were consistently identified: the use of fluoridated drinking water, fluoride supplements, the fluoride toothpaste, and infant formulas before the age of six years [22].

The fluoridated toothpaste was first introduced into Europe in 1962 in Finland and now accounts for over 90% of the market in many countries [36]. In Estonia it was introduced since the beginning of 1990s. No additional fluoride supplements were used regularly.

The optimisation of the fluoride content in drinking water enables to decrease the risk of dental fluorosis significantly. Preventive measures to minimize risk factors for fluorosis include the supervision of tooth brushing by children under 5 years, dispensing the pea-sized quantities of toothpaste for children, and the stringent criteria applied to the administration of fluoride supplements to children [14].

CONCLUSION

The present results and those of the previous studies strengthen the notion that there is a systematic and positive relationship between the fluoride content in drinking water and the prevalence of dental fluorosis. It has been determined that the fluoride concentration in the excess of 1.6 mg/l and over exposes residents to high health risks based on the risk identification.

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RELATIONSHIP BETWEEN PRACTICING SPORTS AND PERFORMING PHYSICAL TESTS AT THE ESTONIAN PUBLIC SERVICE ACADEMY

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ABSTRACT

The purpose of this study was to compare the possible relationship in sports habits, anthropometric characteristics and physical performance among extension service students. Two groups of police and rescue service students answered the query and performed physical tests that are in use for these specialties in Estonia. Additionally their body fat was measured and also their body fat index was calculated. All parameters were compared with each other.

Key words: police, rescue service, students, physical performance

INTRODUCTION

The anthropometric profile of individuals has been reported to be closely related to the level of sports performance [3]. As we had examined the anthropometric characteristics and physical performance of first year regular students in 1999 and found a significant positive relationship between the height of students and the result of the 100 m run (r=0,35; $p<0.001$) and also the correlation between performance of the 100 m run and sit-ups tests [1], we enlarged our survey to policemen and rescuers who continue their studies in our academy.

The knowledge about the relationship between anthropometric characteristics and physical performance is an important tool for planning the syllabus of physical education, as well as for evaluating the physical fitness of students [2,5] also for those who already work as civil servants.

Correlation (r=0,63) was found between doing squats (police test) and percentage of body fat and (r=0,70) between percentage of body fat and the number of chin-ups ($p<0.01$). Among rescue service students there were also found correlations between percentage of body fat and performance of sit-ups (r=0,44, $p<0.01$), as well as between percentage of body fat and performance of chin-ups (r=0,52, $p<0.01$).

MATERIAL AND METHODS

Subjects

The respondents of the study were 35 extension students from the police college, 21 extension and 18 regular students from the college of rescue services. Most of them need to pass annual physical tests in their services [4]. Eleven voluntary regular students from the college of finance and taxation also participated.
Of the 85 participants only 11 were female.

Taking measurements

Height was measured in cm using a Martin metal anthropometer and body mass in kg using medical scales. Body fat was estimated using an OMRON body-fat tester.

Testing procedure

The physical tests were performed at the Sports Centre of the Public Service Academy as follows:
For policemen:

1) squat with no time limit
2) sit-ups with no time limit
3) chin-ups for men (under 40)
4) push-ups for men over 40 and for women
5) 1000 m run for women, 3000 m run for men

For all rescue service students:

1) squat in 60 seconds with 45 kg bar on shoulders
2) bench press in 60 seconds with 45 kg bar
3) sit-ups in 60 seconds
4) chin-ups
5) 500 m rowing on ergometer

(Rowing was chosen instead of running 2700 m, because out-door conditions in December, when the test was performed, prohibited running.)

Query

The participants answered an anonymous questionnaire about their health, sporting and eating habits, smoking and drinking alcoholic beverages. On the same questionnaire they added their anthropometrical measurements and physical test results for future analysis.

Statistical analysis

The results of physical tests and quantitative answers on the questionnaire were compared. Standard statistical methods were used for the calculation of the means. To determine the relationships between dependent variables Pearson correlation coefficients were used. Statistical significance was accepted at $p<0.05$. Data were analysed using the Statistical Package for the Social Sciences (SPSS), version 11.0 for Windows.

RESULTS

Table 1 shows the average age and anthropometric parameters of extension service students (n=56).

Table 1.

	x_n	δ	x_{min}	x_{max}
Age (years)	33	6	22	50
Height (cm)	180	6,9	161	195
Weight (kg)	84	15	50	115

Fewer than half of such students (41%) participate in sports at least once a week. Only 18% of extension service students find performing physical tests easy; 9% say that this is very difficult.

We saw a quite high correlation between sporting activity and performing physical tests. For example there was a correlation of $r=0,84$ between the number of hours spent in high exertion sport (breathing hard and sweating) in a week and the result of running 3000 m ($p<0.01$). The Pearson correlation coefficient was even higher between the running test and going in for individual sports (r=0,86) or participating in some training groups (r=0,91; p<0.01).

There was a correlation of r=0,63 between doing squats (police test) and percentage of body fat and r=0,70 between percentage of body fat and the number of chin-ups (p<0.01). Also among police students the results of 3000 m run and chin-ups were correlated (r=0,86, p<0.01).

There was a similar correlation between age and the parameters from the query and physical tests, as follows: age and body fat percentage (r=0,6; p<0.01), age and sporting activity (r=0,5; p<0.01) age and doing squats (r=0,52; p<0.01). The correlation was even stronger between age and doing chin-ups (r=0,8; p<0.01).

The correlations among these parameters were weaker among rescue service students. The correlation between percentage of body fat and performance of sit-ups was r=0,44 (p<0.01); that between percentage of body fat and performance of chin-ups r=0,52 (p<0.01).

DISCUSSION

The correlation between the percentage of body fat and physical performance clearly shows the necessity of weight control in increasing the total score in annual physical tests. As body fat percentage is a function of eating and physical exercise, students or civil servants can not achieve good results in physical tests without developing different physical abilities.

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FOREFOOT PRESSURE DISTRIBUTION IN FEMALE PATIENTS HAVING HALLUX VALGUS DEFORMITY

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ABSTRACT

Introduction. Hallux valgus deformity is a common foot disorder that causes pain and changes the foot shape. The etiology is multifactorial and among other factors biomechanical disturbances are greatly responsible for development of forefoot deformity and pain syndrome.

Material and methods. Forefoot pressure distribution while walking at self-selected speed was analyzed in 15 female patients (mean age 41 years, min 13 years, max 70 years) suffering from hallux valgus deformity. Plantar pressure distribution data were collected and analyzed using the Footscan Scientific 3D Box system and software (RSscan International, Belgium). The following data were registered for each metatarsal head and great toe: percentage of contact time versus complete stance phase (% Contact), percentage of loading time versus forefoot loading time (Comp%), maximum pressure (Pmax), total amount of pressure during the complete stance phase (Imp). The data were compared with the normal value upper limit of the Footscan software reference base.

Results. Overpressure on projection of 2–4 metatarsal heads while walking was observed in female patients having hallux valgus deformity. Dynamic plantar pressure measurements allow objective assessment of overpressure and its localization in patients with hallux valgus deformity. According to plantar pressure distribution data the custom-made orthopedic insoles could be accomplished for improving functional status of the foot.

Key words: hallux valgus, forefoot pressure distribution, conservative treatment

INTRODUCTION

Hallux valgus (HV) is a common forefoot deformity that causes pain and changes the foot shape. The etiology of deformity is multifactorial [1]. Heredity plays a key role in development of the deformity since it is inherited autosom dominantly and mostly women are affected [2, 3]. Wearing unsuitable shoes [4, 5] and different biomechanical disorders of feet (hind foot and forefoot hyperpronation, hypermobility of I metatarsocuneiform joint, contracture of Achilles' tendon, neuromuscular disorders) contribute to the development of deformity [4].

Plantar pressure measurement is one of the gait analysis methods allowing detection of biomechanical disturbances during walking. Plantar pressure measurement technology is evolving from the research laboratory into clinical practice and offers to clinicians the possibility to investigate changes to foot function over time or the effects of therapeutic intervention [6]. It has been established, that overpressure to foot tissues correlates very well with incidence and magnitude of pain syndrome [7] and with occurrence of plantar skin lesions [8]. Beforehand on the same subject executed studies have shown that in HV deformity the forefoot is overloaded but the controversy exists in exact localization of the overload [9–13]. In HV deformity the first choice treatment is conservative treatment, which includes counseling in choosing suitable footwear and prescribing orthopedic insoles [1, 4]. Although studies have shown that insoles are not effective for prevention of HV deformity development or progression [14, 15], good results have been obtained in palliation of accompanying pain syndrome [4, 7].

The aim of the present study was to evaluate forefoot pressure distribution in female patients having HV deformity.

MATERIAL

The study was carried out at Tartu University sports medicine and rehabilitation clinic outpatient department during 01.01. – 30.06.2004. The study group consisted of female patients having HV deformity that was diagnosed by the orthopedic surgeon. Patients were referred to our setting by general practitioners, orthopedic surgeons or turned to consultation by themselves. HV patients treated surgically on both feet, patients having degenerative or inflammatory arthritis of other joints of lower extremities or nervous system pathology were excluded from the study group. In one patient surgical treatment was performed on the right leg and the measurements of that leg were excluded from the data analysis. The study group consisted of 15 female patients (mean age 40,9 years, min 13 years, max 70 years), representing HV deformity (deformity of I metetarsophalangeal joint 15 degrees or more) in both feet.

METHODS

The plantar pressure measurements were performed with Footscan Scientific 3D Box (RSscan International, Belgium) system that consists of pressure plate (200 x 40 cm, 4 sensors/cm^2) and computer software (Footscan Pro ver. 4.2). The pressure plate is mounted even in the floor in the middle of a 10 meters long walkway. Before starting the measurements patients body weight and foot size were taken and entered into the Footscan program. Patients were instructed to walk at self-selected speed along the walkway and not to change the step length stepping on and off the pressure plate. Before starting the actual measurements each person walked 3–4 times along the walkway in order to get accustomed with the study environment. During the dynamic study patient walked along the walkway at self-selected speed and measurements were repeated for 6 times. The area of interest was forefoot, which was analyzed by the use of Footscan software. To establish the pressure parameters the markers were arranged over the five metatarsal heads (M1-M5) and the first toe (T1) by the Footscan software. The arrangement of markers was evaluated visually by one investigator and rearranged manually if any aberrancy detected. Following parameters were recorded for each marker: percentage of loading under the marker compared to the complete stance phase (% Contact), percentage of loading under the marker compared to the related markers (five metatarsal markers – Comp %), the maximum pressure measured under the marker (Pmax), the total amount of pressure during the complete stance phase for the specified marker (impulse – Imp). The data of last five measurements were used for analysis whereby the minimum and maximum values registered in each region were excluded. Accordingly the mean of parameters for each region was calculated on the basis of three values. Due to the small sample size and not normally distributed variables the Wilcoxon test was used for comparing the registered parameters with the upper limit of normal values of Footscan reference base. The p-values $< 0,05$ were considered statistically significant.

RESULTS

The loading time of metatarsal heads and the first toe related to the complete stance time (%Contact) doesn't exceed the upper limit of reference base normal values in HV deformity patients (Table 1).

Table 1. The loading time of metatarsal heads and the first toe related to the complete stance time (%Contact) compared to the upper limit of Footscan software reference base normal values.

Region	*Hallux valgus* (% Contact) {median (min–max)}	Upper limit of normal values (% Contact)
M5	63 (36–86)	80
M4	74 (45–87)	86
M3	78 (52–88)	85
M2	76 (38–85)	83
M1	59 (25–82)	80
T1	43 (0–70)	70

M5–M1 – metatarsal heads, T1 – first toe, upper limit of normal values – on the bases of Footscan software reference base.

Loading time of the third metatarsal head related to the forefoot loading time (Comp%) was statistically different from upper limit of normal value (Table 2).

The median of maximum pressure was statistically different from the upper limit of normal values in the region of the second, third and forth metatarsal head (Table 3).

The median of impulse registered in the region from second to forth metatarsal heads was statistically different from the upper limit of the normal values of the reference base (Table 4).

Although in tables cited above it could be seen, that recorded variables vary in great extent, in regions where the statistically relevant difference from the upper limit of normal values was found, 65–80% of variables were exceeding this level (Figure 1).

Table 2. Loading time of metatarsal heads related to forefoot loading time (Comp%) compared to the upper limit of Footscan software reference base normal values.

Region	*Hallux valgus* (Comp%) {median (min–max)}	Upper limit of normal values (Comp%)	p
M5	10 (2–25)	11	0,8037
M4	18 (6–27)	18	0,5086
M3	26 (17–58)	23	<0,0001
M2	26 (11–48)	24	0,1421
M1	16 (4–28)	21	0,9972

M5–M1 – metatarsal heads, upper limit of normal values – on the bases of Footscan software reference base.

Table 3. The maximum pressure (Pmax) in the region of metatarsal heads and the first toe compared to the upper limit of Footscan software reference base normal values.

Region	*Hallux valgus* (Pmax–N/cm^2) {median (min–max)}	Upper limit of normal values (Pmax–N/cm^2)	p
M5	20 (4–102)	28	0,5400
M4	54 (14–140)	38	0,0032
M3	77 (15–272)	48	<0,0001
M2	83 (11–214)	50	<0,0009
M1	53 (11–112)	46	0,3327
T1	37 (0–196)	48	0,7915

M5–M1 – metatarsal heads, T1 – first toe, upper limit of normal values = on the bases of Footscan software reference base.

Table 4. Impulse (Imp) in the region of metatarsal heads and the first toe compared to the upper limit of Footscan software reference base normal values.

Region	*Hallux valgus* (Imp–Ns/cm^2) {median (min–max)}	Upper limit of normal values (Imp–Ns/cm^2)	p
M5	4 (0,9–23)	6	0,5602
M4	12 (3–32)	9	0,0050
M3	22 (6–67)	12	<0,0003
M2	20 (4–40)	12	0,0028
M1	9 (1–28)	11	0,8123
T1	6 (0–26)	8	0,9887

M5–M1 – metatarsal heads, T1 – first toe, upper limit of normal values – on the bases of Footscan software reference base.

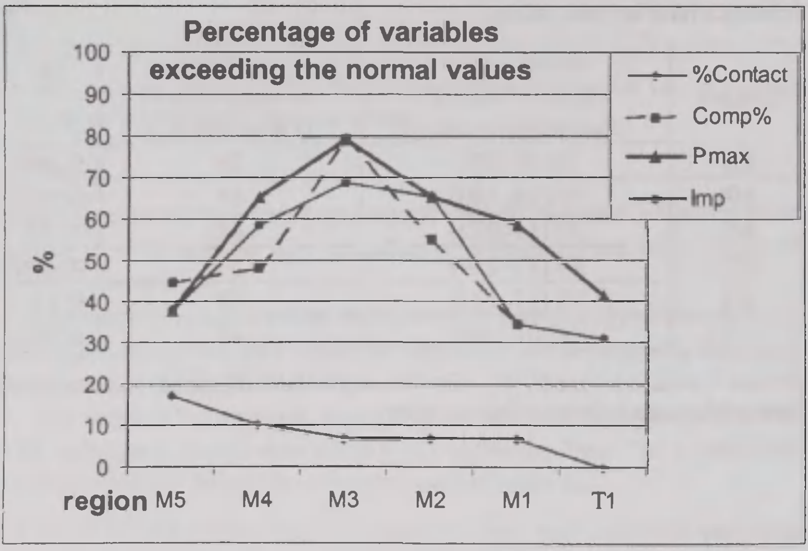

Figure 1. In the forefoot recorded pressure distribution parameters (% Contact, Comp%, Pmax, Imp) variables percentage exceeding the upper limit of normal values.

%Contact – percentage of loading under the marker compared to the complete stance phase, Comp% – percentage of loading under the marker compared to the related markers (five metatarsal markers), Pmax – the maximum pressure measured under the marker, Imp – the total amount of pressure during the complete stance phase for the specified marker (impulse).

DISCUSSION

From the study appeared that the loading time of metatarsal heads and the first toe related to the complete stance time (%Contact) was not informative parameter in female patients having HV deformity. Observing the loading time of metatarsal heads related to forefoot loading time the elongated contact time in M3 region was noticed. Furthermore, the statistically evident difference from upper limit of normal values of maximum pressure and impulse refer to overload in the region of M2-M4 metatarsal heads.

Overloading of anatomical structures of foot is the basis for formation of pain syndrome and skin lesions. Previous studies have shown that beside heredity biomechanical disturbances of foot have a substantial role in genesis of HV deformation, although there is no uniform standpoint in the character of these disturbances. The reason might be the circumstance that study methods vary in great extent: the equipment used, data recording, and selection of study subjects differ a lot. Analyzing the forefoot pressure distribution in HV deformity some authors have found that substantial decrease of plantar pressure in IV and V metatarsal head region and the pass of maximum pressure to the medial forefoot occur in this disease group [9, 10]. On the other hand has been found, that hallux and the II metatarsal head are substantially lesser loaded than III-V metatarsal heads [11–13] and mediolateral load transfer from I-st metatarsal to lesser metatarsals occur. As a consequence the function of hallux in walking stance phase push off is worsened and the overload of lesser metatarsals develops. In clinical practice the static X-ray is taken for evaluation of the extent of deformity and foot condition in HV deformity. At the same time it is known that radiologic characteristics alone do not determine one-to-one the loading parameters of the forefoot and the radiologically determined progression of HV is not connected with increased loading in lateral forefoot regions [13, 16]. Consequently the analysis of plantar pressure distribution gives relevant additional information about functional status of the foot.

Dynamic plantar pressure measurements in HV deformity patients make possible objective assessment and localizing of overloaded regions in forefoot while walking. In HV treatment conservative treatment using orthopedic insoles as well [4] is the first choice. The plantar pressure distribution data can contribute to evidence based manufacturing of custom made orthopedic insoles with intention of decreasing overload in forefoot.

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BONE MINERAL DENSITY IN ADOLESCENT GIRLS WITH DIFFERENT PHYSICAL ACTIVITY PATTERNS: RELATIONSHIPS WITH BODY COMPOSITION AND MUSCLE PERFORMANCE PARAMETERS

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ABSTRACT

The aim of this investigation was to examine the effect of specific physical activity pattern on bone mineral density (BMD) values in adolescent girls. In total, 52 girls, 14 to 15 years of age, participated in this study. All girls were on Tanner stage 4 or 5. Eighteen children were in control group and they participated only in school compulsory physical education lessons two times a week. Exercise groups were 13 girls, who participated in gymnastics four times a week for at least last four years (strength-trained group); and 21 girls, who participated in cross-country skiing four times a week for at least last four years (endurance-trained group). The height and body mass of the subjects were measured and body mass index calculated (in kg/m^2). Body composition and BMD were assessed using whole-body dual energy X-ray absorptiometry (DPX-IQ densitometer, Lunar Corp, USA). Maximal counter movement jump on contact platform and physical working capacity on bicycle were also performed. Bone mineral density was significantly higher in strength-trained group compared to other measured groups. No differences in BMD values were observed between endurance-trained and control subjects. Counter movement jump was higher in strength-trained girls compared with other groups, and endurance-trained girls demonstrated significantly higher values for counter movement jump compared to control group. In addition, strength-trained and endurance-trained girls were not different in physical working capacity values which were significantly higher when compared with control subjects. Bone mineral density was significantly related ($r>0.58$; $p<0.05$) to body fat mass, fat free mass, body mass index and counter movement jump values. Stepwise multiple regression analysis indicated that fat mass ($R^2=0.424$) from body composition parameters and counter movement jump ($R^2=0.384$) from performance parameters best predicted BMD in adolescent girls. In summary, the results of present investigation demonstrate that the specific physical activity pattern is needed for the development of BMD also during adolescent years in girls. It can be concluded that BMD is mostly determined by the capacity to generate muscle power from the performance parameters and the amount of fat mass from body composition parameters in adolescent girls.

Key words: bone mineral density, adolescent girls, physical activity pattern, body composition

INTRODUCTION

In both men and women, bone mineral density (BMD) and bone mineral content (BMC) increase from early childhood and throughout adolescence. Approximately 90% of bone mass is present at the end of skeletal maturation and BMD can explain between 75 and 85% of the variation in bone strength [3]. Factors that affect BMD and BMC are age, nutritional status and physical activity [2–4]. It has been suggested that weight-bearing physical exercise is essential for the normal development and maintanance of a healthy skeleton [3,4]. The specific response to any bone strain depends on a threshold for that bone, and there exists a minimum effective strain for adjusting bone mass and architecture [3]. For example, impact activity such as running can induce strain as a result of the momentary loading of several times body mass. By contrast, activities such as road cycling and swimming are weight supported, involve minimal strain and involve a prone orientation for considerable periods of time [5]. Accordingly, it is likely that specific physical activity for certain sports plays a pivotal role in skeletal adaptation. In our previous study, we demonstrated that the specific physical activity pattern is needed for the development of BMD already during pubertal years [1]. Understanding these specific effects of different physical activities could give exercise advice that is given to young athletes.

Accordingly, the purpose of the present study was to examine the effects of different physical loading pattern on BMD values in young adolescent female athletes.

METHODS

In total, 52 adolescent young 14–15 years old females participated in this investigation. They comprised young competitive athletes and controls, and were divided into groups of cross-country skiers (n=21), gymnasts (n=13) and healthy nonexercising controls (n=18). All participants were on Tanner [6] stage 4 or 5. Controls participated only in school compulsory physical education lessons two times per week conducted by a teacher of physical education. Cross-country skiers and gymnasts participated in training sessions at least four times a week for at least last four years. All measurements were performed in the morning, participants had to attend laboratory measurements two times. At first, all subjects were measured for height and body mass, questioned for their physical activity, competitive history of their sport and their weekly training time. This was followed by maximal counter movement jump test on contact platform (Newtest OY, Finland) and physical working capacity test on bicycle (Tunturi, Finland). The height was measured using a Martin metal anthropometer in cm (±0.1) and body mass was measured with medical scales (A&D Instruments, Ltd, UK). In addition, the body mass index was calculated as body mass (kg)/height (m^2). Second measurement session consisted of body composition assessment by whole-body dual energy X-ray absorptiometry (DPX-IQ densitometer; Lunar Corp., USA). Participants were scanned in light clothing while lying flat on their backs with arms on their sides. DXA measurements and results were evaluated by the same examiner.

Data analysis was performed by using SPSS 10.0 for Windows (Chicago IL, USA). Standard statistical methods were used to calculate mean and standard deviation (±SD). Statistical comparisons between groups were made by using one-way analysis of variance (ANOVA). Independent t-tests were used where post hoc analysis was necessary. Pearson correlation coefficients were also computed between measured variables. In addition, stepwise multiple regression analysis was performed to find a predictive parameter on BMD from measured body composition and performance parameters that demonstrated significant correlation with BMD value. The level of significance was set at $p<0.05$.

RESULTS

The mean body composition, bone density, muscle power and physical working capacity values are presented in Table 1. The studied groups did not differ from each other from age and biological maturation. In addition, strength-trained and endurance-trained subjects did not differ between mean weekly training time. Bone mineral density values were significantly higher in strength-trained group compared to other studied groups. However, no differences in BMD values were observed between endurance-trained and control subjects. No differences between measured groups were observed in height, body mass and body mass index. Counter movement jump was higher in strength-trained girls compared with other groups, and endurance-trained girls demonstrated significantly higher values for counter movement jump compared to control group. In addition, strength-trained and endurance-trained girls were not different in physical working capacity values which were significantly higher when compared with control subjects. Bone mineral density was significantly related ($r>0.58$; $p<0.05$) to body fat mass, fat free mass,

Table 1. Body composition and performance parameters of adolescent girls (Mean±SD).

Variable	Strength-trained (n=13)	Endurance-trained (n=21)	Untrained controls (n=18)
Age (yrs)	14.4±0.9	14.7±0.5	14.2±0.6
Tanner stage	4–5	4–5	4.5
Weekly training (hrs)	5.8±0.7	6.4±0.9	–
Height (cm)	165.0±6.8	164.4±7.1	165.7±8.1
Body mass (kg)	56.4±8.8	50.8±7.0	54.3±6.9
BMI (kg/m^2)	21.0±2.8	19.8±2.0	20.7±7.2
BMD (g/cm^2)	1.06±2.02	1.01±0.01*	1.00±0.01*
Body fat (%)	22.9±3.2	18.9±2.0	23.4±4.4
Fat mass (kg)	12.8±1.3	9.5±1.0	12.6±1.3
Fat free mass (kg)	43.5±3.3	41.3±2.7	41.6±2.5
CMJ (cm)	26.3±4.5	28.6±4.4*	25.8±5.5#
PWC (W)	198.0±9.4	235.4±10.4	186.5±10.4*#

* Significantly different from Strength-trained group; $p<0.05$.

Significantly different from Endurance-trained group; $p<0.05$.

body mass index and counter movement jump values. Stepwise multiple regression analysis indicated that fat mass (R^2=0.424) from body composition parameters and counter movement jump (R^2=0.384) from performance parameters best predicted BMD in adolescent girls.

DISCUSSION

This investigation shows that BMD is higher in strength-trained girls compared to other studied groups, and BMD is associated with measured counter movement jump values in adolescent girls. These results are similar to our previous study with pubertal girls [1] and demonstrate that specific physical activity pattern is important in BMD development. Thus, although the general configuration of the skeleton is genetically determined, the internal structure is in the process of dynamic change according to external stimuli. In this respect, gymnastic exercises appear to cause different adjustments to the mechanostat [i.e., 5]. Experimental evidence demonstrates that power athletes have superior BMD to endurance athletes, although the bone response to mechanical loading is site specific [4, 5]. However, the results of current investigation and our previous study [5] suggest to start using specific physical activity exercises for the bone development as early age as possible.

Another intereseting finding of present investigation is that the amount of fat mass was another significant predictor of BMD in adolescent girls. It is well known that body fat mass is a significant predictor of BMD in middle-aged women [3]. However, it appears that fat mass is already significantly related to BMD in adolescent girls. This is in contrast to our previous study with pubertal girls [1], where the most important body composition parameter that determined BMD was fat free mass. In addition, in contrast to BMD development, there appears to be no need for specific physical activity pattern for the development of other body composition parameters as there was no differences between studied groups in fat mass and/or fat free mass values. These different aspects of the development of different body composition parameters demonstrate that in addition to physical activity pattern, the maturation is very important during growth in girls.

In summary, the results of present investigation demonstrate that the specific physical activity pattern is needed for the development of BMD also during adolescent years in girls. In contrast, other body compositional parameters appear not to be different in adolescent girls with different physical activity patterns. It can be concluded that BMD is mostly determined by the capacity to generate muscle power from the performance parameters and the amount of fat mass from body composition parameters in adolescent girls.

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THE MEASUREMENT OF BODY COMPOSITION BY LIPOMETER AND BIOELECTRICAL IMPEDANCE ANALYSIS IN SPORTSMEN

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ABSTRACT

The aim of this study was to compare different body composition parameters using a new LIPOMETER device and bioelectrical impedance analysis (BIA) in sportsmen. In total 30 sportsmen (21.7±3.1 yrs, 183.1±5.9 cm, 75.5 kg, BMI 22.6±2.0) were studied. They were mostly presenters of endurance sport events or sport games. Their body composition was measured by LIPOMETER (Austria) measuring the subcutaneous adipose tissue thickness at 15 specified body sites (neck, triceps, biceps, upper back, front chest, lateral chest, upper abdomen, lower abdomen, lower back, hip, front thigh, lateral thigh, rear thigh, inner thigh, calf). The body composition was also measured by multiple-frequency bioelectrical impedance (BIA) device MULTISCAN-5000 (Bodystat Ltd, UK). The mean body fat % was slightly lower measured by LIPOMETER compared with BIA (9.76±4.68 and 10.50±2.07% respectively; p>0.05). There are highly significant relationships between body fat % measured by two different methods (r=0.89). The correlation is also high between the two different methods on the lean body mass (r=0.87). We can conclude that the body composition parameters measured by LIPOMETER and BIA are similar in sportsmen.

Key words: LIPOMETER, BIA, sportsmen

INTRODUCTION

As direct measurement of body composition in vivo is not possible in living humans, a series of indirect estimates of body components have been developed. Bioelectrical impedance analysis (BIA) method is an appealing tool for assessment body composition because it is simple, quick and inexpensive to perform. Theoretically, the BIA method is based upon the relationship between the volume of conductor (i.e. the human body), the conductor's length, the components of the conductor and its impedance [1, 7]. It is assumed that the total conductive volume of the human body is equivalent to that of total body water, most of which is contained in muscle tissue and that the hydration of adipose tissue is minimal [1, 2]. The BIA method is highly accepted for measurement body composition in sportsmen. For this purposes several specific equations are presented [1]. However, different equations that claim to be "generalized" to the general population do not necessarily represent athletes unless they have been specifically validated using athletic groups. Finally, the validity of BIA may be particularly under threat with sporting groups due to temperature, previous exercise and dehydration acting as confounding factors, among many others.

A new computerized optical system ("LIPOMETER") was developed in order to permit a non-invasive, quick, precise and safe determination of the thickness of subcutaneous adipose tissue (SAT) at specific body sites. The LIPOMETER measures a single, not compressed, subcutaneous adipose tissue. The technical characteristics of the device and a first validation of the results versus computed tomography as standard for comparison have been published [5]. However, there is a lack of data about the possibility to use the new device in sportsmen.

The aim of this study was to compare different body composition parameters using a new LIPOMETER device and bioelectrical impedance analysis in sportsmen.

METHODS

In total 38 sportsmen (21.7±3.1 yrs, 183.1±5.9 cm, 75.5±7.2 kg, BMI 22.6±2.0) were studied. They all were sportsmen who exercised 4–6 times per week. They mostly were the presenters of endurance sport events or sport games.

Stature was measured using a Martin metal anthropometer in cm (±0.1 cm) and body mass with medical scales in kg (±0.05 kg) and BMI (kg/m^2) was calculated.

The design of the LIPOMETER, a computerized optical measuring system for determining the SAT thickness, was described previously [5]. LIPOMETER measurements were made for each individual at 15 specified body sites (neck, triceps, biceps, upper back, front chest, lateral chest, upper abdomen, lower abdomen, lower back, hip, front thigh, lateral thigh, rear thigh, inner thigh, calf). Subjects were standing. Measurements were taken at the right side of the body. The coefficients of variation of subcutaneous adipose tissue layers are ranging between 1.9% in front chest and 12.2% for rear thigh [6].

The body resistance was measured with a multiple-frequency impedance device MULTISCAN-5000 (Bodystat Ltd, UK). Sportsmen were placed in a supine position with limbs slightly abducted. Skin current electrodes were placed on the right dorsal surface at the hand and feet at the metacarpals and metadarsals. Only the data measured at 50 KHz (as a measure of total body water) was used. Fat free mass (FFM) was calculated using the Segal equation for male subjects with an assumed body fat % of less than 20% [8]. Fat mass was calculated as the difference between body mass and FFM. Percent of body fat mass was calculated as well. Both LIPOMETER and BIA measurements were taken on the same day on the maximum of 30 minutes difference.

Standard statistical methods were used to calculate mean ($\overline{X}$) and standard deviation (±SD). Pearson's correlation coefficients were used to determine the relationships between LIPOMETER and BIA data. Significance was set at $p \leq 0.05$.

RESULTS

The mean body fat % and FFM parameters measured by LIPOMETER and BIA are presented in Table 1. The mean body fat % was slightly lower measured by LIPOMETER compared with BIA (0.76%), but the difference is not statistically significant ($p>0.05$). Slight differences between two methods were also on the FFM ($p>0.05$).

The Pearson correlation analysis indicate that there are highly significant relationships between body fat % measured by two different methods ($r=0.89$). The correlation in FFM between two methods was also high ($r=0.87$).

Table 1. The mean body composition parameters measured by LIPOMETER and BIA in sportsmen ($\bar{X}$±SD)

	X±SD
LIPOMETER:	
Fat %	9.76±4.68
LBM (kg)	67.93±6.21
BIA:	
Fat %	10.50±2.07
LBM (kg)	67.02±5.56

DISCUSSION

The principle of measurement method by LIPOMETER and BIA is different. The LIPOMETER is using the optical principle and BIA electrical conductivity. However, our results indicate that the relationship between two methods in sportsmen is high (r=0.87–0.89).

Several field methods have been recommended to monitor changes in body composition. One of the more practical methods for predicting percent body fat is the measurement at selected skinfold (SF) thicknesses. All SF prediction equations in general use are based on two-component model of body composition [4]. It is well recognized that SF thickness equations for body composition assessment are very population – specific and estimates of body fat obtained from different regression equations may vary greatly among individuals [3]. The LIPOMETER measurements connected with the measurement of the subcutaneous fat tissue. However the fat tissue is not compressed. The LIPOMETER is excellent for presenting subcutaneous adipose tissue topography.

It can be concluded that the body composition parameters measured by LIPOMETER and BIA are similar.

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AN OVERVIEW OF THE STRUCTURE OF THE FACULTY OF MEDICINE AT THE UNIVERSITY OF TARTU (THE FORMER IMPERIAL UNIVERSITY OF DORPAT) IN THE EARLY 19TH CENTURY

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ABSTRACT

The socioeconomic and ideological changes that hit Western Europe in the second half of the18th-century did not leave Russia unaffected. The increasing need for development of higher education and science brought about the reopening of universities in Tartu (1802) and Vilnius (1803) and the foundation of new universities in Kazan (1804) and Kharkiv (1805) [17].

During the more than two centuries since their (re)opening and formative years, a number of historical studies have been published, some of which have also dealt with the formation of the structure of medical faculties in these universities.

We are going to discuss the formation of the Faculty of Medicine at the University of Tartu (the former Imperial University of Dorpat) in order to elaborate and complement the earlier publications.

Nowadays the history of universities cannot be considered purely their internal affair. Therefore, it would be necessary, if possible, to study the problem from the viewpoint of other older Russian universities as well, in order to get a better overview for common European history, including history of science.

INTRODUCTION

During its more than 372 years of existence, the University of Tartu has gone through a discontinuous and complicated route of development; sometimes it has even changed its location (because of wars, it has worked for shorter periods in Tallinn and Pärnu). The longest stage in its history has been the period of the Imperial University of Dorpat (or, from 1893, of Yuryev) within the Russian state (1802–1918). During this period, the University of Tartu became one of the leading universities of the world in natural sciences as well as in medicine.

The achievement of such high standards was partly made possible by the first professors at the Faculty of Medicine of the reopened University of Dorpat (now Tartu). Along with necessary knowledge, teaching skills and research talent, they had to have outstanding organizing abilities [17].

However, a closer look at articles on the initial years of the Imperial University of Dorpat reveals that the professors' titles of office and names of ancillary institutions of the university often differ from the titles or names provided by the university statutes valid at that time. Even the question how many ordinary professors the Faculty of Medicine had at the time of reopening of the University in April 1802 and during the first semester can yield different answers – either two or three [2, 11]. This problem also needs clarification.

Considering all this, we are going to provide an overview of the structure of the Faculty of Medicine in the years before and after the reopening of the University as it was specified in the plan of instituting the university (1799) and in its first statutes (1802, 1803).

In the second part of the article, we are going to look at how the structure of the Faculty of Medicine was used by the university itself in its lists of courses and the first annual reports of the Faculty of Medicine. Thereafter, we are going to discuss the reasons for differences in professors' official titles and names of ancillary institutions compared to the university's first statutes and the inexact numbers of both.

To get a comprehensive answer to the questions under discussion, we will start with a flashback to the two periods of the Faculty of Medicine of the University of Dorpat (Tartu) under the Swedish rule. We will provide a brief overview of the work of professors of medicine, their plans to found ancillary institutions and even founding some of them.

THE FACULTY OF MEDICINE AT THE SWEDISH UNIVERSITY WITH TUITION IN LATIN

The first plans to found an institution of higher education in Livonia (a historical region covering part of present-day Estonia and Latvia) – initially only to train clerics – go back to the early 16th century. Unfortunately, these introductory steps were stifled by the Reformation.

Despite numerous difficulties, war-torn Livonia got its own university. It was opened in Dorpat (now Tartu) on 15 (25) October 1632 by permission of the enlightened Swedish king Gustavus II Adolphus. In the fashion of the universities of the period, it had four faculties: theology, law, medicine and philosophy.

From that time, the activity of the university has been interrupted for several times for different reasons. Even the history of the Swedish university, which operated in Latin, falls into two periods (*Academia Gustaviana Dorpatensis* 1632–1665 and *Academia Gustavo-Carolina* 1690–1710). In these years, the university operated according to statutes taken over from the University of Uppsala (of 1625 and 1665 respectively); the standards of tuition and research were similar to those of other universities of the period [16].

The activity of the Faculty of Medicine in Dorpat was modelled directly on the respective faculty at the University of Uppsala; the curriculum and development of the latter, however, relied greatly on the development of medicine in Western Europe, particularly in the Netherlands.

The Faculty of Medicine in Dorpat (Tartu) was to have two professors. One of them was to lecture on anatomy, botany and physics, and the other taught illnesses and their treatment [12]. There was to be a dissection annually. As the number of students at the Faculty of Medicine was small (due to the long period of studies, normally nine years), often only one professor was employed, and sometimes there was none. All the professors of medicine met the standards of the time, having been trained in the best universities of Europe [16].

As early as at the beginning of the second period of the Swedish university, Prof. Lars Micrander (?–1706?) emphasized the importance of visualization of teaching. He raised the question of building a special "anatomy house" in Dorpat (Tartu) as in Uppsala, where he had studied, an anatomical theatre had been built in 1662–1663.

The idea did not materialize, but the following Professor of Medicine Jacob Friedrich Below (1669–1716, graduate of Utrecht University) furnished an anatomy hall with in-built benches in the main building of the university (the present 8 Jaani St in Tartu). To visualize teaching and to satisfy public curiosity, he conducted the first known dissections of human corpses in Dorpat, anatomizing the cadavers of a man and a woman in the winter of 1697/1698. J. F. Below understood the significance of the clinical method of teaching and applied that a hospital (clinic) as a teaching and research institution should be founded at the university, but his application was rejected [10].

For one reason or another, several professors and graduates of the Swedish-period university ended up in Russia. The first professor of medicine in Dorpat Johann Below (1601–1669, studied at the University of Rostock) was physician-in-ordinary to Grand Duke Mikhail Fyodorovich from 1643–1651, and Jacob Friedrich Below achieved fame as a doctor and scientist in the court of Peter I. The graduate of the university Nikolaus Martini was physician-in-ordinary to Empress Anna from 1735–1740.

As in these years the Russian Empire had not a single university, they lacked an opportunity to pass on their knowledge in an academic form. Still, the Swedish university in Dorpat (Tartu) could be considered a link between Western Europe and Russia in the sphere of medicine.

In addition to the above mentioned, several Dutch doctors who worked in the territory of present-day Estonia (in Tallinn and Narva) also reached Russia and had their role in the fact that the budding medicine of 18th century Russia forged close ties with the medicine of Western Europe, particularly of the Netherlands.

Unfortunately, the activities of this university were severed because of the Northern War and the epidemic of plague that broke out in the summer of 1710 in Pärnu, where the university had taken shelter from the war eleven years earlier. The repeated attempts to reopen the university failed, although the obligation to retain a university in Livonia had been confirmed by Peter I in the act of Livonia's capitulation. Still, the reopening of the university was postponed from year to year; only at the end of the 18th century opportunities opened up for it [16].

DORPAT (TARTU) BECOMES A UNIVERSITY TOWN AGAIN

Trying to curb the influx of the ideas of the French Revolution to Russia, Emperor Paul I, in his ukase of 9 April 1798, forbade Russian subjects to study at the universities of Western Europe and recalled them to Russia within the following months. Simultaneously, the Baltic knighthoods were given permission to quickly open a local Protestant university for the whole of Russia but primarily for the knighthoods of Estonia, Livonia and Courland and to choose the location of the university by mutual agreement. From the beginning, the university was to bear the name of an "imperial university", although it was to be financed by the knighthoods mentioned. The representatives of the knighthoods drafted a plan for founding the university but were unable to decide on its location. Finally, the Senate was offered to choose between two towns – Mitau (Jelgava) and Dorpat (Tartu). The Senate supported the latter because of its central location in the Baltic provinces, favourable climate and cheapness of foodstuffs, which was supposed to offer better opportunities for less affluent parents to school their children. On 4 May 1799, Paul I approved the resolution of the Senate and the plan for founding the university, which, in effect, became the provisional statutes of the university [17].

STRUCTURE OF THE FACULTY OF MEDICINE IN THE PLAN FOR FOUNDING THE UNIVERSITY (1799)

The plan provided for a total of 22 professors in the faculties of theology, law, medicine and philosophy, and, in addition, lecturers in several subjects, including the major languages. Thus, it covered the main areas of knowledge of the period. Tuition was to be organized mainly on the model of Western-European universities and the University of Moscow [17].

The Faculty of Medicine was to have six ordinary professors and the disciplines were divided between them as follows: (1) physiology and pathology (*Physiologie und Pathologie*), (2) therapy and clinic (*Therapie und Klinik*), (3) anatomy and forensic medicine (*Anatomie und medicina forensis*), (4) surgery and midwifery (*Chirurgie und Hebammenkunst*) (5) botany and *materia medica* (study of medicinal remedies) (*Botanik und materia medica*) and (6) chemistry and pharmacy (*Chemie und Phrarmazevtik*).

The plan for founding the university envisaged the foundation of ancillary institutions at the faculties. The Faculty of Medicine was to have (1) a clinical institute (*Klinisches Institut*) with 14 beds for the treatment of therapeutic patients, (2) a surgical hospital (*Wundarzney-Krankenhaus*) with 10 beds, (3) a maternity hospital (*Entbindungs-Anstalt*) with six beds and a school for midwives (*Hebammen-Schule*), (4) an anatomical theatre (*anatomisches Theater*) for dissections and anatomical preparation with a prosector and two assistants, (5) a chemistry laboratory (*chimisches Laboratorium*).

The work of these ancillary institutions was to be supervised by ordinary professors teaching respective subjects; thus, the ordinary professor of surgery and midwifery had to supervise simultaneously the surgical and maternity hospitals.

The university as a whole was to have a library, a manege and a dance hall. The plan also included the annual budget of the university, which covered the expenses for the staff and for the ancillary institutions [13].

PREPARATIONS FOR REOPENING THE UNIVERSITY

Preparations for launching the university and employing lecturers followed as the opening of the university was planned for 15 January 1801 [17]. The first members of the Faculty of Medicine were appointed to their posts on 14 December 1800. They were Ordinary Professor of Anatomy and Forensic Medicine Martin Ernst Styx (1759–1829, studied at the University of Jena) and Ordinary Professor of Chemistry and Pharmacy Erdmann Heinrich Gottlob Arzt (1766?–1802, studied also at the University of Jena) [7].

While the preparations for opening not only the Faculty of Medicine but also the whole university were in progress, Paul I unexpectedly changed his mind and decreed on 25 December 1800 that the location of the university should not be Dorpat (Tartu) but Mitau (Jelgava) as the knighthoods of Courland and Pilten had submitted a respective application. However, the assassination of the Emperor on 12 March 1801 prevented the execution of this order. On 12 April 1801, the new emperor Alexander I appointed Dorpat (Tartu) again as the seat of the university. He substantiated it by the town's central location, its congenial environs, circulation of Russian currency [9] and several other reasons, including the fact that there had been a university in Dorpat (Tartu) before. The scales had tipped in favour of Dorpat (Tartu) again, this time finally [17].

Now, instead of opening of the university, it would be more appropriate to speak about its reopening, actually its next reopening, as the university had already closed down in 1665 and in 1710.

STRUCTURE OF THE FACULTY OF MEDICINE IN THE UNIVERSITY STATUTES OF 1802

In the complicated situation before the reopening of the university, the curators of the university (representatives of the Baltic knighthoods) considered it necessary to make corrections and additions to the plan of founding the university in order to strengthen their influence over the University Council that consisted of professors. The university statutes confirmed thereafter by the ukase of Alexander I of 5 January 1802 provided only 19 professors for all the four faculties; the number of lecturers, however, had somewhat increased [17].

While the plan of founding the university had provided six posts of ordinary professors for the Faculty of Medicine, the statutes confirmed two years and eight months later had reduced their number to four. As hygienic subjects had been added, the number of disciplines taught by the faculty had grown. They were now distributed between the ordinary professors as follows: (1) anatomy, physiology, surgery and midwifery (*Anatomie, Physiologie, Chirurgie und Hebammenkunst*); (2) pathology, semiotics, therapy and clinic (*Pathologie, Semiotic, Therapie und Clinic*); (3) dietetics, state and popular medicine and *materia medica* (*Diätetic, Staats- und populäre Arzeney-Wissenschaft und materia medica*); (4) chemistry and pharmacy (*Chemie und Pharmacevtik*) [15]. The third professor mentioned was to lecture on the main disciplines of hygiene and forensic medicine, which were collected under the name of state medicine [5].

The new statutes did not bring about any changes in the names of the five ancillary institutions that the Faculty of Medicine was meant to have. In supervision of their work, some changes were introduced that were caused by the new division of subjects between the ordinary professors.

The new statutes provided that the ordinary professor of anatomy, physiology, surgery and midwifery, who had to lecture on four greatly different disciplines, had to supervise simultaneously three ancillary institutions: the anatomical theatre, the surgery hospital and the maternity hospital [15].

In addition to the two professors of the Faculty of Medicine who had been appointed earlier, the third was employed on 27 February

1802, i.e. a month and three weeks before the reopening of the university – Ordinary Professor of Pathology, Semiotics, Therapy and Clinic Daniel Georg Balk (1764–1826, had studied at the universities of Königsberg and Berlin) [7].

ON THE UNIVERSITY THAT REOPENED IN DORPAT (TARTU) IN APRIL 1802

The preparations for reopening the university reached their end in April 1802 when, in addition to the first professors employed, the first students were enrolled from 5 April. On 21–22 April, the University of Dorpat (Tartu) was festively re-opened after a long interval of 102 years and 9 months.

On 1 May, work began in the four faculties of the only German-language university of the Russian Empire with 9 professors and 19 students [17]. The Faculty of Medicine started with three ordinary professors (M. E. Styx, E. H. G. Arzt, D. G. Balk) instead of four; all of them were engaged in teaching during the first semester, which lasted for two months [1]. The post of the professor of anatomy, physiology, surgery and midwifery remained vacant. The number of students at the Faculty of Medicine during the reopening of the university was a modest three; by the end of the first semester, it grew to six [4].

In the first years after the reopening, the university suffered not only from a shortage of lecturers who would have met the requirements but also from lack of suitable rooms. Classes were held in private houses and flats given to the university for use or rented for that purpose. Therefore, the construction of new, up-to-date buildings became topical, as the number of students was growing fast. First, the construction of the Anatomical Theatre (the central part of the present Old Anatomical Theatre – the rotunda covered by a dome) started in June 1803 on the southwestern side of Toome Hill [17].

At that time, there were no stable obligatory curricula at the university. The duration of studies had not been fixed, although at the Faculty of Medicine it was initially two years. Checking of knowledge acquired by the students was superficial and unsystematic. Along with obligatory lectures, professors gave students individual tuition and rarely supervised some practical work [17]. Thus, a number of problems concerning the organization of studies had to be solved.

The faculties of theology and law made the Imperial University of Dorpat different from other Russian universities of the early 19th

century. At that time, the training of clerics in the Russian Empire was only the duty of seminaries administered by the church. Independent faculties of law were formed in other universities only after the adoption of the common statutes of universities in 1835; until then juridical disciplines were taught at the faculties of philosophy.

These existence of these two faculties explains why the Baltic provinces needed their own university – it had to train Protestant clerics and teach local law, which was not done in Jena, Göttingen or elsewhere [8].

After good contact had been established between Vice-rector, later repeatedly Rector of the university Georg Friedrich Parrot (1767–1852, studied at the University of Stuttgart) and Emperor Alexander I, the latter, on 12 December 1802, officially took the university under his special protection. Although the university was fully subjected to the Ministry of Education, it retained extensive internal autonomy. Such patronage by the emperor led to a multiple increase in state lands allotted to the university and allocation of funds from the State Treasury for annual expenses – for construction of university buildings and carrying out research [17].

STRUCTURE OF THE FACULTY OF MEDICINE IN THE UNIVERSITY STATUTES OF 1803

In order to improve the structure and administration of the university, its next statutes were confirmed on 15 September 1803. The curators were excluded from their drafting [17] The new statutes provided four ordinary and two extraordinary professors for the Faculty of Medicine.

The disciplines taught were divided between the ordinary professors as follows: (1) anatomy, physiology and forensic medicine (*Anatomie, Physiologie und gerichtliche Arzney-Wissenschaft*); (2) pathology, semiotics, therapy and clinic (*Pathologie, Semiotik, Therapie und Klinik*); (3) dietetics, *materia medica*, history of medicine and medical literature (*Diätetik, materia medica, Geschichte der Medicin und medicinischen Literatur*); (4) surgery and midwifery (*Chirurgie und Hebammenkunst*). In addition, there was to be a post for an extraordinary professor of veterinary art (*Thier-Arzneykunst*). Under the statutes of 1803, the prosector of the anatomical theatre got the rights of an extraordinary professor [14]. Thus, the teaching staff provided by these statutes was quite numerous for the time. In total, the statutes provided for the posts of 29 professors and 12 lecturers. Compared to the 1804 statutes of Moscow University, which provided for 28 professorships, the University of Dorpat (Tartu) could be very satisfied; theology even got more professorships (four) than in Moscow (two) [17].

The 1803 statutes introduced some changes in the ancillary institutions of the Faculty of Medicine. As the teaching of chemistry and pharmacy was transferred to the Faculty of Philosophy, the chemistry laboratory was included among the ancillary institutions of that faculty. The Faculty of Medicine, however, was to have a collection of anatomic specimens (*Sammlung anatomischer Präparate*) and a study room of pathology (*pathologisches Cabinet*). The former was to be supervised by the professor of anatomy, of the latter – by the professor of pathology. The collection of anatomical specimens was to be accommodated in the anatomical theatre; the location of the pathology study room was not specified. The clinical institute and the surgical hospital envisaged in the plan of foundation of the university were in the 1803 statutes renamed the medical clinical institute (*medicinisch-klinisches Institut*) and surgical clinical institute (*chirurgisch-klinisches Institut*). According to the statutes, these ancillary institutions with their new names and the maternity hospital and the anatomical theatre were to be headed by ordinary professors who taught respective subjects. Two ancillary institutions – the surgical clinical institute and the maternity hospital – were thus to be in charge of the ordinary professor of surgery and midwifery [14].

In 1804, the extraordinary professor of veterinary art obtained the status of an ordinary professor. At the request of the University Council, he also was to teach midwifery that was taken away from the ordinary professor of surgery and midwifery [17]. These changes meant that the ordinary professor of midwifery and veterinary art had to be in charge of the maternity hospital and the ordinary professor of surgery – of the surgical clinical institute.

The next statutes of the university, which introduced small changes and additions to the 1803 statutes, were confirmed in June 1820. They became the legal basis for the activities of the university in the following period (1820–1865) [17].

THE STRUCTURE OF THE FACULTY OF MEDICINE IN THE LISTS OF COURSES OF THE INITIAL YEARS OF THE REOPENED UNIVERSITY

Next, we should regard the lists of courses of the initial years of the university, in order to see how they present the professors' titles of office and the names and numbers of ancillary institutions. In addition, we attempt to find an answer to the question about the ordinary professors who worked at the Faculty of Medicine during the first semester.

The list of courses for the first semester of 1802 gives the staff of the Faculty of Medicine as follows: M. E. Styx – Professor of State and Popular Medicine (*Professor der Staats- und populairen Arzney-Kunde*), D. G. Balk – Professor of Pathology and Therapy (*Professor der Pathologie und Therapie*) and E. H. Arzt – Professor of Chemistry (*Professor der Chemie*) [1].

In the autumn semester of the same year: Dr. Styx – Professor of State and Popular Medicine as well as Dietetics (*Professor der Staats- und populären Arzneykunde, wie auch der Diätetik*); Dr. Balk – Professor of Pathology, Therapy and Clinic (*Professor der Pathologie, Therapie und Klinik*) [20].

Here it should be mentioned that, according to the valid university statutes, the professors presented in these lists of courses should have been referred to as ordinary professors. Their titles are also considerably shorter than provided by the university statutes of 1802. Thus, in the spring term, the professors' titles twice include only two subjects instead of four, and once instead of two subjects – one. In the autumn term, however, twice only three subjects out of four are listed.

The list of courses for the autumn term of 1803 included the following professors of the Faculty of Medicine: Dr. M. E. Styx – Ordinary Professor of Dietetics, *Materia Medica*, History of Medicine and Medical Literature (*ordentlicher Professor der Diätetik, Materia medica, Geschichte der Medicin und der medicinischer Literatur*); Dr. D. G. Balk – Ordinary Professor of Pathology, Semiotics, Therapy and Clinic (*ordentlicher Professor der Pathologie, Semiotik, Therapie und Klinik*); Dr. H. F. Isenflamm (1771–1825, studied at the University of Erlangen) – Ordinary Professor of Anatomy, Physiology and Forensic Medicine (*ordentlicher Professor der Anatomie, Physiologie und gerichtlichen Arzneykunde*). Earlier he had been, from 20 March 1803, ordinary professor of anatomy, physiology, surgery and midwifery according to the 1802 statutes that were valid then [19, 7].

Michael Ehrenreich Kauzmann (1769–1816, studied at the University of Erlangen) who had been appointed Prosector of the Anatomical Theatre from 20 May 1803 became after the implementation of the 1803 statutes Extraordinary Professor and Prosector of the Anatomical Theatre (*ausserordentlicher Professor und Prosector des anatomischen Theaters*) [7, 19]. This title was used in the university list of courses when he was first mentioned among the staff of the Faculty of Medicine in the autumn term of 1803. Thus, M. E. Kauzmann can be considered the first prosector throughout the times and also the first prosector within the rights of an extraordinary professor at the Medical Faculty of Tartu University as well as at the Anatomical Theatre.

The spring semester of 1805 was the first time when the list of ancillary institutions given at the end of the list of courses included two institutions of the Faculty of Medicine: the medical hospital (*das medicinishe Krankenhaus*) and the surgical hospital (*das chirurgische Krankenhaus*). In the autumn term of the same year, these were complemented by the maternity hospital (*die Entbindungsanstalt*), the anatomical collection (*die anatomische Sammlung)* and the pathological collection (*die pathologische Sammlung*). According the 1803 statutes, the first two of them should have been called the medical clinical institute and the surgical clinical institute, the two last ones, however – the collection of anatomical specimens and the pathology study room. From the spring semester of 1809, the list of ancillary institutions published at the end of the list of courses included the general academic hospital (*das allgemeine akademische Krankenhaus*), the surgical clinic (*das chirurgische Klinikum*) and the obstetrical clinic (*das geburtshülfliche Klinikum*), which, according to the statutes, should respectively have been the medical clinical institute, the surgical clinical institute and the maternity hospital. The anatomical theatre (*das anatomische Theater*) appeared in the list of ancillary institutions for the first time as late as in the autumn semester of 1810, although it had been envisaged in the plan of founding the university and its first two statutes [21, 14]. Actually, the anatomical theatre was in operation already in 1803–1805 in a private house rented and equipped for that purpose (the present 2 Struve St.) [6] and from September 1805 in a specially constructed building on Toome Hill that is known nowadays as the Old Anatomical Theatre [17]. When the anatomical theatre appears in the list of ancillary institutions, the anatomical collection is excluded from it, but the pathological collection (*die pathologische Sammlung*) remains, although, as we already know, according to the last statutes, it should have carried the name of the pathology study room [19, 21].

Here, we might add that in 1886–1887 a new building was constructed for the Faculty of Medicine. It was meant for the institutes of physiology and pathology and received the name of the New Anatomical Theatre [17]. After its completion, Dorpat (Tartu) became a university town with two anatomical theatres – the old and the new.

The other ancillary institutions of the Faculty of Medicine – the medical clinical institute, the surgical clinical institute and the maternity hospital – started working in 1804–1806, also in rented rooms. All of them were among the first at the universities of Russia. In 1808 they were accommodated in a building on Toome Hill, which was remodelled from a former barracks, and remained there for a longer time [12]. At present the building houses the Supreme Court of the Republic of Estonia.

THE STRUCTURE OF THE FACULTY OF MEDICINE IN ITS FIRST ANNUAL REPORTS

In the annual reports of the Faculty of Medicine that can be found among the materials of the Learned Council of the University (the first of them were written for the years 1803 and 1804), the titles of professors and the names of ancillary institutions and their numbers fully correspond to the university statutes valid at that time [3].

CONCLUSION

The plan for founding the university (1779) and its first statutes (1802, 1803) provided a fixed number of professors (ordinary and extraordinary) and ancillary institutions for all the faculties, including the Faculty of Medicine, and specified their titles of office and names. Here one might ask why their inexact variants that were inconsistent with the statutes came into use, and from what time onwards these began to spread into various publications, as they have done until the present time. As the ordinary professors' titles included the names of all the obligatory subjects they lectured on, they were rather long. Some of the first professors of the Faculty of Medicine taught up to four subjects. This may be one of the reasons why the names of some of the subjects taught have been omitted in the studies dealing with the initial years of the Faculty of Medicine. For the same reason, the shortened names of ancillary institutions may have come into use.

The emergence of titles of office and names of ancillary institutions and their numbers that differed from the statutes could also have several other reasons. During a relatively short time, different statutes introduced several changes in the official structure of the Faculty of Medicine. Because of the small number of copies, the acquisition of the statutes could have been difficult even in the years after the university's reopening, and became even more difficult for later researchers.

The lists of courses for the first semesters of the university had a wider circulation, and this can be a reason why the inexact titles of professors and names of ancillary institutions were transferred from year to year and from one publication into another, and different authors amplified the misinformation in the course of time.

No lists of courses in German have been found for the spring semester of 1803, but from the autumn term of the same year, the titles of both ordinary and extraordinary professors fully correspond to the valid statutes.

The names of ancillary institutions of the Faculty of Medicine gradually appeared in the lists of courses only from the spring semester of 1805, and their names differed from those fixed in the statutes and remained so for a longer period. The anatomical theatre, which was the first among the ancillary institutions of the Faculty of Medicine to start working, was the last to appear in the list of courses – as late as in the autumn semester of 1810 – but it was the only one that was called by the name as it was fixed in the statutes.

The discrepancies between the names of other ancillary institutions in the lists of courses and in the statutes could be explained by the professors' engagement in organizational matters. They devoted their attention to renting or building the necessary rooms, and after that to finding an appropriate name for the structural unit of which they were in charge.

As the lists of courses for the first years included only the filled positions and the operative ancillary institutions, their numbers also differed from those provided by the statutes.

In addition, we might say that several researchers (historians of science) have, when discussing the history of one or another subject taught by the Faculty of Medicine, used the plan for founding of the university from 1799 or even the statutes of 1803 instead of the statutes of 1802. This is also a reason why the professors' titles of office or names or numbers of ancillary institutions differ from the actual ones.

One of the most detailed overviews of the quarter of century after the reopening of the university was compiled under the supervision of the then rector J. P. G. von Ewers. There the professors' titles of office are initially in full correspondence with the 1799 plan for founding the university and the statutes of 1803, but afterwards, for some reason(s), shortened variants of titles and names of ancillary institutions differing from the statutes appear [2].

We should also mention that, while discussing the structure of the Faculty of Medicine before the reopening of the university or in the first decades after the reopening, it is incorrect to use the term 'chair' for the positions of ordinary professors. This term was introduced for all faculties only in the Russian version of the 1820 statutes of the Imperial University of Dorpat [18]. The chairs of that time differed essentially from the chair as the lowest structural unit at Soviet universities as we remember it from the recent past.

Although it was difficult to find good lecturers for Dorpat (Tartu), the university managed to invite and employ the three first ordinary professors for the Faculty of Medicine by the time of the reopening – (in temporal sequence) M. E. Styx, E. H. G. Arzt and D. G. Balk. Instead of the four professors provided by the statutes, the three of them taught all the subjects of the Faculty of Medicine. Thus, we have found an answer to the question about the names and number of the first ordinary professors of the Medical Faculty after the university's reopening in April 1802. After the unexpected death of Prof. Arzt by drowning, the number of professors fell to two, but in eight months, in March 1803, it started to grow again. In a few years, from the spring semester of 1805, all the six posts of professors provided by the university statutes (three theoretical and three practical) were filled.

The reopening of the University of Tartu and the following years of its organizational formation had fundamental historical significance. A centre of higher education and science based on the principles of the Enlightenment was established, which was to have a great future in the development of science in Russia and internationally [17].

The reopening of the University of Tartu and its initial years of operation are likely to be discussed by researchers in the future as well. Therefore, we considered it necessary to present, as an appendix to this article, the titles of the first professors and the names of the ancillary institutions of the Faculty of Medicine and their numbers in the form of tables – according to the plan for founding the university (Table 1) and its first statutes (Tables 2 and 3). In the case of filling the positions, each table provides the names of professors and the dates of their appointment.

Application of the results of the present piece of research may contribute to greater precision and consistency in the publications dealing with the structure of the Faculty of Medicine at the University of Tartu (the former Imperial University of Dorpat) and prevent the spread of existing inexactitudes and emergence of new ones in future publications dealing with the problem.

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Appendix

TITLES OF OFFICE OF THE FIRST PROFESSORS AND NAMES OF ANCILLARY INSTITUTIONS OF THE FACULTY OF MEDICINE OF THE UNIVERSITY OF TARTU (THE FORMER IMPERIAL UNIVERSITY OF DORPAT)

Table 1. Posts of ordinary professors and ancillary institutions provided for the Faculty of Medicine in the plan of founding the university (confirmed on 4 May 1799)

Title of office	Ancillary institution	Name and date of appointment
1. Ordinary Professor of Physiology and Pathology	–	–
2. Ordinary Professor of Therapy and Clinic	1. Clinical Institute	–
3. Ordinary Professor of Anatomy and Forensic Medicine	2. Anatomical Theatre	M. E. Styx 14 Dec. 1800
4. Ordinary Professor of Surgery and Midwifery	3. Surgical Hospital 4. Maternity Hospital with a school of midwives	–
5. Ordinary Professor of Botany and *Materiae Medicae* (study of medicinal remedies)	–	–
6. Ordinary Professor of Chemistry and Pharmacy	5. Chemistry Laboratory	E. H. G. Arzt 14 Dec. 1800

Table 2. Posts of ordinary professors and ancillary institutions provided for the Faculty of Medicine in the 1802 Statutes of the Imperial University of Dorpat

Title of office	Ancillary institution	Name and date of appointment
1. Ordinary Professor of Anatomy, Physiology, Surgery and Midwifery	1. Anatomical Theatre 2. Surgical Hospital 3. Maternity Hospital	H. F. Isenflamm 20 March 1803
2. Ordinary Professor of Pathology, Semiotics, Therapy and Clinic	4. Clinical Institute	D. G. Balk 27 Feb. 1802
3. Ordinary Professor of Dietetics, State and Popular Medicine and *Materiae Medicae*	–	M. E. Styx
4. Ordinary Professor of Chemistry and Pharmacy	5. Chemistry Laboratory	E. H. G. Arzt

Table 3. Posts of professors and ancillary institutions provided for the Faculty of Medicine in the 1803 Statutes of the Imperial University of Dorpat

Title of office	Ancillary institution	Name and date of appointment
a) Ordinary Professors		
1. Ordinary Professor of Anatomy, Physiology and Forensic Medicine	1. Anatomical Theatre 2. Collection of Anatomical Specimens	H. F. Isenflamm
2. Ordinary Professor of Pathology, Semiotics, Therapy and Clinic	3. Medical Clinical Institute 4. Pathology Study Room	D. G. Balk
3. Ordinary Professor of Dietetics, *Materiae Medicae*, History of Medicine and Medical Literature	–	M. E. Styx
4. Ordinary Professor of Surgery and Midwifery	5. Surgical Clinical Institute 6. Maternity Hospital	–
b) Extraordinary Professors		
1. Extraordinary Professor of Veterinary Art	–	–
2. Prosector of the Anatomical Theatre, Extraordinary Professor	–	M. E. Kauzmann 20 May 1803, initially only Prosector of the Anatomical Theatre, according to the 1802 Statutes that were valid during his appointment

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RESULTS OF THE ANTHROPOMETRIC MEASUREMENTS OF PATIENTS WITH A TRANSPLANTED KIDNEY

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ABSTRACT

At the Department of Internal Medicine (Nefrology) of Tartu University Hospital patients with transplanted kidney were measured anthropometrically (females n-16, males n-12) two times: firstly after transplanting the kidney and secondly on average after 21 months. Changes of the body build were analyzed in the period of after transplanting. Certain increase of the body fat content was detected which was evidently caused by the reduction of uremic phenomena and the improvement of appetite.

Key words: body height, body weight, anthropometric variables, chronic renal failure patients, body composition

INTRODUCTION

For the first time female and male patients with a transplanted kidney were measured in the Department of Nefrology using the anthropometric measurement methods. The results of measurement will be linked to biochemical indicators and the continent's eating habits research in the further analysis [5].

Unfortunately there are few references in literature about the results of the measurements of the body build of the patients with a transplanted kidney [3, 4]. Scientific research has shown that patients with chronic kidney insufficiency when the kidney functions decline have a danger of cardiovascular complications [1]. The risks are moderate albuminuria, the increase of the serum's creatinine, diabetic nefropathy, secondary hypertension, anemia and excess weight. The risk factors of chronic kidney insufficiency are also hypertension, hyperglucemia, hyperlipidemia and genetic disposition. With decreasing microalbunuria, proteinuria it is possible to improve the kidney function [2].

On the basic of literature more research of the population has been made stressing the need to have a more profound research of the chemical content of the body general medicine. Researchers and clinicians from many countries have been interested the measurement of body fat and adipose in the form of triglyceride [7]. Body weight increase was accompanied by increase in bone mass, muscle mass and fat mass. Dual- energy x- ray absorptiometry are used for routine in clinical care and can be used to validate other methods of measuring body fat [6]. Waist circumference and the ratio of waist circumference to hip circumference are similarly correlated with measures of risk factors for coronary heart disease. Waist and hip circumference and waist to hip ratio are important be useful in clinical practice.

MATERIAL AND METHODS

The study was carried out in 2003–2005 in Tartu University Hospital in renal transplant patients. The subjects of the study were 28 renal transplant patients: 12 males age of 42.8 ±16.1 (min 18- max 70) years and 16 females age of 47±14.9 (min 21- max 71). Anthropometrical measurements were provided by renal transplant patients in dynamic. The mean time from kidney transplantation was mean 18–21 months.

The following anthropometrical methods were assessed: body weight (kg) and height (cm), body mass index (kg/m^2), body fat mass (%) and total body mass in kg by hand- hand bioimpedance Omron BF 300 body mass monitor, 3 heights; 8 breadth and 2 depth measurements, 13 circumfrences, 11 skinfolds. All the measurements were taken by a well- trained anthropometrist.

The data were processed using the SAS- system at the Institute of Mathematical Statistics, University of Tartu, by one of the authors of the paper, Mare Vähi MSc. Comparison of means (t-test) and correlation analysis were performed. Statistical significance was accepted ad $p<0,05$.

RESULTS

In the study there were 28 renal transplant patients (females n- 16 and males n- 12). The measurement results obtained at the beginning of research (I) were compared with the results obtained at the end of research (II). We can see that the mean weight of female patients had grown a little but not significantly (mean weight from 74.18kg to 76.57kg, p- value 0.0779). The mean height of female patients is dynamic and it decreased by 1.5 cm which can be caused by posture or habitus of female patients (mean height 164.94 cm to 163.44cm, p-value 0.0001). Upper limb length and length of spina iliaca anterior superior do not have essential changes. Mean biacromial breadth, chest breadth, waist breadth, humerus breadth, wrist breadth, femur breadth and ankle breadth do not have essential changes. In pelvis breath (p–0.0351) female patients had an insignificant change which was evidently caused by the changes in the thickness of the subcutaneous fat tissue. In chest depth and abdomen depth no significant changes were found ($p > 0.05$). In the head and neck circumference of the female patients there was an insignificant change (p–0.0289, p–0.0357). The circumferences: upper chest circumference, hip circumference, proximal thigh circumference, middle thigh circumference, upper leg circumference, lower leg circumference, arm circumference (flexed and tensed) and wrist circumference there were no significant changes. Mean arm circumference (relaxed) had essentially decreased (p–0.0288). Forearm circumference had essentially increased (p–0.0348). The mean results of measuring 11 fat folds had not changed significantly. The assessment of the fat content of the body showed one-direction significant change of increasing: mean body fat % by OMRON (33.2–34.97%, p–0.0040), mean body fat in kg by OMRON (26.42–28.51 kg, p–0.00380). In the dynamics the body mass index changed significantly 27.17–28.55 kg/m^2 (p–0.0081), which was caused by the increase of the fat content and the big age variation of the measured subjects (age 18–70).

In looking at the characteristics of men we can see that while the female patients' weight did not change significantly, then the weight of male patients increased significantly (mean 75.34–83.34kg). Already the beginning of measurements was characterized by a big variation in body weight (57.10–134.10 kg), it was also the same at the end of measurements (61.15–138.10kg). The change of the mean weight in the second (II) research was in comparison with the first (I) research statistically significant (p–0.0021). The men's height (p–0.0007) had decreased by 1.29 cm during repeated measurements. There were no essential changes in the upper limb length and the length of spina iliaca anterior superior. In breadth and depth measurements statistically significant were biacromial breadth, pelvis breadth and ankle breadth.

In connection with the increase of body weight significant increase also characterized hip circumference (mean 99.18–102.95 cm), upper leg circumference (mean 34.15–36.65cm), arm circumference (relaxed, mean 30.68–32.21; p–0.0354) and arm circumference (flexed and tensed, mean 32.53–34.61; p–0.0224). The skin measurement results showed a different tendency. Out of 11 measured folds only 5folds changed statistically significantly in the direction of increasing: chin, chest, subscapular, biceps and triceps skinfolds. In the case of the fat content of the male patients the body mass index changed significantly 24.63–27.63kg/m^2. OMRON BF 300, increased at the cost of the circumferences

In conclusion it may be said that all the patients retained a subjectively satisfactory general state of health during observation. Also, objectively no essential worsening of the kidney function was detected during the observation period. Because of the above said, we think that certain increase of the body fat content detected as a result of anthropometric measurements could be connected with the reduction of the uremic phenomena, improvement of appetite and the increase of the amount of food.

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POSSIBILITIES FOR PROGNOSING THE BODY MASS AND HEIGHT ON THE BASIS OF THE BIRTH WEIGHT, HEIGHT AND THE CIRCUMFERENCE OF THE HEAD IN THE AGE OF 0 TO 2 YEARS

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INTRODUCTION

It is each nation's and the state's task to monitor the nation's health and physical development [3, 4, 6, 7]. Anthropometric research is one of the possibilities. When assessing the children's physical development of the body, it is possible to get an overview of their state of health [1]. Many different authors consider the children's bodily development a general indicator of health [2, 8]. The authors of the present article try to prognose the body mass and the height taking into consideration the birth weight, height, the circumference of the head, also age.

MATERIAL AND METHODS

In the present article the data of the height and the body mass of children delivered timely, in normal single births in the years 1989–1997 have been used. The data were collected during 1997 in the framework of the project "Growth and growth disturbances" in cooperation with the Centre for Physical Anthropology, pediatricians and centres of family doctors [5].

The data have been collected in 18 outpatient clinics or centres of family doctors. When making the selection, the authors tried to guarantee that the sample should contain both urban and rural children, so that all the regions might have been represented. In bigger towns (Tallinn, Tartu) as many different districts as possible have been selected to include children who live in blocks of flats. To guarantee the fact that all the age groups in the district are represented, in collecting the data the principle of the doctor's service area has been used, i.e. the data have been collected in each service area. As a result of such a selection, the authors can use the data of 7,182 children (3,517 girls and 3,665 boys) containing each child's body mass, height and the circumference of the head in the age from birth to two years (included). To obtain the data, the authors have used the children's outpatient health cards which contain the result of measurements made in the process of ordinary routine work. In the present paper the authors have used all the measurements of each child made until the child became two years old (including the measurements of a two-year-old child).

When analysing the results, it is necessary to take into consideration the fact that measurements have been made by different people, consequently the correctness of measuring height is ±0.5 cm. In measuring and recording weight the correctness of ±50 g has been considered. As the database is sufficiently large, the results presented should give a truthful overview of the children's weight and height in the given period. For all the 0–2-year-old-children the age has been indicated in months and for each age the arithmetical mean and the standard deviation values have been supplied. The child's age at the time of measurement is calculated in days on the basis of which the children are grouped by age in months following the principle: the children are one month old in 15–45 days, months old 46–76 days, etc. The uneven distribution of children into age groups is caused by the fact that children are not measured and weighed after necessary time intervals.

For statistical processing of data, the program SPSS version 12.0.1 was used.

The boys' and the girls' weight and height are statistically significantly different ($p< 0.05$).

In prognosing the three methods are used:

(1) the authors estimate the weight and height of the first two years of age depending upon birth weight, height and the circumference of the head with the help of one model;
(2) the authors estimate the weight and height of the first year depending upon birth weight, height and the circumference of the head;
(3) the authors estimate the weight and height of the second year depending upon the birth weight, height and the circumerence of the head.

Respectively these are Prognosis 1, Prognosis 2 and Prognosis 3.

RESULTS AND THE DISCUSSION

The aim of the analysis is to estimate the change of height and weight according to birth data (birth weight, birth height and the birth circumference of the head) taking also into consideration the gender (boy- 0 and girl- 1) and the age in months. Another aim is to give an overview of the way how birth data influence the child's further growth (height and weight). When drawing up a model, each measurement is taken as a separate object and one child's measurements are not viewed longitudinally. Consequently, the database contains 62,775 measurements and the most important descriptive statistical aspects of measurements are given in Table 1.

Table 1. Descriptive statistics

	No	Minimal value	Maximal value	Mean	Standard deviation
Birth weight	62775	2000	5000	3507.44	473.854
Birth height	62775	40.00	60.00	50.6420	2.29116
C of head	58700	29.00	41.00	35.5455	1.44278
Height	62775	46.0	103.0	68.623	8.9412
Weight	62775	2.3	20.0	8.278	2.4940

Although the new-born children with the weight lower than 2 kg and above 5 kg were left out from the database, there were many exceptions in drawing up models and they were discarded in conformity with the values of standardized remainders which were having a bigger absolute value than 3. When presenting a model, the model's shape and the determination coefficient R^2 are given. With the purpose of making the model able to better estimate the measurements of children of different ages, the child's age (in months) and also its quadratic term have been introduced into the model because growth does not take place in a linear manner. Linear models were also drawn up but these models did not allow so exactly to estimate the child's measurements at the end of the selected age period. An example can be given of the model for estimating the weight of the second year where the determination coefficient of the linear model was 0.35 and 0.66 in the case of the model with a quadratic term which was two times bigger. In addition to models, also the graphic presentation or the so-called growth graphs with the values of medium weight and height for the two periods of age are given. When the changes in weight and height were prognosed during the first two years of life, using Prognosis 1, the result was the following model:

(1.1) Weight = –0.409 + 0.001 (Birth weight) + 0.026 (Birth height) + 0.026 (Birth C of head.) –0.421 (Gender) + 8.752 (Age) –2.247 (Age^2)
R^2=0.89

(1.2) Height = 35.321 + 0.002 (Birth weight) + 0.231 (Birth height) + 0.043 (Birth C of head.) –1.123 (Gender) + 30.535 (Age) – 7.138 (Age^2).
R^2=0.93

All the characteristic features are statistically significant ($p< 0.05$). as the birth weight is expressed in grams, an impression may be received as if it has a very small impact which is not the case. It can be seen in models if the birth weight is 100g bigger, the child is on average 100g heavier and 0.2 cm longer. Comparing the birth weight with the contribution, it is natural that the birth height has a bigger influence on height and the birth weight on weight. It is also important if the birth weight and the birth height are bigger, the further weight and height will also be bigger.

When the circumference of the head is 1cm bigger at birth, it adds 26g to the weight and 0.04 cm to the height which is not very much. Consequently, we may suppose that the children with a bigger circumference of the head are heavier than the children with a smaller circumference of the head, but the heights do not differ notably.

On average, the difference in weight of boys and girls is 421 g and the difference in height 1.12 cm while the boys are heavier and taller than girls. The quadratic term age starts decreasing the growth of weight from the 4^{th} month of life, in the case of height from the 5^{th} month of life. Figures 1 and 2 present the average prognoses of weight and height corresponding to age.

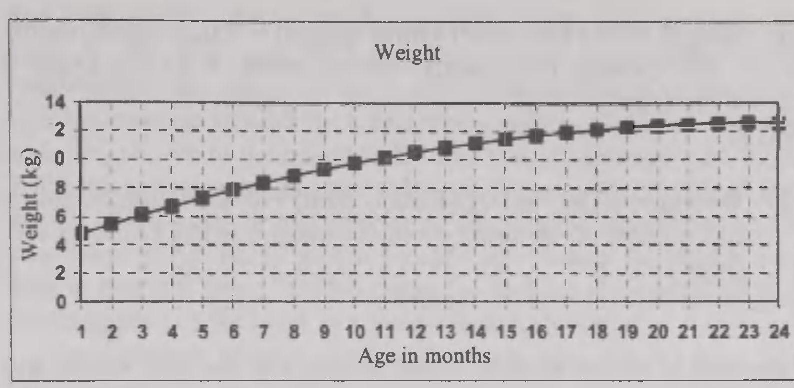

Figure 1. The mean prognosed value of weight in the first two years.

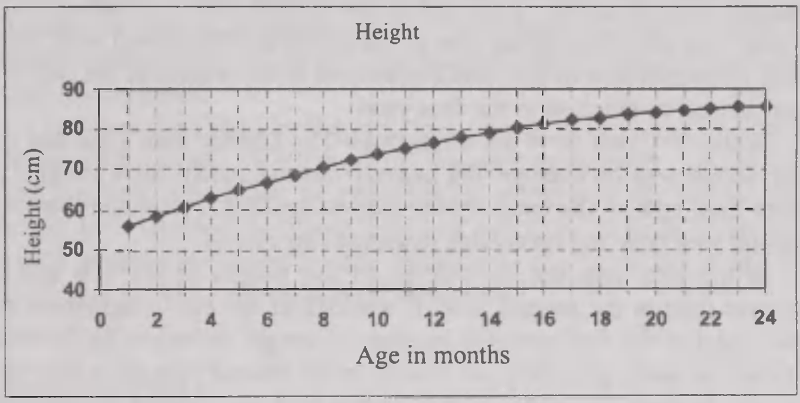

Figure 2. The mean prognosed value of height in the first two years.

Now we shall investigate the first and the second year of life separately to see whether the changes of weight and height are different (Prognosis 2 and Prognosis 3). In the models of the first year there were 48,951 data, in the second year 3,415 but the data for the second year, however, are sufficient. One of the reasons for the scarcity of data is irregular measurement of small children by the family doctor. In the second year of age there was no obligation to visit the family doctor each month and consequently children were measured less.

A model with the same arguments was drawn up separately for the first and the second year.
Models for weight:

(2.1) Weight = –0.742 + 0.001 (Birth weight) + 0.025 (Birth height) + 0.022 (Birth C of head) –0.41 (Gender) + 11.475 (Age) – 4.755 (Age^2)
R^2=0.937

(2.2) Weight = 0.336 + 0.001 (Birth weight) + 0.037 (Birth height) + 0.024 (Birth C of head) –0.46 (Gender) + 6.169 (Age) –1.091 (Age^2)
R^2=0.69

In the case of weight models, it can be seen that the birth weight and the birth height contribute to the growth in the same way in both years – 100g bigger birth weight gives 100g and 1cm longer height gives on average 25g in the first year and in the second year on average 37g which does not differ in the case of the model for the second year. The birth circumference of the head contributes to the weight in the second year almost as much as in the first year.

In the first year boys are on average 41g heavier than girls and in the second year on average 46g heavier. Consequently, boys weigh 5g more than girls in the second year than in the first. The model for the second year does not reveal this difference so clearly.

In the first year the slow-down of the weight increase is much quicker than in the second year. If we look at the age components in the model of the first year, the increase of weight decreases by the end of the first year up to 100g per month, in the second year up to 40g per month. It gives us evidence that in the first six months of life the increase of weight is intensive but slows down in the 7^{th}–12^{th} month and in the second year the increase slows evenly down even more. Consequently, if we prognosed the child's weight with the model of the second year, we would underestimate the child's weight in the first year and would overestimate it in the second

The models for height are the following:
(2.3) Height = 33.57 + 0.002 (Birth weight) + 0.236 (Birth height) + 0.032 (Birth C of head) – 1.157 (Gender) + 39.571 (Age) – 15.614 (Age^2)
R^2=0.96
(2.4) Height = 41.004 + 0.001 (Birth weight) + 0.192 (Birth height) + 0.051 (Birth C of head) – 0.954 (Gender) + 23.504 (Age) – 3.846 (Age^2)
R^2=0.663

The birth weight adds to the height of the child, who weighed 100g more in the first year, 0.2 cm and in the second year 0.1cm, consequently the impact of the birth weight on height in the second year has become smaller by a half. Each additional centimeter of the birth height adds to the height in the first year on average 0.24 cm and in the second year on average 0.19 cm. It can also be seen that the impact of the birth height decreases. The birth circumference of the head adds to the height in the second year almost more than a half than in the first year, but the change of height, depending upon the circumference of the head, is not especially noticeable.

The difference between the height of boys and girls is bigger in the first year than in the second which is different what happens in the case of weight. It may only mean that the boys gain more weight than height in the second year. In the case of the girls it is opposite: the increase in weight is mostly similar with boys but the increase of height is bigger than in boys in the second year. In spite of that boys are 0.95 cm taller.

The described analysis the fact, well known in medicine, that birth data are important. On the basis of the present research, we can say that the best results can be obtained in prognosing the weight and height of a small child in the first two years of life with the model which is designed on birth data considering the prognosis either for the first or the second year weight or height.

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REGULATION OF ACTIVE AND PASSIVE MOLECULAR TRANSPORT IN THE TESTIS

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ABSTRACT

Male infertility and non-barrier contraception remain intractable problems. In addition, a rising incidence of testicular cancer is a cause for concern. Approaches to each of these problems will require a basic understanding of the cellular and molecular biology of the testis. Answers to all of these problems may be hidden in the complex cellular and molecular interactions that take place in the testis and, in particular, in the seminiferous epithelium. In the present study, the regulation of active and passive molecular transport in the testis was studied for the explanation of the control of substance transport through the testicular endothelial barrier and the control of substance transport through the plasma membrane barrier of testicular cells. Sprague-Dawley rats, Wistar rats and BALB/c male mice were used as donors of testis tissue. Human testis tissue was obtained from three patients undergoing orchiectomy either due to prostatic cancer or hydrocele. The expression of insulin signaling cascade elements and glucose transporters in the testis was investigated by immunohisto-chemistry and Western blotting. The distribution of the F(ab)2 fragment of IgG to the testicular interstitial tissue and the luminal compartment of the seminiferous tubules was determined. The present study clearly shows that IRS-1 and IRS-2 are expressed at the protein level in the human, rat and mouse testis. IRS-3, the overexpression of which causes a decrease in the association of

IRS-1 and IRS-2 with the PI 3-kinase, and which can modulate the biological responses to insulin, was not detected in the rat testis. The present finding of immunologically detectable IRS-1 and IRS-2 in Sertoli cells demonstrates that IRS-1 or IRS-2-mediated signal transduction may be active in Sertoli cells. As well as insulin action, the effects of various cytokines on the testicular cells may also be possible through IRS-1 and IRS-2, as several cytokines, i.e. IL-2, IL-4, IL-7, IL-9, IL-13, IL-15, interferon-γ, IGF-I and the leukemia inhibitory factor use IRS-1 or IRS-2 in their signal transduction. GLUT3 was the prominent type of glucose transporters in the human, rat and mouse testis. The F(ab')2 fragment of IgG is transported to the lumen of the male reproductive tract in both the testis and the epididymis.

Key words: IRS, insulin signaling, glucose transporters, testis

INTRODUCTION

The presence of circulating molecules like e.g. glucose and immunoglobulin G, in the testis or inside the testicular cells, is not self-evident. Their access to the various compartments of the testis or into the cells is tightly controlled by active and passive mechanisms. The most important factors of the control of movements of fluids and substances into, out of and inside the testis, and into the cells include: the function of the testicular endothelial cells, the flow of the interstitial extracellular fluid, the tubular barrier-forming inter-Sertoli cell junctional complexes [6,11,12,13], and the transporter molecules in the plasma membranes of the testicular cells. A fuller understanding of the ways in which substances move around in the testis, particularly how they cross the endothelial cell layer or penetrate into the tubules and get access to the intracellular environment, will be necessary for a better knowledge about the testicular function [15]. In the past years, rapid advances in the tools available in cell and molecular biology have led to the excavation of a large number of growth factors, enzymes, transport proteins, and the receptors involved in the regulation of these factors in the testis.

Insulin plays a pivotal role in the development of the testis [20]. The insulin receptor tyrosine kinase family is required for the appearance of male gonads and thus for male sexual differentiation [9]. Insulin itself initiates a wide variety of growth and metabolic effects by binding to the insulin receptor and by activating a tyrosine kinase. Insulin signal transduction takes place through receptor-mediated tyrosine phosphorylation of Insulin Receptor Substrate (IRS) proteins [16,17]. Four members (IRS-1, IRS-2, IRS-3, IRS-4) of this family have been identified, which differ in their subcellular distribution, binding to the insulin receptor and interaction with SH2 domain proteins [16,17,8,7].

It has been found that several cytokines, e.g. IL-2, IL-4, IL-7 [4], IL-9, IL-13 [16], IL-15 [4], interferon-γ [10], IGF-I [2] or the leukemia inhibitory factor [1] use IRS-1 or IRS-2 in their signal transduction. Several cytokines are potent modulators of steroid release from the testis. Testicular cytokines and growth factors (such as IL-1, IL-6, TNF, IFN-gamma, LIF and SCF) were shown to affect both the germ cell proliferation and the Leydig and Sertoli cells functions and secretion. Cytokines and growth factors are produced by immune cells and in the interstitial and seminiferous tubular compartments by various testicular cells, including Sertoli, Leydig, peritubular cells, spermatogonia, differentiated spermatogonia and even spermatozoa. Corresponding cytokine and growth factor receptors were demonstrated on some of the testicular cells. These cytokines also control the secretion of the gonadotropins and testosterone in the testis. Under pathological conditions the levels of pro-inflammatory cytokines are increased and negatively affected spermatogenesis is present. Thus, the expression levels and the mechanisms involved in the regulation of testicular paracrine/ autocrine factors should be considered in future therapeutic strategies for male infertility [3].

In the present thesis, the regulation of active and passive molecular transport in the testis is studied for the explanation of the control of substance transport through the testicular endothelial barrier and the control of substance transport through the plasma membrane barrier of testicular cells.

To reach the aims of the present thesis, the following hypotheses are tested:

1) insulin can regulate the transport of glucose across the plasma membrane through the insulin receptor substrate pathway in the testicular cells;
2) insulin receptor substrate-mediated signal transduction to regulate glucose transport across the plasma membrane does not occur in the germ cells using lactate in their energy metabolism;

3) the transport of glucose across the plasma membrane occurs through one or several of the glucose transporters 1–4 in the testicular cells;
4) the transport of the $F(ab)_2$ fragment of IgG to the testicular interstitial tissue and the luminal compartment of the seminiferous tubules occurs;
5) the transport of the $F(ab)_2$ fragment of IgG to the interstitial tissue and the luminal compartment of the seminiferous tubules changes with age;

MATERIAL AND METHODS

Adult BALB/c male mice (n=12) and adult male Wistar rats (n=12) were used as donors of the normal testicular tissue. Human testis tissue was obtained from three patients undergoing orchiectomy either due to prostatic cancer (n=2) or hydrocele (n=1). The expression of above-mentioned genes was studied at the protein level by using immunohistochemistry and Western blotting.

Sections of 6 μm in thickness were cut in a cryostat, air-dried briefly at room temperature, fixed in cold acetone (–20°C) for 5 min and stored at –20°C. The avidin-biotin-peroxidase method was used for the expression of IRS-1 and IRS-2 and the indirect immunofluorescence method for the expression of IRS-3, GLUT 1–4, SIRP1α, PI 3-kinase and PKB.

Sprague-Dawley rats were used as experimental animals for the determination of volume distribution of the $F(ab)_2$ fragment of IgG to the testicular interstitial tissue and the luminal compartment of the seminiferous tubules. They were at 20, 30, 45 and 60 days of age (n=60).

RESULTS

Positive immunoreaction for IRS-1 and IRS-2 was found in the rat and mouse testis in Sertoli cells, peritubular myoid cells, testicular interstitial cells and testicular endothelial cells. In the human testis, positive immunoreaction for IRS-1 was found in Sertoli cells, peritubular myoid cells and macrophage-like interstitial cells, IRS-2 was not detected. Immunocytochemical analyses demonstrated that GLUT1 was expressed in the rat testis, GLUT2 in the mouse and rat testis, GLUT3 in the mouse, rat and human testis and SIRP1α in the mouse and rat testis. GLUT 3 was the prominent glucose transporter type in the human Sertoli cells, peritubular myoid cells, macrophage-like interstitial cells, testicular endothelial cells and early spermatocytes (Table 1). IRS-3, GLUT4, PKB and PI3-kinase were not detected in the testis by immunocytochemistry. IRS-1, IRS-2, GLUT1, GLUT2, GLUT3, PKB and SIRP1α genes were demonstrated by Western blotting in the testis.

The transport of the $F(ab)_2$ fragment of IgG to the testicular interstitial tissue and the luminal compartment of the seminiferous tubules occurs and changes with age.

DISCUSSION

The present finding of immunologically detectable IRS-1 in Sertoli cells, peritubular myoid cells and macrophage-like interstitial cells demonstrates that IRS-1-mediated signal transduction is active in these cells. Thus, the use of insulin in the regulation of glucose uptake by peritubular myoid and interstitial cells is possible if the insulin receptor is expressed in these cell types. As well as insulin action, the effect of various cytokines may also be possible, as several cytokines use IRS-1 in their signal transduction. However, a precondition for these interpretations is the expression of the insulin receptor, the corresponding cytokine receptors and the other components of the IRS-mediated signal transduction pathway in the cells in question.

The absence of IRS-1 and IRS-2 from the germ cells in the luminal compartment is in accordance with the use of lactate in the energy metabolism of these cells. This finding supports the hypothesis that IRS-mediated signal transduction to regulate glucose transport across the plasma membrane does not occur in the germ cells. However this finding does not finally prove it, because other insulin receptor substrates, not yet known, may exist. The absence of IRS-1 and IRS-2 from the germ cells further supports the dependence of germ cells on Sertoli cells in their energy metabolism.

Furthermore, the lack of IRS-1 and -2 from the germ cells indicates that the cytokines, using IRS-1 or IRS-2 in their signal transduction can not have a full effect on these cells, even if their receptors were expressed by them. As IRS-2 interacts also with the insulin-like growth factor I receptors [2] it is evident that the lack of IRS-2 from the germ cells will also modulate the effects of IGF I on these cells.

Table 1. Expression of the IRS1-3, GLUT1-4, PI 3-kinase, PKB and SIRP1α genes in the different types of cells in different human, rat and mouse testes by immunohistochemistry.

	Sertoli cells			Peritubular myoid cells			Germ cells			Testicular interstitial cells			Testicular blood vessels			Leydig cells		
	human	rat	mouse	human	rat	mouse	human	rat	mouse	human	rat	mouse	human	rat	mouse	human	rat	mouse
IRS-1	+	+	+	+	+	+	0	0	0	+	+	+	0	+	+	0	0	0
IRS-2	0	+	+	0	+	+	0	0	0	0	+	+	0	+	+	0	0	0
IRS-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLUT 1	0	0	0	0	+	0	0	+	0	0	+	0	0	+	0	0	0	0
GLUT 2	0	+	+	0	+	+	0	+	+	0	+	+	0	+	+	0	0	0
GLUT 3	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	0	0	0
GLUT 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PI 3-kinase	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PKB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SIRP 1 α	0	+	+	0	+	+	0	+	+	0	+	+	0	+	+	0	0	0

The high expression of IRS-1 by the human peritubular cells is well in accordance with the high energy expenditure of these contractile cells using glucose in their energy metabolism and thus dependent on the insulin action. However, it is not excluded that the high IRS-1 signal from these cells indicates cytokine effects on these cells in the intra-testicular paracrine regulatory network.

IRS-3, the overexpression of which causes a decrease in the association of IRS-1 and IRS-2 with the PI 3-kinase [18] and modulates the biological responses to insulin, was not detected in the rat testis, suggesting that the differences in signal transduction between the IRS-1- and -2-mediated pathways and the IRS-3-mediated pathway may be functionally significant in the testicular environment.

The fact that GLUT3 was the only glucose transporter presenting in the human testis suggests that in the cases of diabetes-associated disturbances of the structure of the seminiferous epithelium [14], GLUT3 could possibly be involved. In addition, it is very interesting that the early spermatocytes expressed GLUT3 at the protein level in all the studied species, as generally it is thought that these cell types do not use glucose in their metabolism but lactate produced by Sertoli cells. However, the early spermatocytes expressed also IRS-1 and -2 in the rat testis, suggesting that the components to control glucose transport across the plasma membrane are at least in part present in these cells.

GLUT3 has a high affinity for glucose [5]. 86% of testicular, 16% of ovarian, 25% of gastric and 27% of non-small cell lung carcinomas were positive for GLUT3 [19], suggesting that also those tumor cells with their origin in the testis seem to use GLUT3 in their glucose transport.

The presence of GLUT1 in the rat testis and GLUT2 in the mouse and rat testis implies that it may not be possible to use the rodent models to investigate the role of different GLUT isoforms on glucose metabolism in human testis.

That the $F(ab')_2$ fragment of IgG seems to gain access to the rete testis may make passive immunization against sperm using sperm-specific $F(ab')_2$ or Fab' fragments possible. Although the use of exogenous $F(ab')_2$ fragments might cause problems in regard to immunization against them, this is not likely if recombinant $F(ab')_2$ fragments of the same species are used. Thus, specific impairment of sperm-zona interaction or sperm motility might be possible by passive immunization of the male with sperm-specific $F(ab')_2$ or Fab' fragments of IgG. In the experimental animal work blockage of the functions of the sperm plasma membrane proteins by specific $F(ab')_2$ fragments may be possible as well.

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MATURATION OF GIRLS PASSIVELY EXPOSED TO TOBACCO SMOKE BY THEIR SMOKING PARENTS

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ABSTRACT

A questionnaire investigation of 26,008 schoolgirls from three biggest cities of Upper Silesia, Poland, found that 76% of them were passively exposed to tobacco smoke from their parents. The results of the present study indicate that cigarette smoking by mothers is associated with the earlier menarcheal age of their daughters. This effect is still present when confounding factors such as family size, the economic status of the family and parental education are controlled. When fathers smoke, this tendency persists only in families from high SES groups. Detailed analysis of the data gives some support to the hypothesis that earlier maturation of girls might also be due to their exposure to tobacco during foetal life from smoking mothers. However, this needs to be confirmed by further more specific epidemiological studies.

Key words: Passive smoking and girls maturation

INTRODUCTION

Exposure to tobacco smoke as a component of air pollution is regarded as particularly harmful to the human health. This is an especially drastic problem in Poland, where cigarette consumption figures rank among the highest in the world [19].

A number of studies show negative effects of tobacco smoke upon growth of children during fetal life and upon attained size by age of children after birth. Those have been reviewed by Walsh [25]. On the other hand, the impact of the exposure to tobacco smoke on the process of children's maturation has received far less attention.

In the following report we would like to present observations concerning the response of an important and reliable measure of maturity – the menarcheal age of girls, to different degrees of passive exposure to tobacco smoke. Our conclusions are derived from the studies of schoolgirls carried out by us in 1991, in Upper Silesia-the industrial conurbation in the southwest of Poland.

The region of Upper Silesia had been selected for the study because of an exceptionally high incidence of cigarette smoking in the population. Suffice it to say that in a country with state controlled uniformed prices, tobacco expenditure per capita in Silesia in 1991 was 18% higher than the national average [24].

Another reason was that we had at our disposal a unique set of data embracing almost the entire population of girls aged 9 to 15 living in the region's three largest cities. Thus the conclusions we are going to derive, can be justly regarded as valid for the whole population of Upper Silesia.

The ones concerning the impact of passive exposure to tobacco smoke on girls' maturation in the region were first reported by Hulcanicka et al. [13] and Kolasa et al. [16].

The study completed in 1991 repeats and extends a study of 1981 [1]. Both were questionnaire studies of the selected large groups of girls designed to estimate their average menarcheal age. They proved unequivocally that for a long time considerable differences in the rate of growth of girls were caused by social and economic factors. It was also revealed that girls in Upper Silesia mature on average later than their counterparts in other regions of Poland [1, 12].

Another characteristic of the population of Upper Silesia is higher morbidity and mortality rate (8) and a smaller average body height of children [13, 22], which indicates the poor health status of the population.

The causes underlying this situation should be sought in the specific social structure of the population typical of a highly urbanised, industrialised and densely populated region (in 1991 in Upper Silesia lived 10.4% of the Polish population in the territory which accounted for 2.1% of the area of Poland). These figures are reflected in the living standards and the lifestyle of most families.

Furthermore, the Upper Silesia area ranks high among the areas in Europe subject to the highest degree of pollution resulting from communal and industrial activities. This factor has also been proved to have an impact on the development of children. In particular, the exposure of girls to lead-containing dust and precipitation has been revealed to be a significant factor affecting the girl's menarcheal age [7].

The data concerning the health status of the population show that socio-economic conditions continue to differentiate the children's rate of development. This phenomenon has been fading for some time in certain European countries [4, 6, 18], but in a region like Upper Silesia, studies of the harmful effect of tobacco smoke have to take into account the impact of a number of socio-economic factors.

MATERIAL AND METHOD

The material collected in 1991 consisted of information about schoolgirls from grades III to VIII of all the elementary schools in the three largest towns of the region: Bytom, Katowice and Sosnowiec. The girls' parents completed 26,008 anonymous questionnaires. The numbers of girls in each yearly age group were similar, exceeding 3,000. Among other questions the questionnaire contained those searching for information about the girl's place and date of birth and about the socio-economic status of her family.

The question, essential for the present report, was the one regarding parental smoking (separately for each parent). The study of Upper Silesian girls was not initially designed to address the direct effects of smoking on the maturation of girls. As a result, we lack information about the number of cigarettes smoked or the duration of the habit of the parents. It can, nonetheless, be assumed that the error in classifying parents into smokers and non-smokers in our study is small, since daughters verified the answers given by their parents as the questionnaires were being filled. Data on cigarette smoking given by the girls themselves are also lacking. Although smoking attempts may occur at an early age, nicotine addiction in youths usually develops at the age when pubertal processes have already been set off. Thus, we do not consider this factor to be important in our material.

The social and economic status of the family, a factor exerting considerable impact on the development of children, was defined by the father's and mother's educational level, the number of children in the family, dwelling conditions and the family's financial situation. The latter was a composite measure of the financial standing of the family including data on income, housing conditions, and the fact of owning or not owning a flat/house or a car. Detailed information on the classification into subgroups is given in Table 1. The categories of variables provided a basis for the formation of selected subgroups of the girls under study for subsequent stages of analysis.

The data on the menarcheal age of girls were collected according to the *status quo* method. At the time of study girls are asked "Have you already had your first menstrual period?" and the answer yes/no is expected. This means that we have at our disposal only the data on the frequency of girls at a given age who had reached the maturation stage when menstruation occurs and those who had not had their menarche at the time when the questionnaires were carried out. The actual dates of the onset of menarche in individual girls are not available.

The girls have to be arranged in sizeable groups and only the groups can be compared. These data make it possible to calculate the average menarcheal age using Finney's probit method [19], whereby the mean values are estimated from the normal distribution function derived from the frequency count, increasing with age, of girls who answered "yes" to the menarche question.

A requirement for the estimation of the mean menarcheal age is that data are available from an age range that includes girls from an age group in which no girl has menstruated to an age when every girl has had her menarche. Our material, which comprised only girls in compulsory primary-level education of age up to 15, lacked data about older girls. Therefore, to calculate the statistical parameters it was verified by the $\chi 2$ test that the distributions are normal in the whole sample and also in each of the selected groups of girls. The hypothesis to test was that the increasing fractions of girls, who have already had their menarche at a given age, are taken from a sample, which theoretically would extend up to age 19.

Table 1. Categories of variables used in the analysis (composite categories of one or multiple variables were used in certain analyses)

Variable	Categories of variables
Father's education	1. University degree
	2. General or technical secondary education
	3. Vocational secondary education
	4. Primary education
Mother's education	1. University degree
	2. General or technical secondary education
	3. Vocational secondary education
	4. Primary education
Dwelling conditions	1. Good (x–1.1 people/room)
	2. Intermediate (1.2–2.4 people/room)
	3. Poor (2.5–x people/room)
Number of children in family	1. The girl is an only child
	2. Two children
	3. Three children
	4. Four or more children
Financial situation	1. Affluent family (>$85 per capita income per month, good housing conditions, own flat/house, car)
	2. Intermediate (other than 1 or 3)
	3. Poor (<$45 per capita per month, poor housing conditions, no car)
Lead pollution level*	1. Highly polluted area (mean annual air lead concentration >0.6mcg/m^3, mean annual lead precipitation > 200 mg/m^2)
	2. Intermediate (other than 1 or 3)
	3. Less lead polluted area (mean annual air lead concentration <0.3mcg/m^3, mean annual lead precipitation < 100 mg/m^2)
Parental tobacco smoking	1. Both parents smoke
	2. Father smokes
	3.Mother smokes
	4.Parents do not smoke

* Following the ecological approach, the girl's exposure to industry-derived precipitation of lead and the concentration of this element in the air was based on the data available at a Regional Sanitary-Epidemiological Station in Katowice.

In probit analysis, in order to eliminate factors with a known effect on the onset of puberty in girls, groups were formed including individuals from the selected categories of the set of SES variables. These were further subdividing according to the exposure to tobacco smoke. Statistical parameters such as the mean, standard deviation (SD) and standard error (Sm) were calculated for each of the subgroups. If the difference in the mean menarcheal age for two given groups exceeds Sm, this result is statistically significant at p>0,05.

RESULTS

The total percentage of girls exposed to tobacco smoke because of their smoking parent amounts to 76% of all the girls studied. The incidence of smoking among parents generally increases with the decreasing of parental education and family living standards. On the contrary, the mothers who smoke tend to occur more frequently than the in-groups of families with better educated parents (Table 2). The same relationships were observed when the status of a family was defined in relation to the number of people/room in the household. On the other hand, the number of children in the family had a little effect on the incidence of smoking among parents.

Table 2. Proportion of families where fathers have a specific level of education in the total sample and in the samples of families differently exposed to parental smoking (percentages).

Parental tobacco smoking	Father's level of education				
	University	General or technical secondary	Voca-tional	Elemen-tary	Total
Total	14	30	47	9	100%
Both parents smoke	9	28	53	10	100%
Father smokes	11	29	51	9	100%
Mother smokes	20	30	43	7	100%
Parents do not smoke	22	34	38	6	100%

A detailed comparison of the probit means of age at menarche of girls in the groups of families characterised by different contribution of the parents to tobacco smoke air pollution, was made and a similar was analysis performed on the groups characterised by different levels of parental education and housing conditions, producing the following findings:

1. In the families where both parents smoke and where only the mother smokes, the mean age at menarche of daughters is earlier than in the girls living in smoke-free family environments. In the families where only the father smokes, girls were found to mature later than the daughters of non-smoking parents do (Table 3). This is particularly evident in the families where the level of education of the parents was low (Table 4a) and also, when the number of people in the household was high (Table 5a).
2. This relationship assumes a totally different form in the families where the parents are better educated (Table 4b) or in the families, which live in good housing conditions (Table 5b). In such families the menarche occurs earlier on the whole and menarcheal age is much less diversified in relation to parental smoking. In these families father's smoking is not associated with the delayed maturation of the daughter, which actually occurs as early as in the families where only the mother smokes. In some groups differences lose some of their statistical meaning. This is due to the smallness of the group size in the population studied.
3. In the families where both parents smoke the onset of menarche for their daughters is earlier. This tendency was observed consistently in all the study subgroups (Tables 3–5).
4. Significantly, higher housing density, which may be associated with higher concentration of tobacco smoke, does not amplify the above-described relationship between parental smoking and menarcheal age of their daughters (Table 5a).

Another method we employed in our study was the multiple logistic regression analysis, which was used to study the effect of the exposure to tobacco smoke at home on the menarcheal age of girls, together with other confounding factors represented by the variables known to play a role in menarcheal age variability. (The calculations were carried out by. Prof. H. Danker-Hopfe. She used her own software customised for menarche age estimation according to the *status quo* method).

Table 3. Mean age at menarche of girls in relation to the father's and the mother' smoking habit (total sample)

Parents	M	Sm	SD	N
Do not smoke	13.12	0.03	1.07	6175
Only father smokes	13.15*	0.02	1.11	7192
Only mother smokes	13.00*	0.04	1.01	2700
Both parents smoke	13.08*	0.02	1.03	9941

*p<0.05

Table 4. Mean age at menarche of girls in relation to parental smoking and the level of education

a) parents with primary and vocational education

Parents	M	Sm	SD	N
Do not smoke	13.20	0.05	1.10	1670
Only father smokes	13.28*	0.04	1.07	2807
Only mother smokes	13.02*	0.07	1.04	934
Both parents smoke	13.13*	0.03	1.06	4493

*p<0.05

b) father with a university degree, mother with a university degree or secondary education (general or technical)

Parents	M	Sm	SD	N
Do not smoke	13.02	0.06	1.07	1292
Only father smokes	12.96	0.09	1.21	719
Only mother smokes	12.97	0.09	0.96	412
Both parents smoke	12.91*	0.08	1.08	737

*p<0.05

Table 5. Mean age at menarche of girls and parental smoking in relation to dwelling conditions

a) poor dwelling conditions (more than 2.5 persons per room)

Parents	M	Sm	SD	N
Do not smoke	13.32	0.18	1.36	242
Only father smokes	13.49*	0.11	1.06	446
Only mother smokes	13.17	0.23	1.42	133
Both parents smoke	13.29	0.08	1.02	818

P<0.05

b) good dwelling conditions (less than 1.1 persons per room)

Parents	M	Sm	SD	N
Do not smoke	13.03	0.06	1.11	1171
Only father smokes	12.97*	0.06	1.12	1039
Only mother smokes	12.94*	0.08	1.05	509
Both parents smoke	12.88*	0.05	1.01	1300

*p<0.05

The dependent variable considered in this analysis is the occurrence of menarche; the independent variables are the exact decimal age, parental smoking, the family size, father's education, housing conditions, and the financial situation of a family. The exposure of girls to lead-containing dust and precipitation in their homes was an additional variable considered in this analysis.

The basic model, in which all the dichotomic parameters are 0, provides the probability of occurrence of menarche for girls from the following categories: an affluent family, one child families, families with fathers with a university degree, the lead-polluted area of the girl's residence (relatively early maturation of girls was observed in all these groups).

The absence of exposure of the girls to tobacco smoke within the family was also marked as a 0 category.

All dummy variables, which included the remaining categories of the variables, were considered dichotomically. The probability of menarche has been estimated based on the frequencies of pre- and post-menarcheal girls for 0.1 year age intervals. Delayed maturation was seen when the girls from the families, representing other categories of the study variables than category 0, significantly more often answered "no" to the question about menarche in the questionnaire. Significance was studied using Wald' s $\chi 2$ test.

Table 6. Results of the logistic regression analysis of menarcheal age of girls in relation to the father`s or the mother's smoking and other confounding variables.

Variables	B (regression coefficient)	Wald's $\chi 2$	p
Intercept	–21.7645	5463.0509	0.0000
Age	1.7046	6036.3409	0.0000
Father: general or technical secondary education	–0.0189	0.0807	0.7764
Father: vocational or primary education	–0.1941	9.0430	0.0026
Two children in family	–0.2736	21.0378	0.0001
Three children in family	–0.4215	32.3389	0.0001
Four or more children in family	–0.5843	35.5569	0.0001
Intermediate financial situation of family	–0.0698	1.2568	0.2623
Poor family	–0.3502	12.6144	0.0004
Father smokes	–0.0398	0.7773	0.3780
Mother smokes	**0.1409**	**10.9513**	**0.0009**
Less lead-polluted area	–0.1852	6.1176	0.0134
Moderately lead polluted area	–0.1659	8.6367	0.0033

The parameters of the logistic regression analysis, carried out according to the chosen model, confirmed that the girls from the families where the parents have vocational secondary or elementary education, from the families with many children, the families with a poor financial situation, etc., but also from the families where only the father smokes, significantly more often had not had their menarche by the time of the study than the girls from the "basic" group (negative regression coefficients). This testifies to the impact of the factors, discussed above, on delaying the maturation of girls, observed in fact not only in Upper Silesia, but in the entire population of Poland (for review see 15).

On the other hand, it was shown that in the families, where only mother smoked, postmenarcheal girls occurred significantly more frequently (with the probability of chance result $p<0.01$), even if the effect of all the other social and economic or environmental variables analysed was excluded. This result is shown in Table 6, where the effect of the factor "smoking mother" on the variability of menarcheal age is visibly different then the effect of other factors (a positive regression coefficient).

There is no need to add that a similar relationship was also found for the variable "age of the girl." As it could be expected, age is the most important factor influencing the occurrence of menarche.

In other words, the results of the logistic regression analysis confirm what has been shown by the comparison of the probit means, that is: **maternal smoking is an independent factor associated with an earlier onset of menarche in their daughters**.

Relevant information about the rate of sexual maturation of girls passively exposed to tobacco smoke can be found in earlier papers by Polish researches (Table 7).

Table 7. Mean age at menarche of the girls from the Warmia and Mazury region of Poland (Popczyk 1990) and of the university students from the city of Wrocław (Kolasa 1994) in relation to parental smoking.

Parents	School students from the Warmia and Mazury region in Poland (Popczyk 1990)			University students from the city of Wrocław, (Kolasa 1997)		
	Number of daughters	M	Sm	Number of daughters	M	Sm
Do not smoke	1209	13.34	0.06	190	13.38	0.08
Father smokes	1308	13.26	0.06	136	13.20*	0.09
Mother smokes	314	12.98*	0.11	63	13.21*	0.14
Both parents smoke	910	13.12*	0.06	109	12.87*	0.12

P<0,05

This table summarises unpublished data from A. Popczyk's doctoral dissertation presented in 1990 [20]. The author used the *status quo* method to study menarcheal age and found a significantly earlier onset of puberty in the girls whose parents smoked. The difference in

menarcheal age between the girls whose parents smoked and those with non-smoking parents was 0.22 years.
These tendencies were later confirmed in a sample of university students from the city of Wrocław in a 1994 study, with menarcheal age data obtained by the retrospective method [15]. Despite a limited sample size, significant differences in menarcheal age were found, with the daughters of smoking parents having had their menarche half a year earlier than the daughters of non-smokers

DISCUSSION

The relationship between passive smoking of girls and the rate of sexual maturation which we have described has yet to be verified. In order to ascertain whether it actually reflects a direct effect of the constituents of tobacco smoke on the organism of the children or whether early maturation of the daughters of smokers is due to a special social structure of this group.

The rule, the lower the social status, the more smokers, found to be valid in Poland [21] should logically lead to the finding of a delayed menarche in the daughters of smoking parents. However, in our study such a relationship was only found for the category "only father smokes," which is positively associated with a lower education level and poorer dwelling conditions. In the study sample smoking mothers, unlike smoking fathers, are found more frequently in the families with a higher social status.

This leads to a very important conclusion that a smoking father is more often a factor that is "superimposed" on the generally poorer financial situation of the family. Smoking mothers are more often encountered in the situation where the family is "protected" by a generally higher living standard and a higher level of parental education. Against this background, the general finding of a later onset of puberty in the daughters of smoking fathers and an early onset in the daughters of smoking mothers, seen also in groups of families of a low social status, seems logical. This might be interpreted as a corollary of the specific social structure of the parents affected with the smoking habit.

However, the presence of this model is not confirmed in the groups of girls, whose both parents are smokers, because these girls always have their menarche earlier than the daughters of non-smoking parents (even though the latter come predominantly from better-off families).

Neither it is confirmed in the groups of families of the highest social status, where the "father-only" and the "mother-only" smoking patterns are related with the early onset of puberty of the daughters. The independent effect of maternal smoking on the age of menarche in girls is also corroborated by the logistic regression analysis. **All this suggests a direct accelerating effect of parental smoking on the rate of maturation of their daughters**.

In the light of what has been said above, it cannot be maintained that the social structure of smokers is the sole factor responsible for the relationships observed. On the other hand, the following interpretation seems to be valid. It is possible that tobacco smoke actually affects the mechanisms responsible for accelerating the sexual maturation process. But these effects are muffled in families representing the "worse" categories of the SES variables, where living conditions are conducive to delaying the girls' maturation and cigarette buying places an additional considerable strain on the family budget.

When the living standards of the family and the level of the parents' awareness is high, the acceleration of maturation in the daughters of smoking parents, as compared with the daughters of non-smokers, can manifest itself in an unconstrained fashion. A stronger effect of the mother, as compared to the father, is closely consistent with the above-mentioned findings concerned with blood cotinine levels measured in girls, which are higher when the mother smokes than when the father smokes, as shown before [14]. It should be stressed once more that two other Polish studies, mentioned here [15, 20], also revealed that the impact of the mother's smoking is greater in comparison with of father's smoking.

This may be due to several reasons.

First, when the smoker is the mother, the children, whom she attends to, more often, are exposed to larger amounts of tobacco smoke. Moreover, the mother's role is visibly different from the father's also because a substantial fraction of smoking mothers will also smoke during pregnancy. The relationship between earlier maturation of girls with a smoking mother could also be a consequence of the latter and not only the effect of passive exposure to tobacco smoke after birth.

The above is consistent with the growing body of papers on early postnatal growth of the children whose mothers smoked during their pregnancy. These children are characterised by more dynamic growth than the children of non-smoking mothers are. They grow faster to catch up from their initial post-natal retardation [8, 11, 23].

The general sizes of an individual, as well as the rate of growth and maturation, are to a certain extent independent characteristics. Nevertheless, one might speculate that the finding of an earlier onset of puberty of the daughters of smoking mothers is linked to their increased rate of growth immediately after birth. At present more and more researcher tend to believe that it is the conditions in which a child develops in the early period after birth that determine the age of menarche [5, 17].

The finding that the onset of puberty of girls passively exposed to tobacco smoke is not later but even earlier, observed consistently in a number of studies carried out in Poland, should show the direction of future research.

On the basis on what is reported here and also in quite a voluminous literature about the effects of tobacco smoke on body function in various periods of life, a speculative hypothesis could be presented: tobacco smoke accelerates life cycle processes in general, it shortens pregnancy and accelerates puberty, the menopause comes earlier, and earlier comes the death of the woman. These other aspects of tobacco effects however, are beyond the scope of this paper.

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ABOUT THE ESTONIAN NATURALISTS' SOCIETY AND ITS JUBILEE

Linda Kongo

The 150th anniversary of the Estonian Naturalists` Society in 2003 was the event of the year for natural scientists in Estonia. It was celebrated with a conference taking place in the assembly hall of the University of Tartu and in the conference hall of the Scientific Library of the University of Tartu. There were more than 330 participants. Colleagues from Sweden and Finland had come to congratulate the society. The President of Estonia and **representatives** of many Estonian research institutions were greeting the society. For the jubilee a voluminous monograph about the history of the society and an information brochure about the current developments of the society were published.

The past. When speaking about a scientific organisation with such a long period of activities like the Estonian Naturalists` Society (ENS), it is necessary, first of all, to cast a glance at its history. The Naturalists` Society, which was established in 1853 at first as a subsidiary of the Livonian Society of General Utility and Economiy, gained independence in 1868 and from 1878 up to World War 2 was the major organiser of research in natural sciences in Estonia with the support from the University of Tartu. In 1946 the society was affiliated to the Academy of Sciences of the Estonian S.S.R. and it is connected to the Academy of Sciences since 1998 in conformity with the association agreement.

The founders of the Naturalists` Society were 10 members of the academic staff of the University of Tartu and the Livonian Society`s president Carl Eduard von Liphardt who was also elected the first president of the Naturalists` Society. The membership of the society grew constantly involving nature-loving landlords, who were the main supporters of research, the members of the academic staff of the university and other intellectuals outside the university. Until the end of the 19th century, only men were the members of the society. The first woman-member who was the wife of Edmund Russow, the university professor of botany, was admitted only in 1898. At present the society has more than 1,500 active members and amateur researchers. The collections of amateur naturalists served as the basis for research and the respective papers were published in the journals of the society at that time.

The series of scientific publications were started immediately after the establishment of the society and made the exchange of publications possible between foreign and local institutions. The science news of the world reached local researchers. In 1933 the popular natural science journal "Estonian Nature", published in the Estonian language, began to appear in addition to the first publication in foreign languages. "Estonian Nature" as a publication of the society continued to be issued until 1941 with the purpose of publishing research and observation results of a wider circle of natural scientists, amateurs and acquainting the new books dealing with the territory of Estonia. In 1941 the journal was closed. "Estonian Nature" began to appear again in 1958. In the introduction of the first issue it is said that"... the content of the newly published journal is much more comprehensive, following the principles of Soviet materialism, and addressed to a much wider readership than the pre-war journal of the Naturalists` Society bearing the same title. The new journal was also a popular natural science journal of the Academy of Sciences of the Estonian S.S.R.

The members of the society, receiving financial support from the Livonian Society, began to research Estonian nature from different aspects. Friedrich Schmidt and Constantin Grewingk in their research determined the general principles of the geological structure of the Estonian basic rock. Carl Schmidt collected soil samples to establish their chemical composition. As a result of the research of flora, the first overviews of initially limited areas, the so-called local floras, were published. The Naturalists` Society also participated in the exact levelling of land initiated by the Livonian Society, which resulted in producing maps necessary for research activities. It was especially significant from the point of view of mapping the findings of species of flora and fauna.

At first the society was able to publish the results of zoological research of several insect groups in the form of monographs. In 1905 profound research of Estonian lakes started from the point of view of biology and fishing industry. A number of amateur researchers were involved in the research of Estonian birds` migration in spring and autumn, collecting data about the birds` nesting biology. The later founder of Estonian anthropology Juhan Aul also started his scientific career from zoological research. Before the publication of his anthropological research papers, anthropology of Estonians was very little studied and in science even wrong views of Estonians were existing. J. Aul said that the task of anthropology was to establish the changes in physical development, diversity, peculiarities and alterations of the country's population under study. The basis for anthropological research and making statistically correct conclusions is the measurement of a sufficiently big number of people which has been conducted using a unified methodology. J. Aul himself has measured more than 50,000 people. He began to study separate areas of Estonia (counties of Saaremaa, Viljandi, Pärnu and Western Estonia) and then the whole Western area as a bigger part of Estonia. His wide-scale measurement of the Estonian defence forces gives a broad overview of the anthropology of Estonians. He also studied the ethnic groups living in Estonia and in the neighbouring countries-Swedes, Latvians, Votyaks, Izhorians, Germans and Russians. With the study of the skeletons from the Stone Age, paleoanthropological research in Estonia started. J. Aul's work has been continued by his disciples who implement several new research methods.

In 1934 geobotanical mapping of Estonia started on the initiative of T. Lippmaa. A big number of the members of the society participated in this work.

After World War 2, when the Academy of Sciences of the Estonian S.S.R with its research institutes was founded, the activities of the society were somewhat falling back. The society continued nature observations and with its numerous members participated in such wide-scale labour-consuming research programmes of the University of Tartu and the Institute of Zoology and Botany like bird watch and bird count, mapping of hatching birds in Estonia for compiling a bird atlas. Geobotanic mapping, which was stopped by the war, continued. The main activities of the society were the observations of seasonal changes of nature – the phenological observations, the recordings of which form rich archives.

The society was also an initiator of organising nature protection launching the first projects for the establishment of nature reserves and drawing up lists of objects to be protected.

At present the society`s major field of activity is the participation in the monitoring programmes devoted to natural diversity (Artiodactyla, flying squirrel, bat, crayfish). The society has participated in compiling the Red Data Book of the types of habitats in Estonia, in the selection of the potential areas for Natura 2000, in making the maps of species for Natura, in the work of terminology commissions. Data have been collected for compiling the atlas of the habitats for tracheophytes. The society has organised several events (Days of naturalists, Spring Schools for teaching theoretical biology, mushroom camps, exhibitions, etc.) with the purpose of raising people`s awareness of nature protection. Excellent results have been achieved in the research carried out in cooperation with the Centre for Physical Anthropology at the University of Tartu.

The society's biggest treasure is its natural science library being unique in the Baltic countries with its 160,000 units of printed matter. Earlier the library collection was deposited in several places but at present the whole library is in the society's own building at 2, Struve Street.

During the long years of the existence of the Naturalists` Society, many new societies, dealing with particular narrow fields, have been established but there is no other association where the research potentials of all the Estonian natural scientists have been accumulated. Uniting the professional and amateur researchers` activeness and experience, the society helps preserve and develop the Estonian terminology in natural science and arouse young people's interest in the nature of their homeland, make them respect wild life.

During its constant existence within more than 150 years, the ENS has played different roles in different periods. In the first years it was practically the only natural scientists` association beside the university dealing with Estonian nature. At present the society is one of the many organisations connected with nature but, however, the society has several functions which no other institution considers a part of its major activities. Thanks to the society, a certain part of Estonian research potentials, which would otherwise remain unused, are implemented. We can mention research activities outside the framework of the state's targeted programmes, especially the nature research devoted to Estonia (overviews of the situation in Estonian nature, lists and habitat maps of the fauna and flora of Estonia, guides for identification, a part of monitoring data, phenological observations, the research of the history of natural sciences, publications promoting knowledge and awareness of nature, etc.).

The role of the society to form joint interest groups of scientists working or studying at different institutions is most significant in creating a favourable synergy and research environment. The society`s role in developing interdisciplinary activities (theoretical biology, biosemiotics, research of science history) is self-evident.

The jubilee. The festive meeting devoted to the celebrations of the 150th anniversary of the Estonian Naturalists` Society took place in the assembly hall of the University of Tartu. The welcoming speech was made by Academician Erast Parmasto, titled "Where are we from, where are we going?", giving a full overview of the development of natural science until the present day and featuring future developments. At the beginning of his speech he said that the founders of the society had been Baltic Germans and several representatives of other nations had participated in its work. He underlined the main idea of his speech stressing that science is a part of culture and the research of Estonian nature by a scientist of any nationality enriches Estonian culture

The next speaker was Academician **Hans Trass** whose presentation titled "Estonian nature – beautiful and in danger" dealt with the issues of nature protection. He mentioned that the danger is basically related to forests. We have been robbing our forests. Annual felling has grown to 12–13 million cubic meters which damages our forests, especially spruce stands. Within the last ten years forests have been segmented. Each species needs its own territory. Another danger is timber trade.

The third presentation about the long history of the ENS titled "The ENS-150" was made by the society`s president Tõnu Möls.

The society was congratulated by the President of the Republic of Estonia Arnold Rüütel, the Secretary General of the Academy of Sciences Academician Mihkel Veiderma, representatives of Finnish scientific societies: the representatives of the Biology Society Antero Nederström and Antti Pekkarinen, the representative of Societas pro fauna et flora Heinz-Rudolf Voigt. Several Estonian societies had sent their members to greet the ENS.

During the second half of the day the scientific conference continued its work in the hall of the university library. Academician **Jaan Einasto** in his presentation titled "New features of the structure of the Universe" gave an overview of the present structure of the Universe as described by contemporary science. When describing the Earth as a heavenly body, he spoke about the fall of meteorites and its impact on Earth, about the Sun as a generator of life, about other stars and their birth and death. Jaan Einasto said that the location of the systems of galaxy carries information about the creation of the structure of the Universe. He also spoke about hidden matter and its role in the development of the Universe, about the dark energy, which makes the Earth grow more rapidly. Einasto also pointed out the recent discoveries in studying background radiation, distant flashes of gamma radiation and the development of the Universe. The presentation was illustrated with a videofilm about the development of the Universe.

Ivar Puura in his presentation "Search for the earlier traces of life" summed up the search and efforts, also the success made in studying the oldest traces of life. He mentioned that among the traces of life outside the Earth the most important are the part of the crust of the Mars which have reached the Earth as meteorites. It was supposed that they contained biologically formed minerals and organic molecules. Later research revealed that these meteorites were of non-organic origin. Also, the research of primeval rocks on the Earth continues. Consequently, the search for the oldest traces for life goes on.

Toomas Tammaru in his presentation "Why is it necessary to study nature? Examples from ecology" expressed his worries about the preservation of natural culture in Estonia. He gave an example that in evolutionary ecology the comparative method is more widely used. To establish evolutionary changes, we must use the family tree of the group under study. Also, we must know the values of the features under study for many species. Such an approach demands that scientists should have an essentially wider naturalistic background than in the case of the experimental ecology, which has been dominating until now. The ENS has a central role in preserving the naturalistic traditions. The ENS should develop a constructive dialogue with the institutions of nature protection, because very strict nature protection decreases the amateur researcher`s opportunities and is thus a danger factor for our field of culture. He mentioned that the ENS should protect actively and with good reason the amateur researcher`s interests to preserve naturalistic culture.

Tiiu Kull in her presentation "Developments in Estonian botany" characterized the work and the results of research of the last ten years having a longer significance and value. In the field of research in botany it is important to publish taxonomic guides. A three-volume overview of the Baltic flora and the bibliography of Estonian plants have been published. The atlas of Estonian plants has been compiled. More profound study of some taxons is under way, etc. In the study of the vegetative cover profound inventories are made in types of association (bottomland meadows, meadows covered with scattered trees and old stands). Experimental study of the mechanisms of the coexistence of species, the diversity of association and the study of the vertical structure of association continue. In comparison with the previous decade, the trends of research today are more connected and intertwined.

Leho Tedersoo spoke about mycorrhiza in his presentation "The association of a fungus and a plant." Mycorrhiza or a fungus root is a complex organ consisting of the cells of a plant root and a fungus. It has a significant role in the mineral nutrition of some plants. Mycorrhiza is beneficial to both a plant and a fungus. Through mycorrhiza the fungus gets mainly carbohydrates from the plant, the plant gets mineral salts and water from the fungus.

Kadri Tüür in her presentation "150 years of Estonian literature on nature" defined the notion "literature on nature" which can be defined in a wider sense involving all the texts devoted to nature or in a narrower sense as essayistic texts which are based on the author`s direct impressions and the naturalistic knowledge aimed at attracting the reader`s attention to the aesthetic and ethical aspects. In a longer perspective the author`s intention is to take the reader back to such nature which inspired him or her to write this text. Texts on nature are characterized by the vision of nature as a process, not a static background to human activity. She mentioned that literature on nature is characterized by the fact that it is located in a three-directional field of influence. Literature on nature appears at the intersection of scientific literature, fiction and documentary literature. The history of the formation of Estonian literature on nature is only half a century long. At the beginning of the development, we can mention journalistic writing, calendars, school textbooks. The Estonian literature on nature is not so much characterized by featuring global problems of the environment but it shares information about local natural heritage and the respective knowledge.

The conference sessions were followed by the visit to the exhibition and the presentation of L. Kongo`s book "150 years of the activities of the Estonian Naturalists` Society".

The jubilee banquet took place in the restaurant Püssirohukelder (Gunpowder Cellar).

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DYNAMICS OF FUNCTIONAL PARAMETERS OF PEDAGOGICAL HIGHER SCHOOL STUDENTS AT THE INITIAL STAGE OF TRAINING

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ABSTRACT

The data received by the author of this work characterize features of some functional parameters of the dynamics of young people during their studies in pedagogical higher educational institution of Minsk. The significant increase of blood pressure and heart rate of male students during the period from the first to the second years of their training in the higher school is revealed. The adaptational abilities of students, estimated according to individual morpho-functional parameters, on the contrary, reveal a significant decrease. The tone of skeletal muscles, determined according to the hand dynamometric has not changed significantly, despite the considerable increase of many morphometric parameters.

This situation is regarded as alarming and demands more attention to this problem for the university administration, on the basis of which the research has been carried out.

Key words: students, morphofunctional parameters, adaptational abilities

INTRODUCTION

According to many authors [5, 6, 11 and others], for the last years the reduction of health and physical development (PD) level of young men who have entered the Belarus higher schools is observed. The number of students who are attributed to «special medical groups» – the groups of students with health deviations, – is constantly growing.

They are not capable of doing well within the usual programme of physical studies [9]. In the end of education the increase of the disease level is marked [11].

A cardiovascular pathology occupies one of the first places among the infringements of the health of young students. [3, 7]. To a great extent, it is caused by the fact that the cardiovascular system is the first to react to numerous influences of damaging environmental factors. The results of the researching of dynamics of blood circulation parameters give the possibility to appreciate the state of health of the future diploma specialist, to reveal the character of influence of training conditions on the students in a higher school.

MATERIAL AND METHODS

The research object consists of the male students who have entered the Belarusian State Pedagogical University named after M. Tank (BSPU) in 2002. The research has been carried out in 2 stages. In the first stage (September – October 2002) the morphofunctional parameters of 101 first year students were investigated. The second stage was done in September – October 2004, when the young men became the 3-rd year students. The number of the investigated young men was 102 persons, 87 persons of which were researched repeatedly, and 15 of which – for the first time.

The age of the men in the first research was 17–21 (with the prevalence of 18-year-old students). In the second year the group consisted of students of 19–23 (with the prevalence of 20-year-old students). The investigated young people studied at the faculties of history, physics, mathematics and at the faculty of natural sciences.

The anthropological programme included several tens of morphofunctional attributes, among which there were systolic (SP) and diastolic (DP) pressure, pulse rate (PR), PR after a dosed physical exercises, the indications of hand dynamometric, and also the length (L) and the weight (W) of the body, the chest circumference (CC).

Anthropometrical measurements have been made according the standard technique [8]. The metal anthropometer (manufactured in Switzerland) has been used for L measurement. W has been measured with the help of medical scales with the minimal division of 50 g, and CC – with a centimeter tape. The arterial pressure was fixed by the Korotkov's method with the help of the pneumatic tonometer and the phonendoscope. PR was defined by the palpation of arteria radialis for 0.5 minutes. The received frequency was multiplied by 2.

The exercise test (in compound of the modified Martine's test) contained 20 knee-bends for 0.5 minutes.

The hand dynamometric characterized a tone of skeletal muscles. It has been made by the dynamometer with the minimal division of 2 kg (manufactured in the USSR).

For both groups of students the values of the descriptive statistics of the above-stated parameters were calculated: mean (x), mistake of mean (m (x)), an average standard deviation (s), etc. Parameters of blood circulation system (the SP, DP and PR) were estimated according to specifications offered by A.I. Kienja and J.I. Bandazhevskiy [4]. They provide low, medial and high gradation of ratings of the attributes.

Using of the anthopometrical data the adaptational potential (AP) of an organism for each student is determined according to the formula by R.M. Baevskiy et al. [1].

AP (in balls) = 0.011 (PR) + 0.014 (SP) + 0.008 (DP) + 0.014 (A) + 0.009 (W) – 0.009 (L) – 0.27, where SP and DP are the values of systolic and diastolic pressure (in mm Hg); PR – pulse rate in 1 min; A – age (in years); W – weight of a body (kg); L – length of a body (cm).

The thresreshold value for satisfactory adapting is the level 2.1 balls, i.e. all values which are lower than this parameter speak about normal adapting; the values of AP from 2.11 up to 3.2 balls testify to stress of adaptive mechanisms; the limits of oscillations from 3.21 up to 4.3 balls are characteristic of unsatisfactory adapting; the failure of adapting comes after 4.31 balls.

The autonomic index Kerdo (AIK) and the Robinson index (RI) are also calculated.

AIK = (1 – DP / PR) * 100. This index is used for researches of connection of vegetative and cardiovascular systems parameters, as it reflects a status of the vegetative nervous system. The positive values show the prevalence of sympathetic, negative – of parasympathetic regulation of the nervous system. AIK = 0 on condition of full vegetative balance [2]. The norm values from –3 up to +3 were accepted.

RI = SP * PR / 100. The given parameter has a correlation with the consumption of oxygen by a myocardium of ventriculus sinister [10].

T-test and χ^2 criterion were applied for the calculation of the level of signification. All the calculations are carried out with the possibilities of the Microsoft Excel program.

RESULTS

The changes of the mean values of some functional parameters of the BSPU students for two years of studying are shown in Table 1. By the majority of the presented indicators the distinctions are statistically significant.

Significant growth of SP and DP – on 4.72 ($p < 0.01$) and 5.44 mm Hg ($p < 0.001$) accordingly, – displays adverse changes in the blood circulation system of the students. The mean values of the PR in rest, the PR after the exercise test, the hand dynamometric, and also the RI do not reveal significant distinctions.

At the first investigation stage the students in most cases had average ratings of SP, DP and PR parameters (respectively: 67.3%, 62.4% and 82.2%). We found a considerable number of high ratings of the arterial pressure (systolic –32.7%, diastolic –37.6%), with the absence of the lowered. Low and high gradations of PR are submitted in the group in similar shares: 9.9% and 7.9% respectively.

The third-year students show the tendency of increasing of SP, DP and PR values. The medium gradations of attributes consisted respectively: 47.1%, 33.3% and 28.4%; high – 52.9%, 66.7% and 60.8% respectively. The fraction of students with low PR values practically has not changed and is 10.8%.

The change of ratings' structure of SP, DP and PR parameters is displayed in Figures 1, 2 and 3.

For all the three indicators there is a distinct shift to the side of high ratings ($p < 0.01$). Such an increase of the percentage of persons with the high parameters of the cardiovascular system functioning testifies the growth of the influence of stressful factors on organisms of the investigated students and even the occurrence of disadaptation phenomenon by the third year of studies in higher educational institutes.

Table 1. Dynamics of the morphofunctional parameters of male students of BSPU during the first two years of studying

Parameters	2002			2004			p <
	n	x	s	n	x	s	
Height (cm)	101	178.44	6.47	102	178.98	6.52	–
Weight (kg)	100	67.96	10.46	102	72.27	12.99	0.01
Chest circumference (mm)	101	864.00	67.38	102	918.99	78.53	0.001
SP (mm Hg)	101	130.67	11.52	102	135.39	11.81	0.01
DP (mm Hg)	101	85.00	7.94	102	90.44	9.42	0.001
Pulse rate (per min)	101	73.21	12.27	102	73.59	13.18	–
Pulse rate after exercise test (per min)	101	88.50	16.41	102	92.18	14.89	–
Dynamometry, right hand (kg)	101	47.25	7.34	102	49.21	6.99	–
Dynamometry, left hand (kg)	101	44.86	7.16	102	46.94	6.89	–
AP *	100	2.30	0.27	102	2.48	0.35	0.001
AIK **	101	–19.30	22.23	102	–26.20	22.54	0.05
IR ***	101	95.60	17.70	102	99.88	21.22	–

*AP – an index of adaptational potential; ** AIK – autonomic index Kerdo; *** RI – the Robinson index.

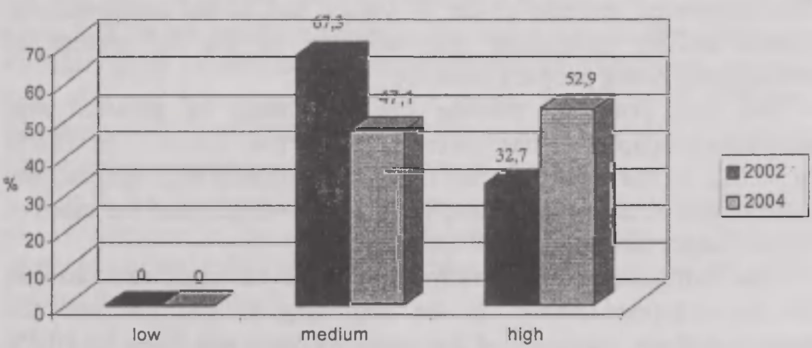

Figure 1. Dynamics of SP ratings of the BSPU students during the first two years of studies.

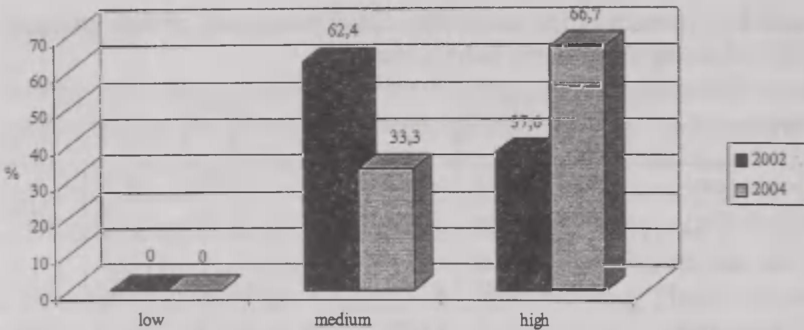

Figure 2. Dynamics of DP ratings of the BSPU students during the first two years of studies.

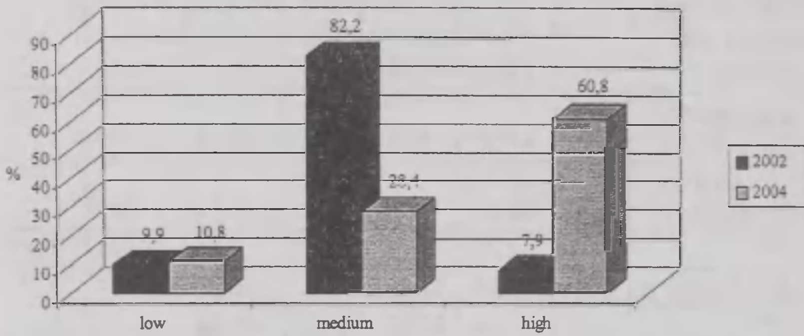

Figure 3. Dynamics of PR ratings of the BSPU students during the first two years of studies.

The discovered increase of the W values and of the cardiovascular system activity parameters was reflected on the AP change of investigated young people (Table 2).

For two years of training the percentage of persons with satisfactory adaptation has decreased more than twice – on 16.2% ($p < 0.01$). At the same time, the number of students with adaptational mechanisms stress has increased to 14.3% ($p < 0.025$) and the cases of unsatisfactory adaptation have appeared.

The distribution of AIK ratings does not reveal significant changes for the examined period. In the beginning of the first year the parasympathetic regulation of the nervous system was fixed for 80.2% of students, normotonic regulation – for 6.9%, sympathetic regulation – for 12.9% of persons. By the third year parasympathetic regulation was registered for 86.3% of young men, normotonic regulation – for 4.9%, sympathetic regulation – for 8.8%. For the overwhelming majority of students the parasympathetic regulation of the vegetative nervous system at both phases of research has prevailed.

Table 2. Dynamics of adaptational potential estimations of the BSPU students during the first two years of training

index gradation	2002	2004	p <
	N=100	N=102	
satisfactory adaptation	27.0	10.8	0.01
stress of adaptive mechanisms	73.0	87.3	0.025
unsatisfactory adaptation	—	2.0	—

DISCUSSION

Thus, the data received by us coincide with the conclusions of some scientists of Belarus and point out to the large stress of adaptational processes for the students of the pedagogical higher educational institution, both right upon entrance and in the beginning of the third year. The results of our research testify to the negative changes in the cardiovascular system activity of the BSPU students during studies in the first and the second years of studies. It is possible to explain the given fact by the peculiarity of training and a way of life of modern students. They experience constant influence of educational stresses, lack of sleep, consequences of bad habits, an irrational nutrition, frequently – lack of motion, etc. Difficult economic and ecological conditions in our republic play their negative role, too.

The facts, discovered by our researchers, speak about the necessity to pay attention to the condition of health of students in the early stages of studies and to develop the preventional program of adaptable failures for young people.

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SOME REMARKS ON PARTIAL AND SPURIOUS CORRELATIONS

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ABSTRACT

The estimation of correlation coefficients has become an easy task since comfortable computer software is available to the end that in numerous publications whole batteries of correlation coefficient matrices are being presented. However, the effects of confounding variables are not always recognized and not searched for. Hence false conclusions are drawn from otherwise important scientific studies.

This study offers a tool which allows researcher to estimate in advance those correlation coefficients which are promising candidates of being biased by a third variable. This is time sparing because only targeted coefficients need then to be recalculated. Furthermore, the tabulated data are given which allow to roughly and quickly estimate partial correlation coefficients.

Key words: partial correlations, spurious correlations, limiting conditions, tabulated figures

INTRODUCTION

Commonly, only if the entire underlying data set is available, do statistical packages (e. g. SPSS) allow the researcher to estimate partial correlation coefficients. However, their retrospective calculation from the given correlation coefficients usually requires a separate calculating step.

To disclose a correlation r_{xy} between the two variables x and y, as being biased by a common variable z, the calculation of partial correlations $r_{xy.z}$ is necessary in order to eliminate its influence. Such procedures are time consuming especially when many variables are involved and all the possible combinations need to be checked. The aim of this communication is to provide an easy to use table covering correlations r_{xz} and r_{yz} in discrete 0.1 steps (range 0.1 to 0.9) which allows the researcher to decide whether the correlation r_{xy} is probably biased or not, and only then to do the necessary exact calculations. Furthermore, an easy way to approximately estimate partial correlation coefficients is offered which only requires a simple algebraic calculator or allows to even proceed without mechanical or electronic tools. Examples from medicine and anthropology illustrate its use.

METHODS AND RESULTS

Let us assume that there are three independent mutually correlated variables x, y and z with correlation coefficients r_{xy}, r_{xz}, r_{yz} which are significantly different from zero. If x and y are suspected to be influenced by the variable z, the calculation of the partial correlation $r_{xy.z}$ is required. The underlying algorithm needs this triplet of correlation coefficients and uses the following formula:

$$r_{xy.z} = (r_{xy} - r_{xz}r_{yz})((1 - r^2_{xz})(1 - r^2_{yz}))^{-0.5} \qquad (1)$$

If all the necessary assumptions (e.g. population homogeneity, independence of variables, etc.) are met, a confounding influence by the variable z obviously can be expected if

$$r_{xy.z} < r_{xy} \qquad (2)$$

and most likely exists if

$$r_{xy.z} = 0 \qquad (3)$$

The influencing part of z is explained by the difference $d = r^2_{xy} - r^2_{xy.z}$. A large biasing effect of z will thus create a markedly large d which reaches r^2_{xy} as a maximum.

After inserting (2) into (1) and rearranging, follows

$$r_{xy} < r_{xz}r_{yz}(1 - ((1 - r^2_{xz})(1 - r^2_{yz}))^{0.5})^{-1} \qquad (4)$$

This marks the "upper" limit for r_{xy} and only for the figures which are smaller a common influence of z on variables x and y may be suspected.

Numerical solutions for r_{iz} (0.1, 0.9; step 0.1) (i = x, y) are listed in the first line of each data set in Table 1.

Table 1. Upper and lower limits for r_{xy} for any given pair of correlations r_{iz} (0.1, 0.9; step 0.1) (i = x, y); the closer r_{xy} comes to the lower figure the more likely a spurious correlation will be suspected

	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
0.1	1.00 0.01								
0.2	0.80 0.02	1.00 0.04							
0.3	0.59 0.03	0.92 0.06	1.00 0.09						
0.4	0.45 0.04	0.78 0.06	0.96 0.12	1.00 0.16					
0.5	0.36 0.05	0.66 0.10	0.86 0.15	0.97 0.20	1.00 0.25				
0.6	0.29 0.06	0.56 0.12	0.76 0.18	0.90 0.24	0.98 0.30	1.00 0.36			
0.7	0.24 0.07	0.47 0.14	0.66 0.21	0.81 0.28	0.92 0.35	0.98 0.42	1.00 0.49		
0.8	0.20 0.08	0.39 0.16	0.56 0.24	0.71 0.32	0.83 0.40	0.92 0.48	0.98 0.56	1.00 0.64	
0.9	0.16 0.09	0.31 0.18	0.46 0.27	0.60 0.36	0.72 0.45	0.83 0.54	0.92 0.63	0.98 0.72	1.00 0.81

It is noteworthy to mention, however, that if r_{xy} exceeds this "upper" limit, then the variable z acts as a suppressor variable [1] which means that by its action a true correlation between the variables x and y is obtunded and will be apparent only after partialising, thus increasing the predictive regression validity.

The "lower" margin for r_{xy} follows from (3) after inserting into (1) which gives

$$r_{xy} = r_{xz}r_{yz} \qquad (5)$$

and figures are given in the second line of Table 1. If (5) is satisfied, then $r_{xy.z}$ becomes zero and if initial conditions are not violated, z will be a strongly biasing variable.

So far it has been assumed that all the correlation coefficients are positive. In the case of inverse correlations several possibilities must be taken into account:

Equation (4) changes into (4') if either r_{xz} or r_{yz} are negative, thus

$$r_{xy} > -r_{xz}r_{yz}(1-((1-r^2_{xz})(1-r^2_{yz}))^{0.5})^{-1} \quad (4')$$

and likewise (5) into (5')

$$r_{xy} = -r_{xz}r_{yz} \quad (5')$$

The tabulated figures may be used accordingly.

For a rough estimate of the partial correlation coefficient $r_{xy.z}$ equation (1) can be transformed into a linear equation of the general form

$$r_{xy.z} = kr_{xy} - b \quad (6)$$

where $k = ((1-r^2_{xz})(1-r^2_{yz}))^{-0.5}$ (7)

and $b = r_{xz}r_{yz}((1-r^2_{xz})(1-r^2_{yz}))^{-0.5}$ (8)

Figures for k and b for r_{iz} (0.1, 0.9; step 0.1) (i = x, y) are listed in Table 2.

DISCUSSION

It must be kept in mind that all the correlation coefficients, r_{xy} as well as r_{xz} and r_{yz}, should be statistically different from zero or, in other words, their confidence intervals should not include zero. Such correlations must not be processed further. Likewise it should be remembered that e. g. for r = 0.20 already about n = 100 elements are needed to cover a 95%-confidence interval between 0.02 and 0.38. Any partial correlation coefficient must be tested for its confidence intervals or must at least be different from zero by using appropriate procedures which will not be discussed here but can be found in any basic textbook on statistics.

The following examples will explain the use of the tables.

Example 1: Based on data from the Framingham study, Florey has presented the following correlation coefficients for a female population [2]: body weight vs body mass index (BMI) (which

Table 2. Figures for k and b from equation (7) and (8) for any given r_{iz} (0.1, 0.9; step 0.1) (i = x, y) for the approximate estimation of $r_{xy.z}$

		0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
0.1	k	1.01								
	b	0.01								
0.2	k	1.03	1.04							
	b	0.02	0.04							
0.3	k	1.05	1.07	1.10						
	b	0.03	0.06	0.10						
0.4	k	1.10	1.11	1.14	1.19					
	b	0.04	0.09	0.14	0.19					
0.5	k	1.16	1.18	1.21	1.26	1.33				
	b	0.06	0.12	0.18	0.25	0.33				
0.6	k	1.26	1.28	1.31	1.36	1.44	1.56			
	b	0.08	0.15	0.24	0.33	0.43	0.56			
0.7	k	1.41	1.43	1.47	1.53	1.62	1.75	1.96		
	b	0.10	0.20	0.31	0.43	0.57	0.74	0.96		
0.8	k	1.68	1.70	1.75	1.82	1.92	2.08	2.33	2.78	
	b	0.13	0.27	0.42	0.58	0.77	1.00	1.31	1.78	
0.9	k	2.31	2.34	2.40	2.50	2.65	2.87	3.21	3.82	5.26
	b	0.21	0.42	0.65	0.90	1.19	1.55	2.02	2.75	4.26

corresponds to r_{xz} in the terminology used here): 0.90 (n = 2519); body weight vs triceps skinfold (r_{yz}): 0.47 (n = 2202); BMI vs triceps skinfold (r_{xy}): 0.46 (n = 2202).

Looking into Table 1 shows that for r_{iz} = 0.9 and 0.5 respectively, r_{xy} must be between 0.72 and 0.45 which is the case. As 0.46 comes very close to the tabulated lower margin, the partial correlation will be certainly very low. A rough calculation can be performed by using Table 2 which gives for r_{iz} = 0.9 and 0.5 respectively: $r_{xy.z} = 0.46 \cdot 2.65 - 1.19 = 0.03$. Using the original figures which are given to the second decimal place $r_{xy.z} = 0.096$ is obtained which in this case is still highly significant ($p < 0.01$). But it shows that from the assumed correlation between BMI and triceps skinfold (r^2_{xz} = 21.2%) only 0.096^2 = 0.92% are explained by the BMI, and 21.2–0.92 = 20.3% are explained by the body weight. It must rightly be questioned if such a low correlation, though statistically significant, would be of any practical relevance.

A remarkable decrease after partialising as just demonstrated can always be expected if basic assumptions are violated. In the presented case the formal or functional correlation between the body weight and the body mass index is responsible for the observed effect.

Example 2: In an attempt to find a reasonable predictor variable for the depth to the epidural space, the lower arm circumference (x) was measured and correlated with the depth to the epidural space (y) found during epidural puncture [3]. The study revealed $r_{xy} = 0.399$ (n = 700). Body weight (z) was also correlated with the other two variables: $r_{xz} = 0.685$ and $r_{yz} = 0.603$.

A quick look into Table 1 shows for $r_{iz} = 0.7$ and 0.6 respectively that r_{xy} should be within 0.70 and 0.42 respectively. r_{xy} approximates this lower margin satisfactorily. Calculating $r_{xy.z}$ from the database on hand with SPSS gave − 0.024 (p = 0.528). Calculation by using Table 2 gives − 0.04 which is in excellent conformity with the figure just mentioned.

In this case the lower arm circumference acts just as a substitute for body weight which is the sole variable which controls the insertion depth. The established correlation is a spurious one.

Time or age act as confounding variables quite often, and in anthropometric studies also weight and height, as the leading variables of body build, should always be suspected to have a strong influence on correlations. The use of the suggested procedures makes an advance testing of partial correlations easy. Its routine use is well recommended in order to not overlook interfering effects.

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THE CONNECTION BETWEEN DIETARY PATTERNS AND BODY BUILD AMONG YOUNG WOMEN

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Despite many nutritional studies, the relations between nutrition and body build are not well explored. This study is focused on students` eating behavior, as they are believed to be more exposed to risk factors and disturbed eating. In total, 759 entrants or students of the University of Tartu, aged from 17 to 23 years, were included. For the assessment of nutrition behavior a questionnaire was used, daily energy and nutrient content was calculated using 24-hours menu. The frequency of eating certain foodstuffs, daily energy intake and nutrient content were compared in specific body build groups. Anthropometric classification was developed using the standard deviation of height and weight. The relations between nutritional variables and anthropometric data were investigated by the multivariate analysis as well. In accordance with previous studies, irregularity of eating and slightly lower energy intake than recommended was confirmed in our study group. Highest differences in food consumption and nutrient content of menus in regard to body build was surprisingly found if calculated per 1 kg of body weight. An attempt to predict the energy and nutrient by body measurements was made with the result of 3–12% description of variability.

INTRODUCTION

The physical health status, physical shape (which is significantly characterized by body build), the psychological personality, nutrition habits and opportunities can determine to a great degree the life quality; coping with life and satisfaction, as well as the duration of productive life-years. The mutual connection of health variables, anthropometric measurements and nutrition patterns have been reported in many studies [1, 2, 4, 11]. Although not being precise tools for assessing the body composition, anthropometric measurements are useful indicators because of their relationships with risk factors. It is well known that the consumption of high caloried nonbalanced food is associated with the risk of fatness, and in combination with other risk factors can cause serious diseases [14]. Dieting and low food consumption is a risk for disorders caused by nutrient deficit. While studying the correlations between body build and nutrition, we have to take into consideration that eating behaviour and food consumption is part of culture and a life style.

The human body build is affected by hormonal status, energy intake, the composition of the diet, food preferences and the behaviour and other, non-nutritional factors [13].

The frequency of restrained eating amoung young people has been rising in the developed countries. A study of European students showed that the level of practice of healthy dietary habits was low. In the multivariate analysis, gender, the dieting status, and dietary health beliefs were significant predictors of healthy dietary habits [15]. Students are exposed to many additional risk factors – time shortage, living on their own, dissatisfaction with one's appearance, eating junk food, the low level of knowledge about healthy dietary habits. Even if the level of knowledge about nutrition among the student population is good, the actual behaviour is poor [8]. Unhealthy nutrition habits can lead a nonbalanced diet and further, to temporary or chronic deficit of needed nutrients. The studies of female students often show the energy intake below the recommended norms and low ingestion of nutrients [5, 9, 11, 12]. The same observations have been made by Estonian authors [6, 10].

The food intake and food preferences are influenced by cultural, social and emotional factors. In groups with lower energy intake the higher percentage of body dissatisfaction is often found. The young female classify themselves as overweight even when they really are underweight on the basis their BMI [3]. In groups with higher BMI the dissatisfaction with one`s own weight can cause the wish for dieting or hiding a part of food eaten while filling the questionnaires [8]. On the other hand, the relative disconcordance of energy intake by a higher BMI may reflect on the different need of energy and nutrients depending on metabolism.

Investigating the correlations between anthropometric parameters, energy consumption and the recommended body weight of subjects, researchers have reached the conclusion that, while studying the eating habits and the actual intake of foodstuffs, definitely the subject's BMI and the concern about their body weight should be taken into account. These factors influence essentially the answers received by questioning [9]. Emotions are strongly correlated with body build, and eating disorders may be a part of general frustration [4].

A number of authors have referred to the correlation of eating habits with anthropometric variables, although the results are often contradictory. The main anthropometric variables used in those studies are height, weight and BMI [1, 2, 4, 7, 8].

The studies of Estonian students show the same trends as in other European countries. The study conducted in 1995–1996 revealed that students eat irregularly, their choice of food is imbalanced and the nutrient content of food does not correspond to recommendations. Young women get 86% of the food energy recommended [10]. Among schoolgirls of Tartu the lower energy intake was found to be associated with a higher weight. In that case the proportions of fats, proteins, and carbohydrates in the daily food energy of girls were the same at the time, there were no differences between subjects with different body build. [6]. However, the regularities of nutrition habits and the food nutrient content in respect to body build need to be more profoundly clarified.

Therefore the main objective of this study was to find possible mutual connections between the nutrition behaviour and body build using different statistical approaches.

MATERIALS AND METHODS

The basis for the study is an empirical dataset identified on a personal level. The data included anthropometric measurements, a questionnaire on eating habits and food consumption frequency* and a 24-hour food-diary.

17–23-years-old female first- and second-year students were studied in 1996/1997.

Food Questionnaire:
The originally developed questionnaire which included the data detecting socioeconomic conditions, general eating habits and meal patterns was used. Subjects also recorded the frequencies of

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* The questionnaire and the test used in this study have not been tested for validity and reliability.

consumption main food groups. A similar questionnaire adopted for schoolchildren has been used before in other studies [6].

Dietary assessment:
was performed using a 24-hour diary; participants were instructed to choose a regular working day for filling in the food-diary.

Anthropometric investigation was performed on all the subjects by the Martin's (1928) classical method. The weight and 48 anthropometric variables were taken – 8 lenght measurements, 10 breadth and depth measurements, 18 circumferences and 12 skinfolds.

From the measured variable relative measurements were developed, the body proportion and the indexes of body composition and cross-sectional areas were used in the analysis. Relative measurements were calculated as ratios of particular measurements to the body height. In addition, body proportions were expressed in indexes and as ratios of respective body parts.

For the body composition analysis the body density, the body surface area, the relative fat content, the mean skin fold and sub-cutaneous adipose tissue weight were included. In addition, the cross-sectional areas of limbs and the trunk were used. The body density and the cross-sectional areas of body parts were calculated by formulas of Wilmore and Behnke [16].

Further, the two-dimensional analysis of anthropometric variables, the typification by standard deviation (SD) of height and weight was used. On the basis of height-weight correspondence classification five classes were formed in total: I – small, II – medium, III – big (corresponding classes) and IV – pycnics, V – leptosomes (non-corresponding classes) – Figure 1.

The statistical analysis was performed using SAS software, version 6.12 (SAS Institute Inc. 1994). Nutrient intake was determined using the Micro-Nutrica software and the food composition database. The $p<0.05$ level was selected as the criterion of statistical significance.

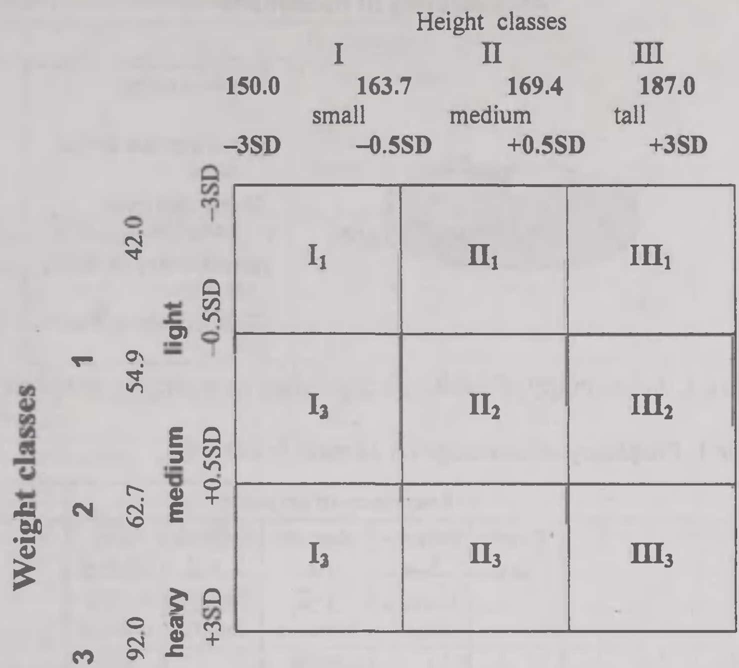

Figure 1. Bivariate classification by height and weight.

RESULTS

90.6% of the respondents considered their economic situation good or satisfactory. However, the subjective influence of the economic situation on the eating habits and restrictions on food choice is demonstrated in Figure 2.

32.8% of the respondents reported irregular eating habits. 38.2% were still eating regularly three times a day. 69.1% of participants had a hot meal at least once a day. The majority of the respondents (95.7%) had breakfeast and only less than 5% of the subjects omitted it. 11.8% ate often or always late at night before going to bed. 39.2% ate sweets or suchlike between the meals, 41.9% had snacks occasionally. 32.5% reported some kind of dyscomfort, caused by food or eating.

The frequency of consumption of the main foodgroups is presented in Table 1. Ii is remarkable how unpopular milk products are as expressed in a high percentage of women who never consume some milk products. Fish consumption is also relatively low.

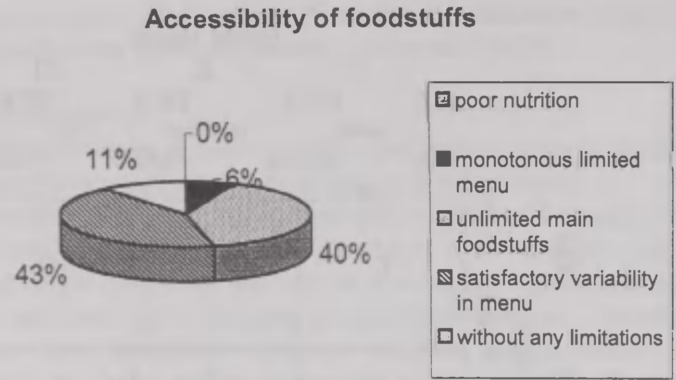

Figure 2. Accessibility of foodstuffs depending on economic situation.

Table 1. Frequency of consumption of main foodgroups.

	Frequency of consumption					
	Every day	Often – 3–4 times a week	Sometimes – 1–2 times a week	Seldom – 1–2 times a month	Very seldom – 1–2 times a year	Never
Milk and milk products						
Whole milk (3.2%)	10.1	12.3	12.8	17.5	15.6	31.7
2.5% milk	15.1	18.2	18.7	21.8	7.8	18.4
Kefir	1.6	10.1	16.9	32.4	20.4	18.5
Sour milk	0.0	2.7	4.6	15.5	22.0	55.2
Buttermilk	1.4	4.6	7.7	18.9	21.9	45.6
Joghurt	12.0	27.4	27.4	25.5	4.3	3.3
Cheese	13.0	30.6	30.6	20.9	3.0	1.9
Curds	4.6	21.0	32.2	36.3	4.4	1.4
Butter	22.7	10.9	12.3	14.2	16.7	23.2
Margerine	29.2	13.4	14.4	14.2	10.1	18.8
Cereal products						
Brown bread	55.3	16.6	13.4	9.5	1.1	4.1
White bread	34.8	21.5	19.9	15.5	4.7	3.6
Wheat bread	2.7	10.1	17.5	25.2	18.1	26.3
Muesli	4.9	9.1	16.5	25.3	20.9	23.4
Cornflakes, riceflakes, etc.	2.7	8.7	15.8	27.2	25.1	20.4
Pasta	1.9	20.5	42.5	29.6	4.9	0.5

Table 1. (Continuation)

	Frequency of consumption					
	Every day	Often – 3–4 times a week	Sometimes – 1–2 times a week	Seldom – 1–2 times a month	Very seldom – 1–2 times a year	Never
Meat and meat products						
Pork	1.1	12.5	33.4	37.0	11.4	4.6
Beef	0.3	9.3	29.7	38.7	16.9	5.2
Game	1.6	9.8	25.3	45.8	10.6	6.8
Sausage	6.1	22.0	27.8	29.8	8.0	6.3
Wieners	3.3	23.2	39.9	29.5	3.0	1.1
Smoked meat products	4.6	22.1	30.3	34.4	5.2	3.3
Fish and fish products						
Fresh-water fish	0.3	2.7	9.5	30.5	38.7	18.3
Dwarf herring, sprats	0.0	4.6	13.6	44.1	23.4	14.2
Salted fish	0.0	1.9	9.0	26.0	27.0	36.1
Smoked fish	0.0	3.3	12.3	37.1	38.1	9.3
Fish fingers	0.8	11.4	25.9	35.7	17.2	9.0
Vegetables						
Potato	30.7	54.6	13.6	1.1	0.0	0.0
Carrot	7.3	25.0	40.8	22.8	3.3	0.8
Cabbage	5.2	25.8	36.4	27.7	3.8	1.1
Rape	0.8	7.1	23.4	39.8	19.3	9.5
Beet	0.5	12.0	26.7	38.7	12.3	9.8
Pumpkin	0.5	2.7	10.6	34.8	36.1	15.2
Onion	7.9	30.6	33.1	16.9	4.9	6.6
Cucumber	17.7	28.6	25.1	22.9	4.9	0.8
Tomato	18.8	29.6	26.1	20.1	3.8	1.6
Pies	2.5	7.4	20.0	42.2	25.2	2.7
Field beans	0.5	2.2	9.8	20.2	34.1	33.2
Garden beans	0.5	3.8	14.7	29.4	33.0	18.5
Fruit						
Apple	56.0	29.6	10.9	2.2	0.8	0.5
Banana	12.1	24.1	33.7	24.4	2.7	3.0
Citrus fruits	7.7	21.6	34.7	31.7	3.8	0.5

Table 1. (Continuation)

	Frequency of consumption					
	Every day	Often – 3–4 times a week	Someti mes – 1–2 times a week	Seldom – 1–2 times a month	Very seldom – 1–2 times a year	Never
Sweets						
Chokolade	6.8	28.3	41.3	19.3	3.3	1.1
Icecream	3.5	17.1	32.3	39.4	6.3	1.4
Jam, compote	6.5	22.9	32.2	27.0	9.3	2.2
Drinks						
Tee	47.7	24.5	13.1	8.7	3.0	3.0
Coffee	30.4	8.4	9.5	10.6	7.6	33.4
Juises	3.5	15.2	41.6	33.7	6.0	0.0
Cocoa	2.5	4.6	13.1	34.4	30.9	14.5
Limonade	2.5	4.4	12.8	31.9	26.2	22.3
Cola-drinks	3.0	7.6	18.5	30.7	23.6	16.6

The distribution of energy obtained from food is presented in Figure 3. By Estonian recommendations on nutrient intake the average daily energy intake for 19–30-year-old women is 2,050 kcal (1800–2300 kcal)**. The average energy intake in the our group was 1,626 kcal which is below the norm recommended by Estonian nutrition experts. The daily energy intake of 71.4% of the subjects was below 1,800 kcal and 78.9% had energy intake below 2,000 kcal.

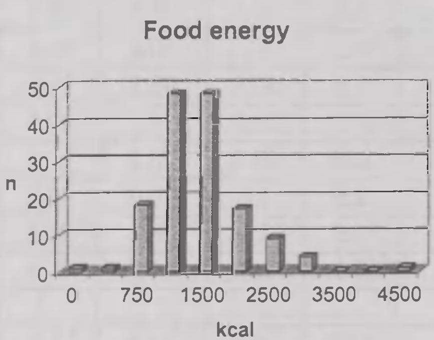

Figure 3. Food energy distribution (n=147).

** – the value has been calculated for weighing women 60kg

The nutrient content of menus is presented in Table 2. In general, the amounts of nutrients obtained from food are close to those recommended; the differences are statistically insignificant.

Table 2. Nutrient content of menus

Nutrient	Norm*	Min	Max	Mean	SD
Proteins, g	51–75	12.4	131.5	53.66	21.56
Fats, g	68	9.2	160.2	55.57	30.6
Carbohydrates, g	280	73.3	647.9	221.91	85.01
Saturated fatty acids, g		2.7	80.58	22.69	14.7
Monounsaturated fatty acids, g		2.44	50.98	17.47	10.7
Polyunsaturated fatty acids, g		1.87	55.19	10.5	6.8
% of proteins in food energy	10–15	5.16	24.95	13.66	3.29
% of fats in food energy	30–32	10.39	53.28	29.96	8.73
% of carbohydrates in food energy	52–60	35.76	78.34	56.36	9.02
% of saturated fatty acids in food energy	10–12	3.05	22.35	12.08	4.23
% of monounsaturated fatty acids in food energy	10	1.74	20.12	9.36	3.56
% of polyunsaturated fatty acids in food energy	10	1.73	18.2	5.84	2.84
Cholesterol, mg	Up to 300	22.19	638.97	181.02	139.33
Fibres, g	20–30	6.4	68.3	21.75	9.77
Retinol, µg-equiv	800	24.9	221	12	26
Vitamin D, µg	5	0.02	16.8	1.59	2.08
Vitamin E	8	2.12	39.44	7.8	4.57
Tiamin (B1), mg	1.1	0.29	2.58	0.9	0.4
Riboflavin (B2), mg	1.3	0.21	3.37	1.19	0.66
Niacin, mg-equiv	14	5.22	47.3	20.05	8.08
Pyridoksine (B6), mg	1.5–1.6	0.21	3.22	1.25	0.59
Cyanocobalamin (B12), µg	3	0.03	108.57	5.18	12.2
Folic acid (B10), µg	200	31.27	786.68	208.93	109.29
Pantothenic acid (B3), mg	4.7	0.56	10.6	3.93	1.66
Biotin (H), µg	100–200	3.1	68.04	22.28	12.56
Vitamin C, mg	60	0	385.8	65.55	61.39
Sodium, mg	1100–3300	446.1	44	21	894.94
Potassium, mg	1900	793.6	71	28	10
Calcium, mg	1000	91.8	22	677.92	388.37

Table 2. (Continuation)

Nutrient	Norm*	Min	Max	Mean	SD
Magnesium, mg	400	100.9	731.9	276.48	105.18
Phosphorus, mg	1000	288.8	27	11	433.2
Iron, mg	18	4.46	30.6	12.46	4.52
Manganese, mg	2.5–5	1.02	17.26	4.84	2.42
Zinc, mg	15	2.36	20.24	8.81	3.49
Copper, µg	2000–3000	291.24	86	12	965.54
Molybdenum, µg	150–500	11.9	226.54	73.34	30.21
Chromium, µg	50–200	3.96	53.17	19.2	8.35
Fluorine, µg	1500	117.08	947.22	407.33	159.15
Iodine, µg	150	2.94	455.16	184.88	91.31
Selenium, µg	30–60	1.57	117.36	50.48	22.03
Aluminium, µg		0.81	10.1	4.31	1.57
Energy/body weight, kcal/kg		7.09	112.04	27.77	12.71
Proteins/body weight, g/kg		0.17	2.86	0.91	0.41
Fats/body weight, g/kg		0.16	3.91	0.95	0.58
Carbohydrates/body weight, g/kg		1.08	15.95	3.79	1.76

* – by Estonian recommendations

The correlation analysis was carried out between nutrients and body measurements and indices calculated from them. The results are given in Table 3. Statistically significant correlation coefficients are marked by asterisks. The analysis revealed the measurements characterising body obesity yield statistically significant correlations with food energy and main nutrients. The length measurements were connected with nutrition mainly by the indices characterising body build.

On the basis of what has been said above, the regression analysis was carried out. An attempt was made to predict energy content and the main nutrients in daily food according to anthropometric characteristics. The significance level was placed at 0.1. The results are presented in Table 4. The stepwise regression showed that the mean skinfold was a significant independent variable, and the formulae obtained describe 3–12% of the variability of the dependent variables. The best prognosis was given to carbohydrates. Thus, although in the age bracket under discussion no essential differences were revealed between different age groups in anthropometric measurements or nutrition, the age still has a certain influence on the eating behaviour. Nutrition is influenced both by external factors and the individual peculiarities of metabolism. The latter obviously causes differences in eating habits and nutrients intake in persons with a different body build.

Table 3. Correlations between body measurements and nutrients.

	Energy	Proteins	Fats	Carbo-hydrates
Weight	–0.20*	–0.12	–0.14	–0.21*
Upper chest circumference	–0.22*	–0.09	–0.17	–0.23*
Waist circumference	–0.17	–0.07	–0.10	–0.21*
Pelvis circumference	–0.23*	–0.10	–0.17	–0.25*
Hip circumference	–0.25*	–0.14	–0.18	–0.25*
Waist skinfold	–0.25*	–0.16	–0.18	–0.27*
Suprailiac skinfold	–0.28*	–0.15	–0.22*	–0.28*
Umbilical skinfold	–0.30*	–0.22	–0.22*	–0.30*
Subscapular skinfold	–0.30*	–0.17	–0.21*	–0.32*
Thigh skinfold	–0.27*	–0.15	–0.20*	–0.28*
BMI	–0.23*	–0.15*	–0.17*	–0.23*
Rohrer index	–0.23*	–0.16*	–0.17*	–0.23*
Body surface area	–0.17*	–0.09	–0.11	–0.18
Total body fat	–0.30*	–0.17*	–0.21*	–0.32*
Mean skinfold	–0.29*	–0.17*	–0.20*	–0.31*
Mass of subcutaneus adipose tissue	–0.26*	–0.16*	–0.17*	–0.28*
Body density	0.22*	0.08	0.17*	0.23*

Table 4. Prediction of nutrient content by anthropometric variables.

Regression formula	R^2
ENERGY = 2245.444 – 50.274(mean skinfold)	0.085
PROTEINS = 66.101 – 1.029(mean skinfold)	0.03
FATS = 76.867 – 1.724(mean skinfold)	0.041
CARBOHYDRATES = 464.268 – 6.84(age) – 8.266(mean skinfold)	0.12

Table 5. Frequencies of consumption of main foodstuffs in SD-classes of height and weight

Groups of foodstuffs	1. small n=57	2. medium n=51	3. big n=55	4. pycnic n=74	5. Lepto-somic n=92	
Dairy products	28.16 ±6.62	30.23 ±7.38	28.48 ±6.66	29.27 ±6.42	30.01 ±5.43	
Grain products	23.43 ±5.48	24.50 ±4.92	24.15 ±6.44	22.83 ±5.02	24.51 ±5.53	
Meat	27.22 ±7.21	27.06 ±7.73	26.69 ±6.10	25.55 ±7.42	27.52 ±7.21	
Fish	11.05 ±5.46	13.58 ±4.95	11.35 ±4.56	11.53 ±5.26	11.19 ±5.15	
Vegetables	42.07 ±12.73	48.17 ±11.98	45.26 ±11.88	46.00 ±12.64	43.29 ±11.39	
Fruit	44.40 ±12.48	43.24 ±11.07	43.43 ±11.01	43.39 ±11.17	45.20 ±10.71	
Sweets	24.23 ±7.45	23.59 ±7.89	22.65 ±6.63	20.52 ±5.35	24.18 ±5.95	*** 1&4;4&5
Juices	11.11 ±3.87	11.14 ±3.40	9.65 ±3.75	9.73±3.21	11.20 ±3.26	
Soft drinks	6.75 ±3.23	6.62±3.53	6.76 ±2.55	6.78±3.28	6.91±3.13	
Coffee, tea	10.69 ±4.12	10.86 ±3.81	10.39 ±3.89	10.36 ±4.26	9.95±3.89	
Alcohol	5.19 ±2.90	4.90±3.35	4.75 ±2.77	5.49±2.87	5.05±3.31	

Table 6. Comparison between food energy and main nutrients content in SD-classes of height and weight

Variable	1. small n=57	2. medium n=51	3. big n=55	4. pycnic n=74	5. Lepto-somic n=92	
Energy content, kcal	1590 ±797	1752 ±707	1540 ±585	1469 ±523	1736 ±526	
Proteins, g	48.2 ±22.7	60,4 ±24,8	51.3 ±24.8	51.1 ±19.5	57.5 ±21.1	
Fats, g	54.3 ±33.7	56.0 ±27.8	51.8 ±32.2	47.2 ±27.0	63.3 ±29.1	
Carbo-hydrates, g	221.7 ±108.1	244.1 ±116.8	212.1 ±75.0	205.0 ±76.3	228.1 ±66.2	
Proteins (% of food energy)	12.69 ±2.86	14.36 ±3.55	13.53 ±3.85	14.38 ±3.84	13.62 ±3.04	
Fats (% of food energy)	29.65 ±7.70	28.95 ±9.59	29.33 ±9.73	28.15 ±8.57	32.15 ±8.15	
Carbohydrates (% of food energy)	57.67 ±7.27	56.68 ±10.95	57.14 ±10.83	57.47 ±8.99	54.23 ±7.72	
Energy/body weight, kcal/kg	32.2 ±19.6	29.7 ±12.3	21.4 ±8.2	23.7 ±10.0	30.2 ±10.0	*** 1&3
Proteins/body weight, g/kg	0.98 ±0.54	1.02 ±0.43	0.71 ±0.34	0.82 ±0.37	1.00 ±0.39	
Fats/body weight, g/kg	1.10 ±0.78	0.95 ±0.49	0.72 ±0.44	0.77 ±0.48	1.10 ±0.54	
Carbohydrates/body weight, g/kg	4.49 ±2.71	4.13 ±1.99	2.97 ±1.11	3.30 ±1.45	3.97 ±1.25	*** 1&3

The estimates of consumption of various foodstuffs by height-weight classes are presented in Table 5. The subjects assessed the frequency of consumption of each foodstuff on a 5-grade scale, and the grades given in Table 5 have been obtained by adding the grades of the respective group of foodstuffs. The frequency of consumption of main foodstuff groups did not differ in general between different height-weight classes. The class of "pycnics" differs statistically significantly from the class of "small" and "leptosomic" girls in sweets consumption.

The content of energy and the main nutrients in a 24-hour menu, compared by SD-classes of height and weight, is presented in table 6. The energy intake was low particularly in the group of pycnics. It is possible that this group underestimated their daily menu. A limitation of the present study was that factual nutrition was observed during one day only, which is probably insufficient for a more precise assessment of the daily energy intake and the nutrient content of the menu.

Still, statistically significant differences between the small and big classes were revealed when comparing the amount of energy and carbohydrates per one kilogram of body weight. In the case of relatively similar nutrition and different body build the intake of energy and nutrients per one kilogram is different.

DISCUSSION

It is obvious that all the observed variables depend on sex and the age of persons studied and they can change dynamically, depending also on ethnic and cultural background. For drawing competent conclusions there is need for fixing a relatively homogenous study group in regard to some of the named variables. In this study, young women of 17–25 years of age have been chosen. Among others the choice was based on the raised frequency of pathological restrained eating in young women.

The study of their eating habits revealed, in accordance with the earlier investigations, that a considerable number of respondents are eating irregularly, had snacks (sweets) between meals, etc. Irregular eating and having snacks between meals is in concordance with the previous studies. Still, only less than 5% of the subjects omitted breakfast. The energy content of the food remained lower than recommended, particularly in the group of pycnics. It is possible that this group underestimated their daily menu. Nonetheless, the nutrient content of the menus was more or less within the norms. A limitation of the present study was that factual nutrition was observed during one day only. A 24-hour questionnaire probably is insufficient for a more precise assessment of the daily energy intake and the nutrient content of the menu.

The comparison of eating habits of young women with different body build did not reveal any significant differences between the SD-classes. Statistically significant differences were noticed only in the consumption of sweets in the extreme classes. Namely, differences were revealed between the classes of small and pycnic subjects and pycnic and leptosomes. While comparing the daily energy intake and the consumption of main nutrients in height-weight classes, certain differences could be noticed both in the energy intake and the main nutrients. Statistically significant differences between the small and big classes were revealed when comparing the amount of energy and carbohydrates per one kilogram of body weight. This shows that, in the case of relatively similar nutrition, in the case of different body build the intake of energy and nutrients per one kilogram is different.

The correlation analysis showed a statistically significant correlation between the food energy and the main nutrients content, and the measurements and the indices characterizing body obesity. The length measurements were connected with nutrition mainly by the indices characterizing body build. While predicting the consumption of nutrients by body measurements, the significant arguments were skin folds and the age which described up to 12% of the dispersion of energy and the main nutrients` amount. Thus, although in the age bracket under discussion no essential differences were revealed between different age groups in anthropometric measurements or nutrition, the age still has a certain influence on the eating behavior. Nutrition is influenced by both external factors and the individual peculiarities on metabolism. The latter obviously causes differences in the eating habits and the nutrient intake in persons with different body build.

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ANALYSIS OF THE PHYSICAL ACTIVITIES AND HEALTH-RELATED BEHAVIOURS OF THE CADETS OF THE NATIONAL DEFENCE ACADEMY OF LATVIA

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ABSTRACT

Physical activities occupy a special place in human life. Nowadays scientific and technical development have limited people`s time for individual sports activities. Physical endurance is very important for people who want to connect their lives with the army. The officer`s profession is the one which demands that a person should be physically fit. The purpose of our research was to analyse and evaluate the level of physical activity the cadets of NDA. The respondent group includes 54 persons. We distributed a questionnaire and after collecting responses evaluated the data of physical activity. There are 20 positions in the questionnaire. We kept the score and divided all the respondents into four groups according their physical activity level before their studies at the NDA: a high level, a good level, a moderate level, and a low level.

The data of the questionnaire show that 31.5% of the cadets had a high level of physical activity before service, 67.5% of cadets had a good and a moderate level of physical activity, 10.1% of cadets had a low level of physical activity in civilian life before training at the NDA. The questionnaire included the position about harmful habits – smoking and an alcohol related problem.

The individuals who decide to connect their lives with a military speciality must be active in sport. The evaluation of the physical activity level encourages respondents to adopt an active health-related behaviour.

Key words: physical activity, fitness, health-related behaviour, cadets.

INTRODUCTION

Physical activities and health-related behaviour are important for everyone to keep oneself physically fit and mentally healthy. It is very important for the choice of the future professional career. The individual who decides to connect his life with the Army should take into consideration the fact that during military service the individual is exposed to various physical and mental overload. Successful fulfilment of military tasks depends on the individual`s skills and physical endurance [1, 7, 8].

Physical preparedness and physical endurance are developed during a long time thanks to permanent physical activities. One of the major benefits of regular physical activity is improving the heart, the lung and the muscle function, also metabolic processes [2, 3]. The last research of public health indicated that an individual spends less time for physical activities than in the previous period [4, 5, 6]. The rate of some diseases that are connected with physical inactivity, such as heart attack, heart failure stroke, obesity, diabetes, bone diseases increase. The criteria of public health become lower. The questionnaire of young people (students) has shown that the level of physical activity during the examination session time was only 39–46% of the physical activity level during the vocation period. The physical activity level at the time of study during the semester constituted 56–65% of the physical activity level at the vocation time. Students spend 80% of their time during the year of studies in the state of physical inactivity. Therefore, there is no surprise that many young people have heart diseases, bone and joint diseases. Obesity has become a problem of the young people.

MATERIAL AND METHODS

An individual starts his studies at the NDA after graduation from a civilian higher school with his Master`s or Bachelor`s degree at the age of 22–24. We decided to determine and analyse the level of physical activity before the studies at the NDA for cadets. We prepared a questionnaire. The data were evaluated in points, the definite number of points showed the corresponding level of physical activity (low, moderate, good, high). The questionnaire was given to 54 cadets.

RESULTS

Usually an individual begins his morning with morning exercises which stimulate, activate and prepare him for different kinds of activities. We have put the question about the attitude to morning exercises. In 57.4% of the cases we have received a positive answer- yes- made morning exercise, but 1/3 (29.6%) of the respondents have given a negative answer, 12.9% of the cadets made morning exercises (before their studies at the NDA) irregularly.

The next question was about using a lift, 70.4% of the cadets prefer to go upstairs and downstairs on foot. But 14.8% use the lift when it is possible. During the climb all the muscle groups are involved in motion, the heart and the respiratory system are activated. The stepping is a natural simple motion and it is recommended to individuals with physical inactivity.

A question about going to work and back home was included. Going on foot was chosen by about 60% of respondents, but 1/5 rejected such way of physical activity and referred to going by any form of transport.

One of the most important kinds of physical activity is sport exercises during the week in the period of free time and during the weekend. We get information about the cadet's attitude to sport exercises, 64.8% of cadets go in for sport during the whole week at their free time, 29.6% of cadets go in for sports irregularly but 4.7% do not pay any attention to sports, 29.6% of cadets spent their weekend time in sport activities, 35.2% of cadets go in for sports irregularly and 35.2% of cadets do nothing connected to physical activities in the weekend (Figure.1).

Some harmful factors have an influence upon individual health – smoking, alcohol use, regular meal times, and sleeping management.

The cadets's attitude to smoking was the following: 51.8% of cadets were non-smokers, 24.1% of cadets were irregular smokers, but 24.1% of cadets were smokers

The analysis of the questionnaire data concerning alcohol use were the following: refrain from alcohol is typical of 18.5% of cadets. 72.2% of cadets use alcohol irregularly, 5.5% of cadets use alcohol regularly.

In the questionnaire we included some questions about mealtimes. 80% of cadets have regular meals. Sleeping management was the following: 64.8% of cadets have the duration of sleep about 6 to 8 hrs, 31.5% of cadets have irregular sleeping time.

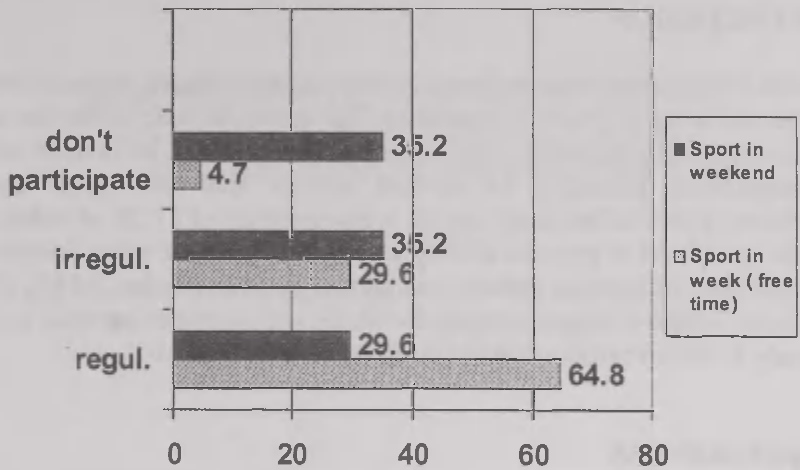

Figure 1. Respondents' division (%) according their attitude to sports during the whole (free time) and in the weekend

The analysis of the questionnaire data allows us to divide all the respondents into four groups according their physical activity level (low, moderate, good and high). 10% of cadets form the group with the low level of physical activity, the moderate level of physical activity characterizes 27.7% of cadets, the good level of physical activity is shown by 29.6% of respondent cadets and the high level of physical activity before studies at the NDA is characteristic of 31.5% of cadets (Fig.2).

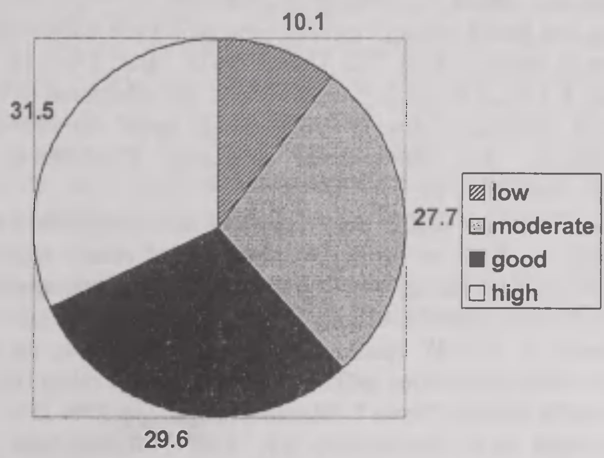

Figure 2. Respondents division (%) according their physical activity level

CONCLUSION

The low physical activity level of 10% cadets indicated indirectly to the low level of physical endurance. The group of these cadets has a have risk of manifested signs of physical overload. The division of respondents according to physical activity level was even: the moderate level of physical activity is characteristic of 27.7% of cadets, the good level of physical activity is fixed for 29.6% of cadets and the high level of physical activity was seen in 31.5% of cadets. 64.8% of cadets are active in sports during the whole week (at their free time) and only 29.6% of cadets are active in sports in the weekend.

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MORPHOFUNCTIONAL PECULIARITIES OF 17-YEAR-OLD BELARUS PUPILS OF DIFFERENT SOMATOTYPES

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ABSTRACT

On the basis of the new principle of distinguishing of somatypes we carried out the comparative analysis of anthropometric indices of physical development, of functioning of the cardiovascular system and its vegetative regulation for the representatives of different somatotypes. The purpose of the analysis was to define constitutional peculiarities of organism adaptation reaction of young men and girls to the deficiency of vital macro- and microelements in soils and potable water on the southern region of Belarus. The typological specificity of organism reactivity on the unfavorable geochemical situation of the southern region of Belarus was revealed in young men and girls in different degrees of the tension of the adaptation processes. The constitutional condition of the degree of tension of adaptation processes was exhibited in the young men and girls, referred to different somatotypes, in the series of peculiarities of morphofunctinal reactivity in the unfavorable geochemical situation of the southern region of Belarus.

Key words: adaptation, geochemical region, morphofunctional indications, somatotype, physical development, pupils.

INTRODUCTION

The purpose of the research consists in defining the reactivity character of the blood circulation system and the vegetative nervous system in the 17-year-old urban pupils referred to different variants of somatotypes and living in different ecological conditions in the territory of Belarus. 3 lithogeochemical regions are chosen: northern (Poozer'e), central (Central) and southern (Poles'e). The northern region is characterized by a maximal concentration for the republic of all the macro- and microelements in soils and water with the lowest concentration of silica, and the Southern – by a maximal concentration of silica and copper with a low concentration of other elements in the combination of the deficiency of iodine. The central region occupies an intermediate position.

MATERIAL AND METHODS

In 2001—2003 in the cities of the average level of urbanization with centralized water supply – in Polotsk (the Northern region) and in Pinsk (the Southern region) – 116 young men and 151 girls being 17 year old (of 1984—1987 years of birth) were investigated according to the complex program, including series of anthropometric and function indicators. After the disaster of the Chernobyl nuclear power station in 1986 on the considerable part of the southern territory of the republic the fall-out of short-living radioisotope J-131 was observed. At this time the investigated young men and girls were in the most ecosensitive stage of development.

Anthropometry was carried out according to the standard methods. The basic morphological indices of physical development – body length and mass are considered in the article.

We determined the most informational indices of hemodynamics, which play an important role in the adaptation processes – the systolic blood pressure (SBP), the diastolic pressure (DBP), the index of compensatory abilities of organism, offered by R.M. Baevsky et al. [1] – the adaptational potential (AP) and the autonomic index Kerdo (AIK), reflecting a dominance of influence of either sympathetic or parasympathetic departments of a vegetative nervous system, or their balance.

For the definition of AP the formula is offered by R.M. Baevsky et al. [1]. It can be used for the mass researches of the population with a different age and sex structure.

AP (in balls) = 0.011 (PR) + 0.014 (SBP) + 0.008 (DBP) + 0.014 (A) + 0.014 (A) + 0.009 (W) – 0.009 (L) – 0.27, **(1)**

where **SBP** and **DBP** – the value of systolic and diastolic pressure (in mmHg), **PR** – the pulse rate in 1 min, **A** – age (in years), **W** – body weight (kg), **L** – body length (cm).

The threshold value for satisfactory adapting is the level **2.1 balls**, i. e. all the values which are lower than this parameter speak about normal adapting; the values of AP **from 2.11 up to 3.2 balls** testify to the stress of adaptive mechanisms; the limits of oscillations **from 3.21 up to 4.3 balls** are characteristic of unsatisfactory adapting; the failure of adapting comes **after 4.31 balls.**

The autonomic index Kerdo is defined according to the formula:

AIK (in points) = (1 – DBP / PR) * 100, **(2)**

The labels of indices are the same, as for AP **(1).**

For the detection of constitutional peculiarities of the cardio-vascular system reactivity, which reflects the adaptation abilities of organism, Salivon and Polina [3] worked out a special method for the definition of the body constitution (somatotype), taking into account the continuity of variability of the complex of the most informative anthropometric indices. For the basis 12 indices are taken: height, weight, chest breadth and depth, the breadth of distal epiphysis of humerus (elbow), femur (knee), the circumferences of distal departments of forearm and crus in the narrowest parts, 4 skinfolds on the extremities and the trunk.

The scheme of somatic typifying included 5 indices. They were: **1) WLI – weight-length index** (ratio of body mass in kg to body length in cm, multiplied by 100); **2) IFT – index of the form of a thorax** (ratio of a sagittal diameter in mm to a transversal diameter in mm, multiplied by 100); **3) AMS4 – the average magnitude of 4 skinfolds** – on triceps, front thigh, subscapular and abdominal ones; **4) AMTD – average magnitude of transversal diameters** of distal epiphysises of a humerus and femur; **5) AMG – the average magnitude of girths** of a forearm and crus in the narrowest places.

For each index the standards of point estimations, taking into account standard deviations (SD) from simple average magnitudes (M), were separately designed: **0** point (at the magnitude of indices in the range from M – SD to M + SD), **1** point (from M + SD to M + 1,5 SD) and **–1** point (from M – 1,5 SD to M – SD); **2** points (from M + 1,5 SD to M + 2 SD) and **–2** points (from M – 2 SD to M – 1,5 SD).

While compiling normative scales, standard deviations for each of the selected index were taken into account (Table. 1), and the somatotype of an individual was diagnosed according to the sum of points in the five magnitudes indicated.

Somatotype was diagnosed by a total point estimation of five indices. Accordingly, there were 7 somatotypes chosen on a degree of increase of body components: asthenized leptosome (**AstL** – total points **less than 4**); leptosome (**L** – from **–3** to **–4**); mesoleptosome (**ML** – from **–1** to **–2**); mesosome (**M – 0**); mesohypersome (**MH** – from **1** to **2**); hypersome (**H** – from **3** to **4**); adipose hypersome (**AdH** – **more than** –4).

Because of a small number of extreme variants in samples, they were combined into **leptosome** (AstL+L) and **hypersome** (H+AdH) cohorts.

RESULTS

Among the young men of the Southern region, in comparison with the coevals from the Northern region, the contrast variants of somatotypes were less often observed: leptosome (17.0% against 20.3%) and hypersome (3.6% against 15.7%). Among the investigated girls, quite on the contrary, in the Southern region hypersomy predominated (40.9% against 29.6%) at insignificant differences on the frequency of leptosomy (7.2% against 9.2%).

The constitutional peculiarities of the status of the investigated contingent are submitted in Table 2.

Table 1. Norms of point ratings of morphological indices for the 17-year-old Belarusian pupils of different somatotypes

	−2	−1	0	1	2
Indication	from (M – 2SD) to (M – 1.5SD)	from (M – 1.5SD) to (M – SD)	M $\pm$ SD	from (M + SD) to (M + 1.5SD)	from (M + 1.5SD) to (M + 2SD)
			Boys		
WLI	27.9–30.2	30.3–32.7	32.8–42.6	42.7–45.0	45.1–47.5
IFT	56.9–59.6	59.7–62.5	62.6–74.0	74.1–76.8	76.9–79.7
AMS4	1.9–3.9	4.0–6.0	6.1–14.5	14.6–16.6	16.7–18.7
AMTD	78.0–79.9	80.0–81.9	82.0–90.0	90.1–92.0	92.1–93.9
AMG	178.9–184.2	184.3–189.7	189.8–211.6	211.7–217.1	217.2–222.5
			Girls		
WLI	28.1–29.9	30.0–31.8	31.9–39.4	39.5-41.3	41.4–43.2
IFT	58.5–61.0	61.1–63.7	63.8–74.4	74.5–77.0	77.1–79.6
AMS4	9.5–11,.	11.7–13.9	14.0–22.9	23.0–25.1	25.2–27.3
AMTD	69.5–71.0	71.1–72.6	72.7–79.1	79.2–80.8	80.9–82.4
AMG	171.8–176.5	176.6–181.4	181.5–200.8	200.9–205.6	205.7–210.4

WLI – weight-length index (ratio of body mass in kg to body length in cm, multiplied by 100);
IFT – index of the form of a thorax (ratio of a sagittal diameter in mm to a transversal diameter in mm, multiplied by 100);
AMS4 – average magnitude of 4 skinfolds – on triceps, front thigh, subscapular and abdominal ones (in mm);
AMTD – average magnitude of transversal diameters of distal epiphysises of a humerus and femur (in mm);
AMG – average magnitude of girths of a forearm and crus in the narrowest places (in mm).

Table 2. Typological peculiarities of morphofunctional traits of 17- year-old pupils from the Northern (Polock) and the Southern (Pinsk) geochemical regions of Belarus (2001—2003)

Variable	Geochem. region	Somatotypes*				
		AstL+L	ML	M	MH	H+AdH
Boys 17 years						
Number	northern	13	23	12	6	10
	southern	9	16	15	10	2
Body length (cm)	northern	174.8	176.0	180.2	179.8	183.9
	southern	173.4	178.4	176.6	178.5	182.8
Body mass (kg)	northern	56.0	62.6	64.8	65.4	83.6
	southern	57.7	63.1	65.1	72.4	93.0
SBP** (mm Hg)	northern	124.3	124.2	127.8	121.2	136.4
	southern	125.8	122.2	123.9	122.5	112.5
DBP*** (mm Hg)	northern	73.2	79.9	78.6	72.8	85.0
	southern	72.6	73.8	74.2	77.6	76.5
AP**** (balls)	northern	2.09	2.18	2.20	1.96	2.56
	southern	2.14	2.08	2.18	2.19	2.00
AIK***** (balls)	northern	4.68	–4.23	–2.33	–9.30	–5.52
	southern	7.60	1.83	5.25	–3.95	–29.74

Table 2. Continuation

Variable	Geochem. region	Somatotypes*				
		AstL+L	ML	M	MH	H+AdH
Girls 17 years						
Number	northern	21	15	15	13	7
	southern	32	18	12	12	6
Body length (cm)	northern	164.5	164.4	163.0	169.8	163.1
	southern	162.1	165.0	163.7	167.3	169.0
Body mass (kg)	northern	49.4	55.5	57.4	61.7	67.5
	southern	48.5	53.9	56.9	61.9	78.6
SBP** (mm Hg)	northern	118.5	114.9	113.7	112.4	118.1
	southern	114.7	116.4	123.2	111.6	119.0
DBP*** (mm Hg)	northern	68.8	72.5	67.7	73.7	72.0
	southern	70.2	69.8	71.9	72.5	74.2
AP**** (balls)	northern	2.07	2.06	1.98	2.01	2.29
	southern	1.96	2.03	2.25	1.99	2.29
AIK***** (balls)	northern	17.57	8.26	8.72	3.20	15.91
	southern	7.24	11.07	14.11	2.09	5.91

Somatotypes*: AstL – asthenized leptosome, **L** – leptosome, **ML** – mesoleptosome, **M** – mesosome, **MH** – mesohypersome, **H** – hypersome, **AdH** – adipoze hypersome;

SBP (mmHg)** = systolic blood pressure, **DBP*** (mmHg)** – diastolic blood pressure, **AP**** (balls)** – adaptive potential, **AIK***** (balls)** = autonomic index Kerdo.

Both in the Northern and in the Southern regions young men, referred to hypersome variants, were the tallest and the representatives of leptosome variants – the lowest. In the south the young men of all body build types have a smaller body length than their coevals from the Northern region do, and it is combined with the bigger indices of body mass and of chest circumference. The range of average magnitudes of body length variability between the extreme variants of somatic types is 9.1 cm in the Northern region, and 9.4 cm in the Southern.

Among girls this tendency is expressed weaker. Girls of all the somatotypes in the Northern region differ little in their body length. The maximal magnitude is characteristic of mesohypersome schoolgirls. The difference in average values of this index between the extreme leptosome and hypersome variants is 1.4 cm. In the Southern region the difference of body length between the leptosome (min) and the hypersome (max) of schoolgirls is 6.9 cm.

In both regions the body mass of the male and female representatives gradually increases from extreme leptosomy (min) to extreme hypersomy (max): the difference between them is 27.6 kg for young men in the Northern region and 35.3 kg in the Southern region, for girls – 18.1 and 30.1 kg accordingly.

Among anthropometric indices an authentic level was reached only by the dominance of the body mass indices of mesohypersome young men from the Southern region in comparison with their coevals from the Northern – it was 7.0 kg ($p < 0.001$).

The comparison of blood pressure indices for 17-year-old young men and girls of different somatotypes from the Northern and Southern regions has revealed the following tendencies.

For young men from the Southern region the SBP is gradually reduced in the direction from leptosome types (max) to hypersome (min), except for the mesosome variant, which breaks this tendency. The difference between extreme values is 13.3 mm Hg. In the Northern sample young men with adjacent body build had the extreme values – (min) for mesohypersome and (max) for hypersome (the difference was 15.2 mm Hg). Approximately the same magnitudes of SBP are characteristic of the Northern schoolboys with leptosomy indications, while mesosome types are marked by the increase of this index.

The dominance of SBP values for 17-year-old young men from the Northern region in relation to their coevals from the Southern region is observed for the representatives of 3 body build variants: mesoleptosome, mesosome and hypersome types.

As to DBP, young men from the Southern region are characterized by a weakly expressed reverse tendency, marked for SBP, it means that the value increase is observed from (min) leptosome types to the (max) mesohypersome type (the difference is 5.0 mm Hg), while for the hypersome type the DBP slightly decreases. Young men from the North, as well as in the SBP analysis, reveal the minimal DBP for mesohypersome types, and the maximum – for hypersome (the difference is 12.2 mm Hg).

The comparison of DBP for young men from the North and the South, as well as in SBP analysis, shows higher values for the Northern region inhabitants (except for mesohypersome schoolboys).

For schoolgirls from the Southern region the average SBP magnitudes increase in the direction from leptosome to mesosome (max), and then, after a sharp decrease (down to min) for hypersome, when the difference was 11.6 mm Hg, there is a small increase of the index for hypersome.

For girls from the North of Belarus, as against those living in the South, there is a gradual decrease of SBP from leptosome types (max) to mesohypersome (min) – the difference was 6.1 mm Hg ($p < 0.02$), – with the subsequent increase for hypersome practically up to leptosome variants level.

Higher values of SBP are marked among girls from the Southern region in comparison with the Northern for the representatives of 3 somatotypes (mesoleptosome, mesosome and hypersome), the dominance of the index for mesosome was 9.5 mm Hg for certain ($p < 0.05$).

A rather narrow range of DBP variability for the girls from the South reveals the tendency of the increase from mesoleptosome (min) to hypersome (max) types (difference – 4.4 mm Hg).

Such a tendency is not observed in the distribution of the average DBP values for the Northern girls, min is marked for mesosome types, max – for hypersome (the difference is 6.0 mm Hg, $p < 0.02$).

As well as, while considering SBP, Southern girls reveal the dominance of the average DBP magnitudes in 3 groups of somatic types – between leptosome, mesosome and hypersome variants of body build. However, these differences are not significant.

The comparison of average values of integrative adaptation index – AP – has revealed the index level, which exceeds 2.1 points, for young men from the Southern region in 3 groups of somatic types – leptosome, mesosome and mesohypersome (max) schoolboys, which means the tension of adaptation mechanisms. The values of AP in groups of mesoleptosome and hypersome (min) young men were within the limits of satisfactory adaptation.

In the Northern region the AP is rising, besides mesosome (as in the Southern region), is marked for mesoleptosome and hypersome young men. The difference in indices of hypersome and mesohypersome (min) schoolboys – 0.59 ($p < 0.01$) is statistically significant.

The AP values are a little higher in the groups of mesoleptosome, mesosome and especially hypersome young men from the Northern region, in comparison with those living in the southern region.

For girls from the Southern region the distribution of average AP values in somatic types groups is very similar to those revealed in SBP analysis. The same increase from leptosome (min) to mesosome type, the decrease of the index for mesohypersome type and the increase for hypersome (max). The difference in indices of leptosome (min) and hypersome (max) schoolgirls – 0.33 ($p < 0.05$) is statistically significant. The tension of adaptation according to average values is marked for mesosome and hypersome schoolgirls of southern region.

In the Northern region only hypersome schoolgirls discover the tension of adaptation, the AP variations in the remaining somatic type groups are insignificant. The differences between hypersome (max) and mesosome (min) girls from the North of Belarus are certain – 0.30 ($p < 0.05$).

The AP indices for the girls from the North in 3 somatic type groups are slightly higher than for those living in the South, while for the hypersome the increased index values are equal among themselves. For the Southern schoolgirls of mesosome types the index excess in comparison with the Northern (0.27) reaches a reliable level ($p < 0.02$).

Besides the analysis of average AP values distribution in somatotypes groups, we considered the frequencies of persons with the adaptation tension (from 2.11 up to 3.2 points) occurrence, depending on body build (Table 3). Despite the significant frequency variations of this index category, we did not reveal statistically significant differences between young men from the Northern and Southern regions. An especially high percentage is characteristic of leptosome and mesosome schoolboys in the South, and hypersome in the North, among whom there were no young men with the satisfactory adaptation, and one of the representative was marked by the unsatisfactory adaptation.

Table 3. Distribution of AP indices of 17-year-old pupils depending on the status of adaptation mechanisms in the Northern (Polock) and the Southern (Pinsk) geochemical regions of Belarus (2001—2003)

Somato-types	Northern							Southern				
	N	up to 2.1 balls		2.11-3.2 balls		3.2-4.3 balls		N	up to 2.1 balls		2.11-3.2 balls	
		n	%	n	%	n	%		n	%	n	%
				Boys								
AstL+L	13	7	53.8	6	46.2			9	3	33.3	6	66.7
ML	23	7	30.4	16	69.6			16	7	43.8	9	56.3
M	12	5	41.7	7	58.3			15	6	40.0	9	60.0
MH	6	4	66.7	2	33.3			10	3	30.0	7	70.0
H+AdH	10			9	90.0	1	10.0	2	1	50.0	1	50.0
				Girls								
AstL+L	21	11	52.4	10	47.6			32	24	75.0	8	25.0
ML	15	11	73.3	4	26.7			18	9	50.0	9	50.0
M	15	11	73.3	4	26.7			12	4	33.3	8	66.7
MH	13	9	69.2	4	30.8			12	8	66.7	4	33.3
H+AdH	7	2	28.6	5	71.4			6	2	33.3	4	66.7

Among schoolgirls from the Southern region there is an increase of persons with the adaptation tension percentage in the direction from leptosome to mesosome and hypersome types (accompanied by a sharp decrease for mesohypersome). The girls from the Northern region demonstrate two poles with high frequencies of adaptation tension for the representatives of extreme somatic types – leptosome and hypersome – while these frequencies are lower for the representatives of 3 intermediate types. The dominance of frequency of the persons with the adaptation tension among mesosome girls from the Southern region in comparison with the Northern is so significant (40%), that it reaches the certainty authentic level ($p < 0.05$).

The sexual differences in average AIK values variability in somatotypes groups are indicative (see Table 2). For young men of both regions there is a tendency to the dominance of the para-sympathetic department of the vegetative nervous system in the regulation of adaptation processes, which intensifies in the process of hypersomy increasing. The following leptosome individuals are marked by a slightly expressed sympathicotonia.

The AIK differences between lepto – and hypersome schoolboys, living in the Southern region, reach an authentic level – 37.34 ($p < 0.001$). Insignificant sympathicotonia in the Southern sample is marked also for mesosome schoolboys. To those with described balance of vegetative regulation (AIK values from –3 up to +3), we considered mesoleptosome and mesohypersome young men in the Southern region, and only mesosome in the Northern.

As against the young men, girls of all investigated somatotypes groups in both regions are all more or less characterized by sympathicotonia. The influence balance of both sympathetic and parasympathetic departments of vegetative nervous system on adaptation regulation is characteristic only of the schoolgirls of mesohypersome variants of body build – both in the South and in the North of the republic.

Maximal AIK magnitudes in the North are marked for contrast somatotypes – leptosome and hypersome, and in the South maximum is characteristic only for mesosome girls. The differences between leptosome (max) and mesohypersome schoolgirls (min) in the Northern region are authentic – 14.38 ($p < 0.01$).

DISCUSSION

The purpose of the comparative analysis of the anthropometric indices of physical development, of the cardiovascular system functioning and its vegetative regulation for the representatives of different somatotypes was to define constitutional peculiarities of organism adaptation reaction of young men and girls to the deficiency of vital macro- and microelements in the soils and the potable water of the Southern region of Belarus. Constitutional peculiarities of organism reactivity to discomfort condition of organism formation in the Southern region allow us explain the bigger range of the typological variability of body weight and chest circumference. Also, in this region the variability of function indices – SBP and DBP for young men, DBP and AP for girls – are more expressed, depending on the body build type.

The originality of the blood circulation system reactivity in the somatotypes groups of schoolboys of the Southern region is reflected in the percentage distribution of the corresponding adaptation tension AP values (from 2.11 to 3.2 points). Their higher frequencies occur more often for young men in the South in comparison with those living in the North. As against Northern girls, among whom the representatives of contrast somatotypes – leptosome and hypersome – are less adapted. Their Southern coevals are marked by the increase of percentage of persons with the adaptation tension from leptosome types to mesosome and hypersome.

From the vegetative regulation side displays of sexual dimorphism are more in comparison with regional differences. The observed for young men tendency to vagotonia intensifies as long as hypersomy increases. Only among leptosome young men there is a slightly expressed dominance of the sympathetic link of the vegetative nervous system regulation, which is characteristic of a female organism. For Southern schoolgirls the sympathicotonia increases from leptosome types to mesosome, and for Northern the maximal values are characteristic of the contrast somatotypes groups – leptosome and hypersome. From the point of vegetative nervous system balance, safer indices are characteristic of mesoleptosome, mesosome and mesohypersome young men and mesohypersome girls in the South, while in the North – for mesoleptosome and mesosome young men and mesohypersome girls. That means that in both regions the regulation of vegetative nervous system is balanced only for young men of mesoleptosome and mesosome types and for mesohypersome girls.

Thus, the offered approach to somatic typifying has allowed us to define more precisely the constitutional peculiarities of the organism reactivity in the discomfortable environment.

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CHANGES IN HUMAN MORPHOLOGY DURING THE 20TH CENTURY (EXAMPLE FROM THE CZECH REPUBLIC)

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ABSTRACT

The mean stature increased in male teenagers in the Czech Republic in the course of the 20th century by about 20cm, in young adults by 15 cm, and in adults by 10 cm. The age of onset of menarche in girls decreased from 15 to 13 years, the period of puberty has shortened. The final adult stature was attained in males at the age of 25 to 30 a hundred years ago, whereas nowadays it is reached at 18 or 19 years of age. Early in the second half of the century a discrepancy arose between the acceleration of growth and sexual maturation, which since the early 60s came practically to a halt. A slight tendency to slenderness took place. Whereas the first erupted tooth had been M1 in preschool children at the beginning of the century, the I1 was in prevalence at the end of the century in city children (in 1/3 of the children in villages, in 1/2 of the children in bigger towns and in 2/3 of the children from the Capital Prague.

The mean index cephalicus diminished, approximately during the last three decades from 87 to 77 in 3 year old children and from 85 to 80 in youths. Hyperbrachycephaly changed into mesocephaly.

The increase in stature has a practical significance in daily life, in medicine, ergonomics, architecture, in the production of products for the household and office, and in furniture, shoe, clothing, building, transport etc. industries. Accelerated maturation has social and sociological consequences: young people are living as adults earlier than before, which may sometimes raise educational, and even legal problems.

Key words: secular trend, stature, sexual maturation, tooth eruption, debrachycephalization

INTRODUCTION

Man undergoes changes and the end of the century may be the right time for their evaluation. It is not necessary to mention that these changes could be registered and proven only due to a great many growth studies, which did not always receive adequate recognition at the time when they were undertaken. They were reviewed recently by Eveleth and Tanner (1990) worldwide and by Prokopec (1989, 1994) for the Czech Republic.

The “secular” means “long lasting” or “lasting for a century”. During approximately the last hundred years in industrialized countries and recently also in some developing ones, children were getting larger and growing to maturity more rapidly. Those adults who reached their final body height years ago, are to-day, due to the secular trend, relatively smaller in comparison with those young males and females who just attained their adult stature. We believe that the narrowing and prolongation of the heads of our children are also somehow related to the secular trend of the 20th century. The underlying biological process responsible for the secular trend is often called “acceleration” (Tanner, 1992). Though we understand, in most cases, secular trend to be an upward trend, it may also be downward (Tobias, 1985).

MATERIAL AND METHODS

The secular trend may be studied by comparing anthropological data, obtained for the same population and using the same methods in the past and at present or by comparing younger and older age groups of the same population, measured at one time. Data from cross-sectional child growth studies were collected by instructed school teachers at schools and by paediatricians and their sisters in Child Health Centres (Matiegka, 1927; Lukášová, 1926; Fetter-Láb, 1954; Prokopec, 1994).

Adult persons were measured by anthropologists on the occasion of the International Biological Programme (IBP), national sport festivals or for ergonomical purposes. Data on conscripts and soldiers were also used (Fetter et al., 1967; Prokopec, 1972, 1973, 1974; Hemala, 1967; Klementa et al., 1976; Bláha, 1984, 1986; Èížková 1991).

The age of menarche was taken from Matiegka (1927), Lukášová (1934), Prokopec et al. (1962, 1988), and Lhotská et al.(1995). The last two authors used the "status quo" method in collecting the data and a logit technique in treating them statistically. The type of eruption of the first permanent tooth in preschool children was established according to Valšík (1956). The M-type means that the first erupted tooth in the child's mouth is the first molar, and the I-type means that the first erupted tooth is the median incisor.

The head measurements and head indices (head breadth x 100/ head length) were taken from Øehák (1923), Dokládal (1958), Figalová and Šmahel (1972), Suchý (1972), Brùžek et al. (1988), Krásnièanová et al. (1990), and Hronová and Øeèinská (1989).

RESULTS

Acceleration of growth in children and youths

The mean height in 14-year old Czech boys increased from 1895 to 1991 by 20 cm and in girls of the same age by 16 cm (Table 1). The age difference between 1895 and 1991 in boys attaining the mean height 145 cm and in girls of the mean height 141 cm amounts to 3 years. Figure 1.

A consistent growth acceleration in the second half of the 20th century may be observed from the age of 1.5 years in boys and from the age of 3 years in girls. The difference between the means in height from 1951 and 1991 at the age of 14 years amounts to 9.1 cm (which is equal to 1 SD) in boys and 6.8 cm (which is more than 1 SD) in girls. Figures 2–5.

The age difference in two average boys, one from the year 1951 and the other from the year 1991, being both of the same height of 140 cm, is one year, and being both of the same height of 168 cm, one year and a half. This was the height of an average 16-year-old boy in 1951 but also the height of a 14-and-a-half year old boy from the year 1991.

The height of an average 14-year-old girl from the year 1951 (which was 156 cm) was reached by an average 12-and-a-half-year old girl in 1991. The age of the peak height velocity in the second decade of life has lowered down in the 20th century and the period of puberty has shortened. Differences in cm between boys and girls from 1895 and 1991 in selected age groups are given in Table 1 and results of five nation-wide cross-sectional surveys of Czech children and youths are in Tables 2–5. Table 6 shows different trends of growth expressed in cm per decade in selected age-groups of boys and girls.

Table 1. Differences between the mean height in Czech boys and girls in 1895 and 1991 in cm

Age (years)	BOYS	GIRLS
6–7	10,8	13,3
10–11	14,1	15,5
14–15	20,3	15,8

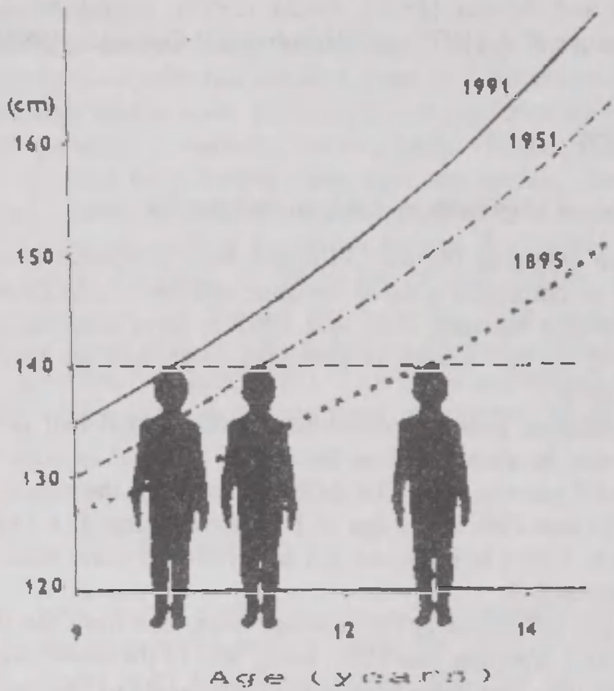

Figure 1. Schematic presentation of secular trend in Czech boys 1895–1991

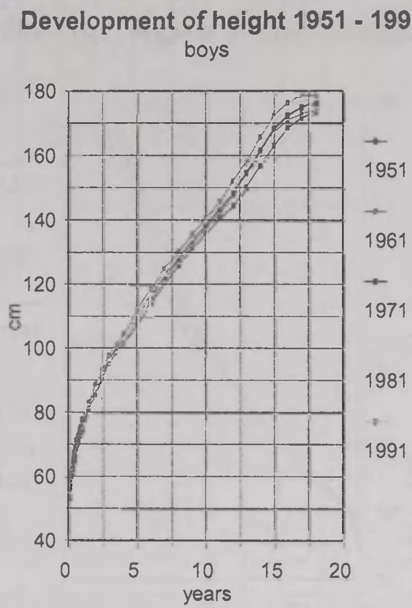

Figure 2. Development of height 1951–1991 (Czech boys) NAS

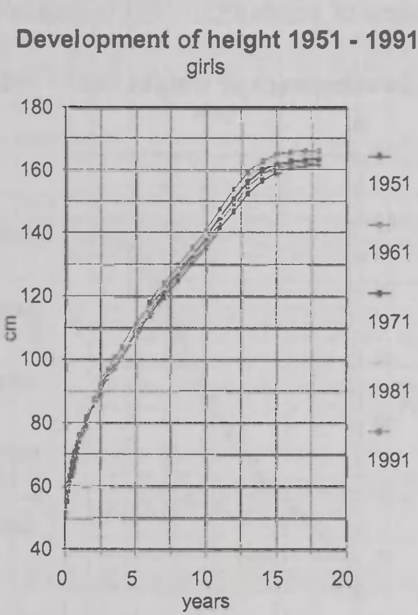

Figure 3. Development of height 1951–1991 (Czech girls) NAS

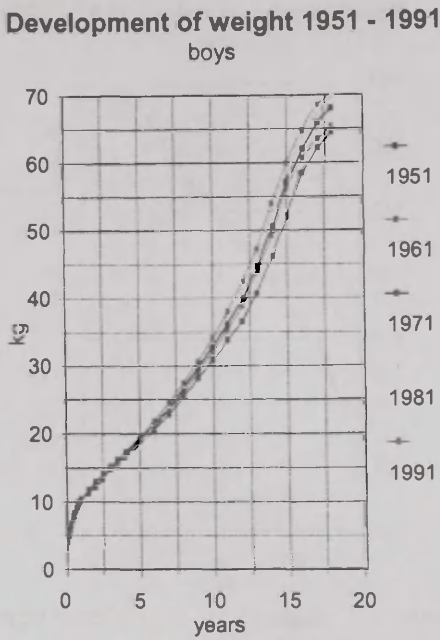

Figure 4. Development of weight 1951–1991 (Czech boys) NAS

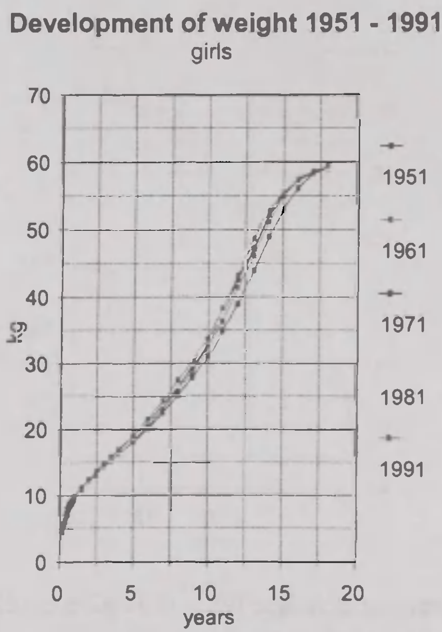

Figure 5. Development if weight 1951–1991 (Czech girls) NAS

Table 2. Height boys

age	1951			1961			1971			1981			1991		
	n	**mean**	**SD**	**n**	**mean**	**SD**	**n**	**mean**	**SD**	**n**	**mean**	**SD**	**n**	**mean**	**SD**
months															
1	30	53,4	1,7	549	54,4	2,7	493	54,67	2,82	730	54,3	2,94	423	53,94	3,16
2	59	56,6	2,7	640	58,1	2,8	586	57,95	3,22	579	58,31	3,32	364	57,92	3,16
3	55	60	2,7	714	61,6	2,9	595	61,52	3,47	605	61,58	3,33	401	61,63	3,41
4	50	62,4	2,9	773	64,6	2,7	602	64,77	3,45	583	64,66	3,26	374	64,46	3,39
5	55	64,9	1,9	690	66,9	2,8	613	67,27	3,42	612	67,07	3,19	373	66,96	2,96
6	56	66,4	2,8	702	68,9	2,7	632	69,26	3,26	574	69,39	3,37	382	69,09	3,24
7	65	68,5	2,6	689	70,1	2,8	645	71,03	3,8	597	70,7	3,18	391	70,59	3,05
8	60	69,9	2,4	585	71,3	2,5	606	72,16	3,04	612	72,15	3,17	381	72,09	3,47
9	58	71,1	2,3	523	72,3	2,5	589	73,08	3,17	555	73,46	3,22	360	72,82	3,34
10	44	72,6	2,5	524	73,4	2,6	583	74,34	3,3	578	74,46	3,06	370	74,73	3,2
11	66	73,8	2,4	534	74,5	2,7	592	75,52	3,29	545	75,85	3,24	323	75,46	3,47
12	54	74,8	2,7	492	75,8	2,9	1477	77,19	3,44	1661	76,97	3,56	343	77,77	3,16

Table 2. Continuation

age	1951			1961			1971			1981			1991		
	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD
years															
1,5	82	80,9	3	1112	82	3,3	1788	82,6	3,87	1784	82,96	3,6	1192	83,2	3,65
2	89	85,5	2,9	1007	87	3,7	2007	88,47	4,3	2770	88,07	4,1	1855	88,87	4,2
2,5	97	90,61	3,9	1113	91,8	7,8	2369	92,49	4,27	2531	92,85	4,1	1502	93,56	4,9
3	900	95,3	4,4	1201	95,7	3,7	2288	96,5	4,4	2214	96,87	4,14	1575	97,76	4,13
3,5	918	98,6	4,4	1469	99,1	4,4	2341	100,29	4,47	2441	100,66	4,34	1530	101,33	4,41
4	1839	101,9	4,5	1355	102,5	4,5	3172	103,8	4,8	3972	103,76	4,9	2536	104,92	5,09
5	2400	107,5	4,7	1381	109,2	4,7	3150	111,02	5,3	2885	110,97	5,22	1887	112,07	5,25
6	3998	114,3	5,3	760	115,6	4,8	2390	116,68	3,3	1395	117,1	5,14	1530	118,46	5,51
7	3679	120,4	5,6	1686	121,5	5,6	2433	122,65	5,5	2349	123,3	5,46	1786	124,89	5,44
8	3713	126	5,7	1877	127,5	5,8	2347	128,2	5,9	2351	129,22	5,88	1922	130,33	6,03
9	3381	131,4	6,1	2226	132,6	6	2552	133,84	6,1	2341	134,56	6,24	1902	135,88	6,22
10	3232	136,1	6,4	2427	137,7	6,4	2614	138,62	6,4	2257	139,88	6,44	1930	140,84	6,6
11	5863	140,7	6,9	2788	142,5	6,8	2989	143,65	6,7	2225	144,99	6,89	2014	146,06	6,84
12	6894	144,7	6,9	3369	147,7	7,2	2357	148,39	7,1	2289	150,5	7,27	2189	152,06	7,61
13	6769	150,1	8	4083	154	7,9	2461	154,61	8,4	2435	157,17	8,57	2311	158,12	8,61
14	6795	156,7	8,9	5242	160,4	8,7	2508	161,59	9	2243	164,6	8,81	2335	165,77	9,14
15	4641	163	8,8	5027	167,2	8,4	2338	168,19	8,5	2301	171,28	7,93	2601	172,42	8,14
16	3599	168,4	7,6	3926	171	7,4	2405	172,36	7,5	2543	175,21	7,16	2547	176,32	7,25
17	2530	171,6	6,8	2068	172,9	6,7	1702	174,91	6,8	2413	177,2	6,71	2177	178,71	6,79
18	1513	173,4	6,3	675	174,3	6,5	586	176,38	6,4	2006	178,15	8,63	1218	178,84	6,81

Table 3. Height girls

age	1951			1961			1971			1981			1991		
	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD
months															
1	26	52,4	1,8	493	53,3	2,5	486	53,83	2,7	724	53,14	2,63	411	53,54	2,99
2	65	55,1	2,3	641	56,9	2,9	592	57,06	3,06	503	56,73	3,21	357	56,81	2,97
3	44	58,4	2,5	699	59,9	2,6	594	60,22	3,18	624	59,68	3,88	414	60,1	2,95
4	57	60,9	2,2	738	62,9	2,6	600	62,91	3,11	567	62,7	3,13	380	62,56	3,2
5	45	63	2,5	722	65,1	2,6	607	65,37	3,19	600	65,45	3,15	358	64,91	2,91
6	55	64,7	2,3	668	66,8	2,6	624	67,34	3,2	609	67,39	3,16	405	66,89	3,07
7	63	66,3	2	633	68,3	2,6	637	68,94	3,11	567	69,13	3,18	395	68,43	3,3
8	45	68	2,2	612	69,5	2,8	611	70,31	3,07	616	70,3	3,2	379	70,49	3,31
9	62	69,5	2,5	523	70,8	2,9	604	71,52	3,11	531	71,72	3,35	360	71,14	3,19
10	51	70,7	2,6	509	72	2,8	576	72,78	3,35	600	73,12	3,23	335	72,57	3,18
11	65	72,4	2,4	526	73,3	2,7	588	73,84	3,35	575	74,13	3,49	358	73,59	3,41
12	45	74	2,6	482	75,6	2,8	1206	75,48	3,42	1668	75,28	3,47	355	75,97	3,17

Table 3. Continuation

age	1951			1961			1971			1981			1991		
	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD
years															
1,5	69	79,1	2,8	1048	80,7	3,3	1755	81,41	3,76	1872	81,67	3,81	1185	81,8	3,55
2	98	85,4	2,7	1034	86,1	3,5	2042	87,31	4,09	2826	86,74	4,14	1854	87,62	4,14
2,5	83	89,2	3,2	1142	90,7	3,7	2362	91,45	4,34	2525	91,78	4,39	1493	92,55	4,08
3	970	94	4,4	1179	94,6	3,8	2365	95,6	4,46	2203	96,17	4,65	1573	97,05	4,08
3,5	965	97,5	4,5	1551	98,2	4	2325	99,52	4,46	2451	99,76	4,37	1554	100,82	4,41
4	1669	101,1	4,6	1291	101,8	4,3	3167	103,1	4,91	3975	103,09	4,93	2553	104,15	5,05
5	2460	107,5	4,7	1335	108,4	4,6	3145	110,26	5,31	2876	110,44	5,36	1865	111,49	5,15
6	3923	113,6	5,3	1763	114,6	4,6	2422	116,9	5,45	1405	116,6	5,08	1708	117,97	5,78
7	3654	119,9	5,5	1851	120,7	5,5	2582	122,06	5,73	2266	122,78	5,45	1800	124,08	5,8
8	3719	125,2	5,6	2113	126,8	5,8	2470	127,7	6,02	2437	128,34	5,88	1861	129,96	6,11
9	3406	130,5	5,9	2324	131,6	5,9	2530	133,13	6,26	2341	133,91	6,2	1889	135,5	6,45
10	3163	135,6	6,5	2797	136,3	6,6	2662	138,42	6,64	2269	139,48	6,58	1859	140,81	6,91
11	6278	141,4	7,1	1355	143,1	7,2	3004	144,76	7,29	2280	145,71	7,44	1934	147,22	7,34
12	7266	146,6	7,4	3263	149	7,2	2561	150,82	7,42	2330	152,28	7,57	2094	153,7	7,53
13	7228	152,3	7,2	3155	154,6	7	2648	156,03	7,15	2485	158,03	6,96	2256	159,35	6,99
14	7214	156,4	6,4	2903	158,4	6,1	2643	159,88	6,51	2233	162,1	6,51	2342	163,18	6,26
15	4390	159	6	2650	160,9	5,9	2343	161,91	5,99	2486	164,13	5,87	2732	165,49	6,08
16	2969	160,7	5,8	2402	162	5,8	2136	162,87	5,87	2832	164,69	5,95	2945	165,92	6,08
17	2105	161,7	5,4	1375	162,2	5,5	1769	163,46	5,78	2884	165,07	5,77	2598	166,4	6,02
18	1379	162,1	5,8	364	163,1	5,1	694	163,77	5,65	2418	165,35	5,83	1460	166,2	6,36

Table 4. Weight boys

age	1951			1961			1971			1981			1991		
	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD
months															
1	30	4,2	0,44	549	4,2	0,8	493	4,27	0,62	730	4,14	0,64	423	4,08	0,68
2	59	5,08	0,65	640	5,2	0,7	586	5,15	0,86	579	5,19	0,77	364	5,04	0,69
3	55	5,76	0,71	714	6,1	0,8	595	6,11	0,84	605	6,15	0,87	401	6,08	0,82
4	50	6,62	0,83	773	7,1	0,9	602	7	0,87	523	6,98	0,82	374	6,79	0,8
5	55	7,29	0,67	690	7,9	0,9	613	7,72	0,92	612	7,66	0,88	373	7,45	0,87
6	56	7,94	1,07	702	8,3	0,8	632	8,27	0,96	574	8,22	0,92	382	8,04	0,91
7	65	8,55	1,07	689	8,6	1	645	8,72	1	597	8,72	0,92	391	8,49	0,94
8	60	8,87	0,96	585	9	1	606	9,09	1,05	612	9,04	1	381	8,96	0,99
9	58	9,27	1,03	523	9,5	1,1	589	9,85	1,13	555	9,51	1,1	360	9,31	0,98
10	44	9,98	1,06	524	9,7	1,1	583	9,85	1,13	578	9,95	2,91	370	9,74	1,11
11	66	9,97	1,21	524	10	1,1	592	10,12	1,13	545	10,16	1,17	323	10,06	1,12
12	54	10,35	1,15	492	10,3	1,1	1177	10,52	1,18	1661	10,42	1,26	343	10,6	1,16

Table 4. Continuation

age	1951			1961			1971			1981			1991		
	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD
years															
1,5	82	11,36	1,15	1112	11,7	1,3	1788	11,68	1,37	1784	11,82	1,35	1192	11,84	1,35
2	89	12,27	1,24	1007	12,8	1,4	2007	12,96	1,47	2770	12,9	1,49	1855	13,1	1,56
2,5	97	13,43	1,3	1113	14	1,5	2369	13,91	1,61	2531	14,02	1,6	1502	14,21	1,64
3	988	14,9	1,7	1201	14,9	1,6	2285	14,95	1,8	2214	15,04	1,73	1575	15,28	1,81
3,5	918	15,8	1,75	1469	15,8	1,8	2341	15,99	1,9	2441	16,14	1,89	1530	16,28	1,98
4	1839	16,7	1,8	1355	16,6	2	3172	17	2,1	3972	17,02	2,07	2536	17,35	2,3
5	2400	18,6	2,2	1381	18,6	2,5	3150	19,32	2,7	2885	18,01	2,45	1887	19,57	2,8
6	3998	20,6	2,6	760	20,9	3	2390	21,43	3,2	2334	21,64	2,81	1530	21,96	3,39
7	3679	22,9	3,1	1686	23,5	3,4	2423	23,91	3,6	2349	24,09	3,64	1786	24,67	3,71
8	3713	25,5	3,5	1877	26,2	4,2	2347	26,75	4,6	2351	27,07	4,4	1922	27,58	4,85
9	3381	28,2	4,3	2226	29,1	4,7	2552	29,78	5	2341	30,23	5,37	1902	30,68	5,38
10	3232	30,9	4,6	2427	32,2	5,5	2614	32,86	6	2257	33,65	6,19	1930	34,1	6,49
11	5863	33,8	5,1	2788	35,3	6,3	2989	36,15	6,6	2225	37,23	7,13	2014	38,03	7,41
12	6894	36,6	5,8	3369	38,8	7	2357	39,93	7,6	2289	41,09	7,89	2189	42,49	8,46
13	6769	40,7	7,2	4083	43,8	8,1	2461	44,59	8,9	2435	46,79	9,57	2311	47,26	9,62
14	6795	46,1	8,3	5242	49,2	8,9	2508	50,54	9,8	2243	52,71	10,14	2335	53,95	10,34
15	3599	52,2	8,8	3926	56,1	9,4	2405	57,13	10,3	2301	58,97	9,59	2601	60,03	10,14
16	3599	58,5	8,2	3926	60,8	8,8	2405	62,07	9,3	2543	63,97	9,33	2547	64,77	9,74
17	2530	62,2	7,7	2068	63,5	8,4	1702	65,91	8,8	2413	67,29	8,98	2177	68,61	9,7
18	1513	64,6	7,2	675	65,5	8	586	68,13	8,4	2006	69,74	8,48	1218	70,44	9,26

Table 5. Weight girls

age	1951			1961			1971			1981			1991		
	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD
months															
1	26	3,83	0,44	493	3,9	0,6	486	4,03	0,54	724	3,84	0,54	411	3,89	0,62
2	65	4,62	0,63	641	4,8	0,7	592	4,83	0,67	563	4,73	0,65	357	4,71	0,62
3	44	5,42	0,59	699	5,7	0,6	594	5,67	0,79	624	5,59	0,7	414	5,47	0,7
4	57	6,08	0,59	738	6,4	0,8	560	6,42	0,82	567	6,4	0,77	380	6,26	0,75
5	45	6,78	0,78	722	7,1	0,8	607	7,1	0,86	600	7,11	0,85	358	6,78	0,78
6	55	7,13	0,75	668	7,6	0,9	624	7,7	0,9	609	7,6	0,85	405	7,42	0,82
7	63	8,17	0,87	633	8	0,9	637	8,13	0,93	567	8,08	0,87	395	7,88	0,93
8	45	8,53	0,95	612	8,4	1	611	8,49	0,98	616	8,47	0,98	379	8,37	0,94
9	62	8,82	1,01	525	8,7	1	604	8,9	1,07	531	8,83	1,08	360	8,59	1,02
10	51	8,93	1,07	509	9,1	1,1	576	9,23	1,13	600	9,23	1,05	335	9,07	1
11	65	9,51	1,07	526	9,4	1,1	58,8	9,45	1,11	575	9,39	1,11	358	9,22	1,05
12	45	9,93	0,99	482	9,7	1,1	1206	9,84	1,17	1811	9,75	1,19	355	9,94	1,1

Table 5. Continuation

age	1951			1961			1971			1981			1991		
	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD
years															
1,5	69	10,93	1,2	1048	11	1,2	1755	11,06	1,28	1872	11,11	1,3	1185	11,18	1,24
2	98	12,18	1,25	1034	12,2	1,3	2042	12,4	1,48	2826	12,27	1,47	1854	12,45	1,48
2,5	83	13,17	1,37	1142	13,3	1,6	2362	13,43	1,65	2525	13,47	1,62	1493	13,58	1,6
3	970	14,4	1,7	1177	14,3	1,6	2365	14,55	1,9	2203	14,56	1,76	1573	14,77	1,73
3,5	965	15,2	1,9	1551	15,2	1,7	2325	15,54	1,92	2451	15,58	1,91	1554	15,82	2,01
4	1669	16,2	2	1291	16,2	1,9	3167	16,6	2,5	3975	16,51	2,16	2553	16,9	2,35
5	2460	18,1	2,2	1335	18,2	2,1	3145	18,86	3	2876	18,79	3,36	1865	19,03	2,6
6	3923	20,1	2,8	763	20,4	2,5	2422	21,17	3,5	1405	21,24	2,89	1708	21,56	3,45
7	3654	22,5	3,3	1851	23,1	3,6	2582	23,56	4,3	2266	23,7	3,81	1800	24,27	4,03
8	3719	25,2	4,9	2113	26,1	4,4	2470	26,51	5,1	2437	26,62	4,48	1861	27,42	5,14
9	3406	27,9	4,6	2324	28,8	5,1	2530	29,58	5,9	2341	29,85	5,47	1889	30,36	5,77
10	3163	31	5,5	2797	32,5	6	2662	33,11	7	2269	33,37	6,35	1859	33,68	6,77
11	6278	34,9	6,2	1355	36,3	7,2	3004	37,39	8,4	2280	37,31	7,71	1934	38,18	7,67
12	7266	38,8	7,2	3263	41,3	8,1	2561	42,61	8,9	2330	43,23	9,26	2094	43,17	8,87
13	7228	43,9	8	3155	46,1	8,5	2648	47,16	8,8	2485	48,24	9,21	2256	48,7	9,08
14	7214	48,9	8	2903	51,1	8,4	2643	52,22	8,3	2233	52,77	8,74	2342	52,88	8,32
15	4390	53,1	7,6	2650	55	7,8	2343	55,16	7,9	2486	55,87	8,17	2732	55,48	7,56
16	2969	56,1	7,5	2402	57,3	7,9	2136	57,51	7,9	2832	57,78	8,33	2945	57,37	7,76
17	2105	58,4	6,9	1375	58,3	7,4	1769	58,55	7,4	2884	58,87	7,71	2598	58,62	7,8
18	1379	59,5	7	364	59	7,8	694	59,09	7,5	2418	59,08	7,89	1460	59,42	8,56

Table 6. Trend in height in Czech boys and girls from the year 1951 to 1991 in cm/10 years

Age (years)	Boys	Girls
6	1,1	1,1
10	1,5	1,3
14	2,1	1,7
18	1,6	1,1

Increase of adult stature

The term "average height": of Czech males and females is a broad term, because it is strongly influenced by age due to secular trend. The final adult height is reached at a much lower age now than before. Growth ceases at the age of 18 in the majority of boys and at the age of 16 in the majority of girls at present. Adult height was attained at the beginning of the century not earlier than at 25 years. Conscripts from the first half of the century did not reach their final height at the age of 18 years.

Matiegka presented mean heights and weights of Czech males and females divided into age groups by one year from 24 to 30 years and then by 5 and 10 years at the Ethnological Exhibition in 1895 (Matiegka, 1933). The results showed, that the greatest mean height appeared in males not earlier than before their thirties and that there was only a slight diminishing in the mean adult stature for quite a long time after the life maximum had been reached. The peak mean height was relatively high in European measures of that time (170.6 cm in males of 31 and 160.5 cm in females of 29 years of age). This is contrary to what is a rule at present. The life maximum is attained early in life and the older age groups show a rapidly decreasing trend of the mean height. A good example of this was shown Klementa et al. (1976) in participants of Sport Festivals from 1955 to 1975 (Figure 6). Matiegka showed also that apprentices lost a few centimetres of their mean height during World War I.

A model of the secular trend in height for Czech males was established, taking into consideration the data on conscripts (only data from the years 1921–1928 and 1955–1976 were available), from nation-wide growth studies of school children and youths 1951–1991, of soldiers, of participants of sport festivals, of a sample of Czech males and females investigated for the IBP. We chose 179 cm as a mean height for 18 to 19-year-old males in 1991 (the life maximum of

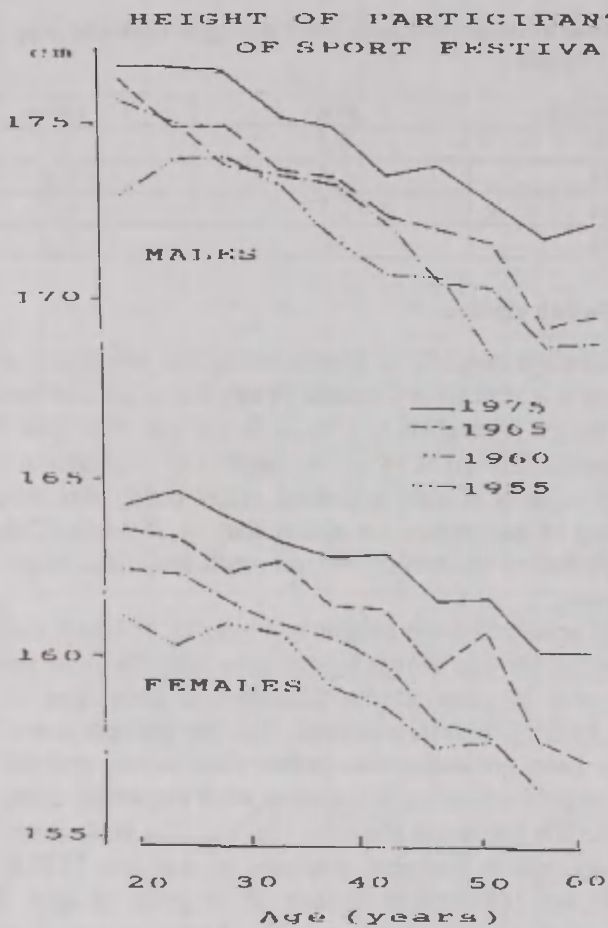

Figure 6. Decreasing mean height in participants of Sport Festivals with age (after Klementa et al., 1976)

that time). It is possible to estimate a theoretical height of 18-year-old males at any date (starting from the early 20s) in the 20th century from this fixed mean by subtracting 1.5 cm per decade (Figure 7). Example: An estimated mean height of 18-year-old males in the year 1971 is 176 cm, i.e. 179 cm minus 3 cm (2x1.5). Similarly we may estimate the probable mean height of males older than 18 years by subtracting 1.5 cm from 179 cm for each decade. Example: The mean height of males in their sixties is approximately 173 cm, i.e. we subtract 6 cm (4x1.5) from 179 cm. (This of course does not include eventual physiological diminishing of stature due to age etc.)

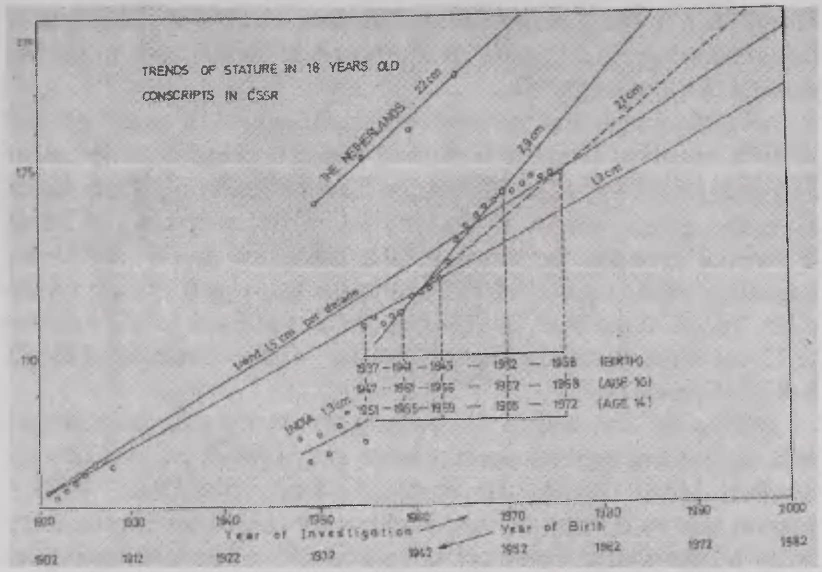

Figure 7. Trends of stature in 18 year old conscripts in ÈSSR

The trend of the increasing mean height in young males at the rate of 1.5 cm per decade was not constant during the 20th century. It has been only 1.3 cm per decade during certain periods, or on the other hand, temporarily even 2.9 cm per decade. An interesting phenomenon and a nice example on catch-up growth may be seen in conscripts born immediately after World War II. The accelerated trend started in conscripts born in 1946 and lasted for 7 years. The 2.9 cm-trend returned then to its initial 1.3 cm-trend. Based on the conscript data, the predicted trend of stature increase in young males from 1900 to 1955 would be 1.4 cm per decade and from 1955 to 1991 1.9 cm per decade. It seems that the secular trend is coming to an end towards the end of the century.

The conscript data were given after 1918 jointly for Czechs and Slovaks. Sometimes they were available also for each nation separately. The mean heights of the Czechs were usually 1 cm above the common mean and those of the Slovaks about 2 cm below the common mean. The state-wide child growth studies showed that the differences in growth between Czech and Slovak children, found in 1951, were much smaller in 1981. The gross increments in height for the 30 years from 1951 to 1981 were by about 1/3 greater in the Slovak than in the Czech children. This was ascribed to the intensive industrialization in Slovakia in the post-war period and to the yet unsaturated state of growth..

All anthropometrical surveys with the exception of conscripts and soldiers, involved females. It showed that it is possible to deduct an approximate mean height of females from the mean height of males from the given sample of the population by subtracting a stable difference between the sexes, which amounted to 11 cm at the beginning of the century and 12 cm in the major part of it, from the mean height of males. It is expected that this difference will increase to 13 cm at the end of the century (belating of the female mean height behind the male one).

During the first half of the century and partly also in its second half, differences between social classes and between city and country dwellers were found. Upper-middle-class boys from Prague, investigated by Borovanský and Hnìvkovský (1930) were equal in the mean height with the national sample of 1951. The anthropological survey of inhabitants for the IBP in 1972 showed differences between the mean stature in professional groups. The white collars were tallest, agriculturists were smallest and workers were in between (Prokopec et al., 1983). University students represent a social group with the highest mean stature. They were ahead of the rest of the population by 25 years and they are expected to lead also in the future.

A moderate prediction for the future is based more on the stagnation of growth in conscripts from the tallest populations of Europe (Schmidt, 1995) than from our own data. We predict the mean height in 18-year old males the 180 cm in 2001, 180.7 in 2011 and 181 cm in 2021. Figure 8 shows the mean height in conscripts from various European countries, depicting the end of the secular trend after 1980 in states with the world highest stature (North European countries and The Netherlands). Similar stagnation of the trend is expected to take place in Czech males in the near future.

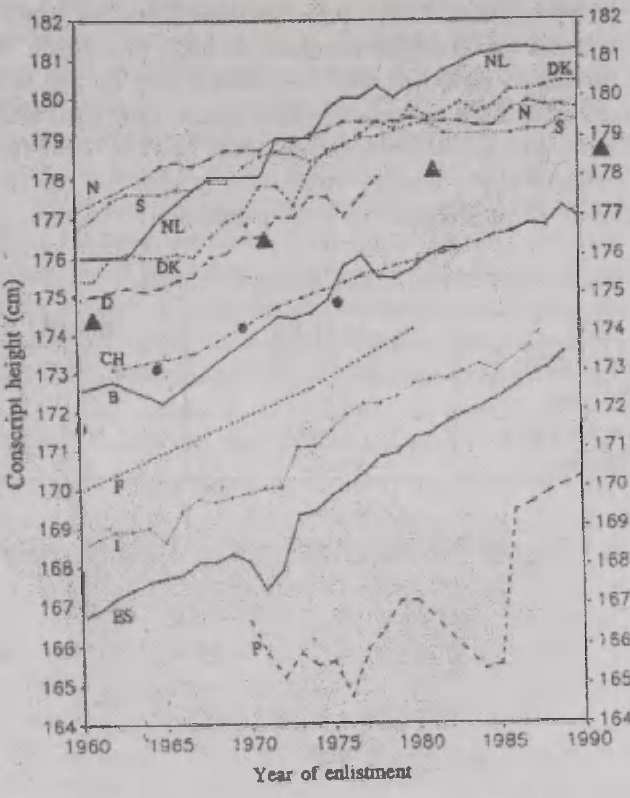

Figure 8. Mean conscript height during the period 1960–1990 in 11 European countries after Schmidt et al. (1995). Countries are marked by motor-car signs. Mean heights of Czech 18-year-old males (nation-wide sample) is marked by black triangles and those of Czech and Slovak conscripts by heavy dots.

Changes in body proportions

A widely used criterion of body proportions and of the state of nutrition is the body mass index (BMI, which is weight in kg/stature in m^2). The positive trend in height is not necessarily bound with a positive trend in weight. A slight tendency towards slendering of the body was observed in children and youths in the course of the century (more pronounced in girls than in boys). The mean weight in girls at the age of 18 years remained unchanged for 40 years from 1951 to 1991. The BMI uncovered an unfortunate impact of the Second World

War on the physique of Czech boys between 9 and 18 years of age. We may call it a social negative impact on body proportion. No such negative impact on girls was observed, which may be due to the fact that females resist hard times better than males. Low BMI indices are seen in Czech girls between 15 and 18 years in 1981 and 1991 which may be attributed to voluntary restriction in diet for the sake of a smart figure (a cultural impact on body proportion). Figure 9.

Table 7. Distribution of the BMI according to Knight

SEX	MALES	FEMALES
Underweight	below 20	below 19
Normal	20–25	19–24
Overweight	25–30	24–29
Obezity	over 30	over 29

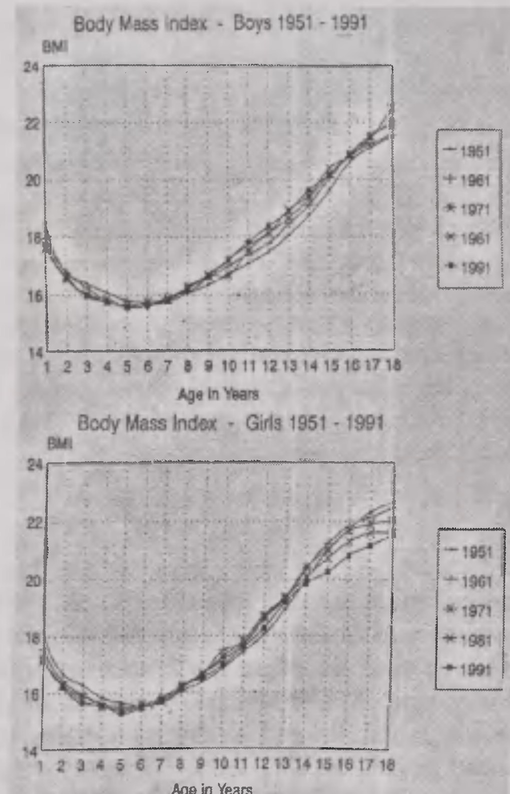

Figure 9. Mean BMI in Czech boys and girls 1951 – 1991.

The mean BMI in Czech soldiers at the age between 18 and 23 years, investigated by Čížková (1991) in 1987 was between 23.0 and 23.4. The mean BMI in contemporary adults between 35 and 40 years of age amounts to about 25 in males and 23 in females. About 20 years ago females used to have higher BMI than males. The results of the IBP showed the mean BMI in males to be 25.2 and for females 26.5. A survey undertaken by nutritionalists among hard working people in the mid sixties gave the mean BMI for males 26.2 and for females 28.0 (Prokopec, 1978). A lower average BMI in females than in males is an evidence of a progressive slandering of Czech females in comparison with males. This trend started in the early sixties in girl students and city women and spread stepwise on a nation-wide scale.

Secular trend in onset of maturation

Matiegka (1897) found the mean onset of menarche in Czech girls at 15 years and 1 month, Lukášová (1934) in country girls at the age of 14 years and 3 months and in city girls at 13 years and 8 months. Prokopec (1962 and Prokopec et al. (1988), gave the mean age of menarche in Czech girls in 1962 at 13 years and 1 month, in 1981 at 13.1 years, and Lhotská et al. (1995) in 1991 at 13.0 years. The rapid lowering down in the mean age of menarche from 1895 to 1962 came to a halt and remained practically unchanged for the next 30 years (Figure 10). The lowering down of the onset of menarche, which was observed until the early sixties in Czech girls and an acceleration of growth does not mean a precocious aging. A good witness of this statement is the fact that menopause in Czech females appears at older age now. (Linc, 1971).

Tooth age

Valšík (1953) found in a sample of Brno pre-school children of both sexes (ambisexual sample) that the first tooth which erupted in the mouth of children was M1 in 66.3% of cases and that in 33.7% it was the inner incisor (I1). He repeated the study in children from Brno in 1973 and found that the frequency of I1 doubled (the incidence was 56%). In Prague he found in 1974 the I-type in 65% of cases.

Příbrská and Pavlovská investigated 614 children in Prague in 1984 and their results were nearly identical to those of Valšík 11 years ago – 64.2% of the I1 types. They not only proved that the progressive I-type is more frequent than the M-type but showed also the stagnation of the trend in another biological trait bound to maturation, as had been shown before by menarche.

They concluded that the more frequent I-type of tooth eruption coincides with better socio-economical conditions and with the city way of life. To prove this hypothesis, they investigated a small sample of children in Železná ruda, a little place in a mountainous area. They found 35.3% of I-types there, which corresponds well with findings of Valšík¨s pupils in Slovakian villages close to Spiš (34.9%) or in Èadca (36.3%). Large Slovakian cities showed a higher incidence of I-types: Bratislava in 1972 51.3%, Trnava 48.3%. the Moravian city of Olomouc revealed in 1974 52.5% of I-types.

Change in the head shape

Vercauteren, Susanne and Orban (1983) observed a prolongation of heads in Belgian children from 3 to 12 years of age and connected this phenomenon with the secular trend of increasing stature. Gast (1983) observed the same in German children between 1953 and 1976. Shortly after that the process of debrachycephalization came to the attention of Czech anthropologists (Brùžek et al., 1988). Krásnièanová et al. (1990) showed a distinct change in the head shape (head index) in 3-year-old Czech children from Prague between the years 1958 and 1987 amounting to 10 index units (from 87 to 77). Table 8.

Table 8. Changes in cephalic index in Czech children /after Krásnièa-nová/

Locality	Praha 1958		Praha 1987		Písek 1987	
Sex	boys	girls	boys	girls	boys	girls
Index cephalicus	87,4	87,6	76,7	77,4	78,6	78,9

Hronová and Řečinská (1989) measured the heads of Czech children from 4 to 10 years of age. The mean index cephalicus calculated for each one-year age group was between 77.2 and 80.0 in boys and between 77.2 and 81.0 in girls, with a tendency to lower their values with increasing age. In 93 elder males, born before 1927, the mean head index amounted to 82.6 and in 307 elder females 83.0 – thus, in both sexes higher than the mean indices found in children. The differences were statistically significant (p=0.01). The head indices of

Czech boys at the age between 6 and 10 years, published by Øehák (1923), revealed mean indices from 86.6 to 88.3.

Hronová and Řečinská compared their results with those of other authors (Table 9). During 17 years which elapsed since the study of Figalová and Šmahel (1972), the mean head index in children changed in boys at the age of 2 to 6 years from 87.1 to 77.8,. and in girls of the same age from 86.2 to 79.2.

Table 9. Comparison of cephalic index in children from the year 1989 with previous findings

Author and year	Figalová Šmahel 1972 –		Dokládal 1958		Hronová - Øeèinská 1989	
Age (year)	boys	girls	boys	girls	boys	girls
2–6	87,1	86,2	–	–	77,9	79,2
7–14	–	–	85,8	85,3	79,5	78,7
15–18	–	–	84,9	85,4	79,9	79,5

Note: Differences between the results of Hronová and Řečinská and those of other authors were statistically significant (p=0.01).

In the course of 31 years, from 1958 to 1989 (Dokládal, 1958) the mean index cephalicus changed in children of the ages of 7 to 14 years in boys from 85.6 to 79.5 and in girls from 85.3 to 78.7.

In teenagers from 15 to 18 years of age the index diminished in boys from 1958 to 1989 from 84.9 to 79.9, and in girls from 85.4 to 79.5.

In professional language the head form in Czech children changed during the time periods described above from hyperbrachycephaly and brachycephaly to mesocephaly (Fetter et al., 1967 – index distribution according to Saller).

DISCUSSION

How much has the Czech man changed anthropologically in the course of the 20th century?. He is taller, more slender, he matures earlier, his head is more narrow and longer than earlier, but whereas the trend towards higher stature continues, the trend of accelerated maturation in girls has come to a halt.

Why did the discrepancy between trends in maturation and growth develop? What is the reason for the prolongation of the head ? What is the biological, social, and cultural significance of these changes ? Does it mean a further development of the not yet finished Homo sapiens? The prolongation of the head in the present generation of Czechs means from the historical point of view a reverse trend towards the past, because the old Slavs had long heads. The explanation may be purely mechanistical and the head prolongation may be just a result of greater freedom of movement which to-day´s babies have in comparison with their predecessors who were fixed in a swathe on their backs.

The up and down changes in the mean stature are well known from history. Hunters and gatherers were taller than the inhabitants of medieval cities. The height of a mammoth hunter from Pøerov (skeleton No.10) was 169.2 cm 25 thousand years ago. The height of the old man from Cro-Magnon was 182 cm, which equals the mean height of university students of to-day.

Three main factors participate in the changes of man in the 20th century: a genetical one, an endocrinological one, and a nutritional one which is again conditioned by health and by socio-economic conditions. Changes which we observe at present probably mean nothing more than adaptations of the young human organism to stimuli from the environment, which clash with genetically coded properties as well as with biological mechanisms of growth and development resulting in various microevolutionary changes.

What was the reason for the change in the eruption pattern of the teeth in preschool children, we do not know. It seems that the mean stature in young males is coming close to its theoretical potential or to its biological ceiling.

The acceleration of maturation went hand in hand with the trend towards higher stature but since some time the process of maturation is stagnating. It may be just a warning that the growth process is coming to a halt. Some other traits in human body might have changed as well (at least these which correlate positively with body height), but they have not been noticed or documented. The 20th century has been for the Czechs a century of great political changes and two World Wars and also a century of a defined secular trend. It started in it and it has come to an end in it.

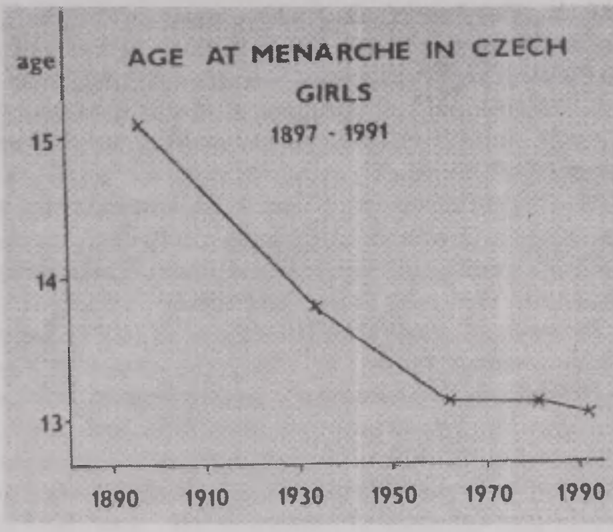

Figure. 10. Age at menarche in Czech girls according to Matiegka (1897), Lukášová (1934), Prokopec 1962), Prokopec et al.(1986), and Lhotská et al. (1995)

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TRAUMATIC LESIONS ON THE SKELETON FROM THE GRAVE 466 FROM THE MEDIEVAL NECROPOLIS OF DRASTAR (SILISTRA), BULGARIA. EVENT RECONSTRUCTION

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A skeleton from the medieval necropolis (14^{th} century) of Drastar (Silistra), Bulgaria was studied. The age of the individual at death was determined as 65–70 years and sex as male. Bones provided extended information for the survived trauma in the cervical region of the vertebral column (on the second vertebra, axis), were the dens axis was fractured and the right hip joint, with ankylosis, which totally immobilized the joint. After the event, which caused the traumas, the individual lived with disability, which caused a chain of adaptation changes, observed in the bones of the vertebrai column and limbs. A riding accident was supposed, which led to the traumatic condition of the individual.

The grave 466 (picture 1) is situated in the Basilica complex in the town of Drastar (now Silistra – Bulgaria, on the Lower Danube River at the Bulgarian side). After the archaeological evidences, mostly the stratigraphy of the site in the preliminary report the grave is dated to the 14^{th} century AD*. At the time Drastar was a developed center on the lower Danube, at a water way from West to East in Europe and the Black Sea. The northern side of the grave was found destructed from the Danube River, which also affected most of the left part of the skeleton.

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* The site was excavated by an archeological expedition under the guidance of Associate Professor S. Anelova and Assistant R. Coleva. Here their preliminary data of the archaeological situation and the dating of the find from the official preliminary report were used. To these resources I address special thanks.

Figure 1. Grave 466, Drastar (Silistra), field situation

MATERIAL AND METHODS

The studied material consists of bones and fragments from the cranial and postcranial skeleton as follows:

Cranial skeleton. The cranial skeleton is represented by the frontal bone, both parietals, occipital with the squamous part and the fragment of the basilar part, both temporals. A fragment from the facial part of the maxilla (alveolar and palatine processes) and the whole mandible were found. Big parts of orbits can be reconstructed. The preservation of the cranium can be evaluated as calvaria. The fragment of maxilla reveals the complete loss of teeth. As some alveoli were not completely ossified, but at the developed stage of ossification, it should be concluded that some teeth were lost shortly before death (the right lateral incisor, the left canine, the left first premolar). The whole mandible shows only one preserved tooth, highly abraded at the occlusive surface and with carious lesion at the cervical surface. The left lateral incisor and the left first premolar are abraded to the level of the alveolar process, and from them only roots are found. As at maxilla, at the mandible alveoli at developed stage of ossificationare also found, but not completely ossified at the places of the right lateral incisor and the first right premolar. The alveolar processes of both, maxilla and mandible, show a high degree of reduction.

Post cranial skeleton. All the vertebrae from the vertebral column are found: from the cervical part – two fragments of the atlas (C 1) with the frontal arch and articulation parts with the cranium and the second vertebra. The part of posterior arch is missing. Vertebrae C 2–5 are found intact, from C 6 the left fragment is found, C 7 – intact. Vertebrae from the thoracic (Th 1–12) and lumbar (L 1–5) compartments are found intact, the sacrum was fragmented, but a reconstruction was achieved. From the pelvis the right part and the left sciatic bone were found, while coccyx and the left pubic and the iliac bones were missing. Most of the costae from the rib cage were found. From the bones of the limbs the right femur, the right tibia, the right humerus, the fragments of the right radius, the right and the left ulnae, the right and the left clavicles, the right scapula were found. Carpal, tarsal, metacarpals and metatarsals and phalanges were also present.

Sex determination. Sex was determined after the data of the cranial and postcranial skeleton. The following features were found on the cranium – a highly oblique backwards frontal bone with a highly developed relief of the supraorbital and glabella region, the temporal bones also showed a pronounced relief in the root of the zygomatic arch, which was clearly evident over the external acoustic meatus. On the pelvis the investigator evaluated the pubic angle, which the after reconstruction of one of the pubic bones showed to be under 80° and the angle of the great sciatic notch, also a pronounced small angle. The following measurements were taken: the diameter of the head and the bicondilar breadth of the right humeral bone, the diameter of the head of the right radius (Table. 1). After these features and measurements the sex was determined as male [1], [6], [2], [4]. This determination is supported by the observed massiveness of long bones. The sacrum showed some degree of shortening, which should be explained with the age alterations and the adaptation processes after the survived trauma, observed at all the sections of the vertebral column. Its destruction level did not allow to carry out further investigation. The mandible, being with the pronounced age alterations – nearly a complete loss of teeth and a highly pronounced reduction of the alveolar processes could not be used for the sex determination (Figure 2).

Table 1. Dimensions of long bones in mm:

Bone	Dimension in mm	mm
Right humerus	diameter of the head	44
	bicondilar breadth	60,5
	length	30.8
Right radius	D caput	230
Right clavicle	length	141
Left clavicle	length	140
Right femur	antero-posterior diameter	27
	latero-medial diameter	35
Right tibia	най-голяма дължина	33.8
	antero-posterior diameter at the nutrient foramen	32
	latero-medial diameter at the nutrient foramen	24.5

Figure 2. Vertebrae.
2.1. Axis, proximal view
2.2. Axis, frontal view
2.3. Atlas proximal view
2.4. Atlas, articulation surface on the frontal arch with the dens axis
2.5. Atlas, distal view
2.6. Eight thoracic vertebra, proximal view

Age determination. After the relief of the symphyseal surface of the pubic bone the age at death of the individual should be determined as over 50 years. [1], [5]. The synostosis of the endocranial surface of coronal, sagittal and lambdoid sutures is in a completed stage and only traces of sutures are found on some segments – S 2 on the sagittal suture and L 1 on the lambdoid suture. The parieto-mastoid suture is evaluated as in the finished and the occipito-mastoid suture as in the developed stage of synostosis. According to these data the age at death of the individual can be evaluated at about 65–70 years [8]. The same age at death is obtained after evaluating the synostosis at the ectocranial surface of cranial sutures, which revealed to have reached development to the finished stage at all areas, determined by the method of Meindel-Lovejoy [1]. This age corresponds to the nearly complete loss of teeth and the reduction of the alveolar processes of the maxilla and mandible (Figure 2).

The stature is estimated to be 163.52 and 159.38, calculated from the length of humerus and tibia (Table. 1) after the formulas of Trotter-Gleser and Pearson-Lee respectively [7]. The indexes calculated after the dimensions of femur and tibia (Table. 1) classify the femur as platimeric (77.14 index of platimery) and tibia as euricnemic (76.56 index of platicnemy) [7].

RESULTS AND DISCUSSION

Traumatic lesions

The fracture of the second cervical vertebra (axis): the dens axis is lost during life after a survived fracture (Figure 3). The fractured part is most probably necrotized after loosing the connection with the body of the vertebra and is not found in the material. At the anterior part of the vertebral body a small thorn is preserved at the place of the basis of dens axis (4 mm). The surface at the place is with a formed articulation surface, highly polished. The first vertebra (atlas) revealed the articulation surface anteriorily at the anatomical place of the previous articulation with the dens axis.

Ankylosis of the right hip joint (Figures 4, 5). At the right hip joint is present ossification of the anterior fibers of illio-femoral ligament is present at the whole length from the attachment site at the illium to that of the femur (Figure 4). The same ligament shows the ossification of the proximal and distal posterior fibers at the attachment sites at the illium and femur respectively. Similar ossification is established at the

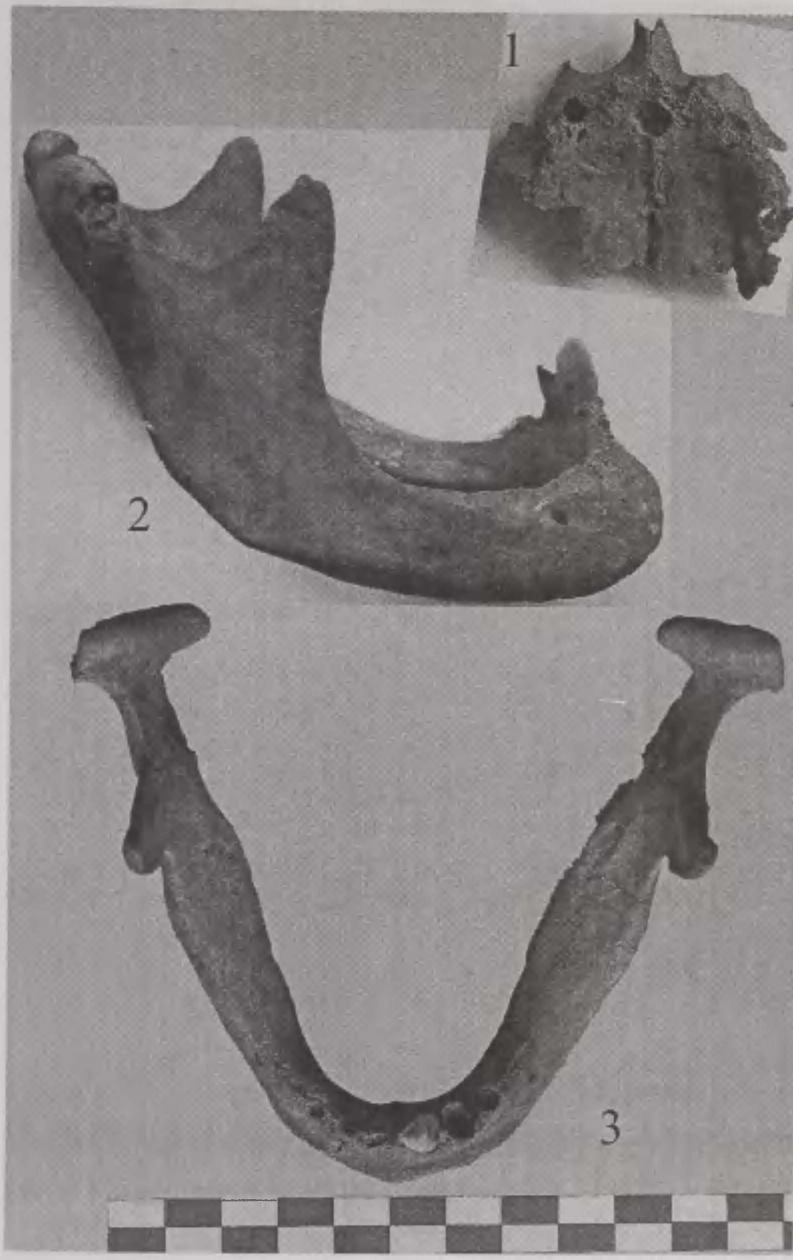

Figure 3
3.1. Fragment of the maxilla, distal view
3.2. Mandible, right lateral view

Figure 4. Right hip joint, ankylosis, anterior view

Figure 5. Right hip joint, ankylosis, posterior view

attachment site at ischium of ischio-femoral ligament. A lesion of periosteal reaction is present at the surface of illium and anteriorily of the greater trochanter, as well as at the attachment site at the femur of the pubo-femural ligament. Ossification is revealed at the attachment site of quadratus muscle at the lesser trochanter of the femur. The fibers of adductor magnus at the attachment site of medial-proximal part of linea aspera are also ossified (Figure 5). A highly developed relief is present at the attachment sites of the gluteus medius, minimus and maximus at the femur along the gluteal tuberosity and at the greater trochanter anteriorily and posteriorily (Figures 4, 5). The whole shaft of proximal 1/3 of femoral diaphysis, anteriorily, under the greater trochanter, shows periosteal reaction, which could be explained with internal hemorrhage.

Other traumatic lesions or fractures are not found at the remaining bones of the cranial and postcranial skeleton

Adaptation and age changes. False articulation surface on the second cervical vertebra (C 2): discovered polishing on the proximal and anterior surface of C 2 (Figure 3), where there was the base of dens axis, should be interpreted as a new formed articulation surface, where the new articulation between C 1 and C 2 after the lost communication between dens axis of C 2 and the cranial base occurred. The loss of the dens axis may have caused the slight displacement of C 1 and the cranial base backward with articulation between C 1 and C 2, which caused the polishing of the articulation surface proximally at the body of C 2 at the place of basis of dens axis. The body of C 2 shows pits backward from the sclerotic changes and spondylosis at the borders of articulation surfaces with C 1 proximally and C 3 distally, a slight press of the vertebral body is also observed.

In a big part of vertebrae is observed distorting of vertebral body form with shifting of the vertebral medial axis laterally can be observed (Figure 3). This distortion could have been caused by the twisting of the spinal column around the vertical axis from left (at the proximal part) to right (at the distal part). This twisting is to be explained by a compensatory position for the balance achievement in a sitting posture with unloading of the right pelvis area, being an impossible flexion in the right hip joint, and loading left pelvis area on the left ischial tuberosity. This possibility is also supported by the periosteal reaction ascertained to the right ischial tuberosity. The spondylosis of the articulation surfaces of vertebrae was evaluated with simultaneously specifying presence/absence of osteochondrotic changes of vertebral bodies. A higher level of spondylosis is associated with the lower part of cervical (C 5 – C 6), the lower section of thoracic (Th 9 – Th 11) and the proximal part of the lumbar (L 1 – L 2) compartments of the vertebral column. A higher level of spondylosis corresponds to the compartments with vertebrae showing distorted geometry of the bodies and points to a higher loading stress at these areas. Slight osteochondrotic changes were found only at the distal vertebral body of Th 12.

The determination of presence/absence of pathological bending of the vertebral column in the frontal and the sagittal plane in posttraumatic adaptation to the immobile right hip joint and the cervical trauma, was achieved by measuring the following dimensions of vertebral bodies: anterior and posterior vertebral body height and superior and inferior vertebral body length for the calculation of anterior body wedging, ascertaining the kyphotic/lordotic bending, and the right and the left vertebral body height and the vertebral body width for the calculation of lateral vertebral body wedging, ascertaining the scoliotic bending (Table 2). After the methods of Di Giovanni et al. [3] signs of slight kyphosis were ascertained with the anterior vertebral body wedging angle exceeding 5° at the fifth, the eleventh and the twelfth thoracic vertebrae. A right scoliotic wedging was assigned to the fourth thoracic and the left scoliotic wedging at the sixth thoracic vertebrae. The fourth thoracic vertebra is from the area with distortion vertebral body form with the rotation of the maximal diameter to the left of the sagittal plane, observed at the third to the fifth vertebrae. The sixth thoracic vertebra is situated at an area of distorted vertebrae with the rotating of the maximal diameter to the right of the sagittal plane. Being not highly changed in the frontal plane, according to the assigned age of the individual, the vertebral column was specifically changed in the sagittal plane in response to the survived trauma. These changes should be related to the static sitting posture, at which without a possibility of flexion of the hip joint the individual was keeping the balance by twisting the vertebral column from right at the proximal part to left in the distal direction. This caused the distortion of the vertebral body form and scoliotic changes in the right direction proximally and the left direction distally.

Table 2. Dimensions of vertebrae

	Sagittal diameter			Body height			
SPECI-MEN	Superior	Inferior	Width	Ant	Post	Lat rt**	Lat lt**
T 1	16.50	17.90	28.80	16.5	17	15.5	15.2
T 2	16.50	17.00	28.00	14	16.5	16.6	16.5
T 3	18.50	19.10	26.10	17.2	17.9	15.5	16.1
T 4	20.00	20.00	26.10	18.5	19.5	15.00	17.00
T 5	20.90	21.50	26.00	18	19.9	18.00	18.10
T 6	22.50	24.00	23.10	19	21	19.90	18.00
T 7	24.60	26.05	31.20	19.5	21.5	20.40	19.60
T 8	26.10	22.90	32.10	19.5	21	20.00	20.10
T 9	27.50	28.50	33.50	21	21.5	19.90	20.00
T 10	28.30	27.10	35.00	21.1	22	19.90	20.00
T 11	27.60	29.00	36.90	20.5	24.5	21.10	22.00
T 12	30.00	31.50	39.50	22.5	25.9	23.10	22.70
L 1	31.00	32.00	37.50	24.5	26.5	23.00	22.50
L 2	31.00	33.00	38.80	25.5	25	23.00	22.00
L 3	33.90	34.00	39.90	25	25	24.00	24.00
L 4	34.90	34.90	42.10	25.2	23.8	24.50	25.00
L 5	*33.00*	32.20	49.50	*26*	21	25.00	24.60

***rt – right*
lt – left

The inflammation process of the surface of the left sciatic tuber: on this place acute periosteal reaction is observed distally and posteriorily (Figure 6). This change is to be explained by the long sitting position on hard surfaces with the asymmetrical loading of the left side of pelvis.

Changes on the articulation surfaces of long bones: a thickening of the edges of articulation surfaces is found on the right humeral bone, the right and the left ulna, proximally and distally, on the right proximal fragment of the radius, proximally, the right scapula – on the edges of glenoidal fossa and coracoideal process. These changes, as a slight spondylosis on the vertebral bodies and articulation surfaces of the vertebral processes, should be explained with age specific changes and a higher loading of muscles of upper limbs by helping in motion. The loading of upper limbs in the body support during walking is evident by the development of the relief of muscle/ligament

Figure 6. Left ischial tuberosity

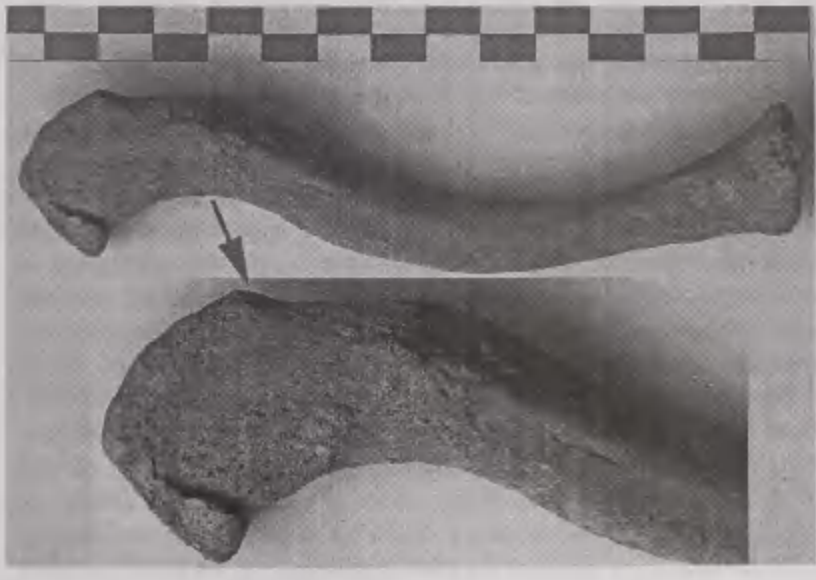

Figure 7. Left clavicle, distal view

attachment sites on the humerus – deltoid tuberosity and clavicles – trapezoid line and conoid tubercle (Figure 7), especially the right clavicle. The changes at the bones of the right shoulder point to the use of the long supporting stock to the right shoulder. The advanced age probably has also contributed to the development of the observed changes on the borders of the articulation surfaces.

CONCLUSIONS

Event reconstruction

The traumatic changes at the right hip joint should be explained with the dislocation of the femoral head from the acetabulum as a result of a strong force acting in distal direction with the simultaneous rotation from the posterior to anterior direction. This force caused rupture in some of the fibers of ligaments at the hip joint capsule and strong inflammation after stretching of the others, such as pubo-femoral and illio-femoral ligaments. The rupture of fibers and a strong traumatic stretch stress was probably present at the muscles and tendons from the back compartment of the hip – gluteuses and great adductor.

The trauma in the cervical compartment of the vertebral column should be a result of a strong force, which caused sudden bending and the displacement of the head. It is very difficult to judge in which direction this force was acting so not to cause a sudden death of the individual breaking the spine cord. According to the small preserved thorn from the dens axis at the anterior side of the vertebral body f C 2, it could be supposed that the head moved backwards and the force was acting from the posterior to the anterior plane. No cranial trauma was observed at the preserved to a great extent cranium. No fractures were observed at the bones of the thoracic cage, upper limbs and shoulders as well. It makes it possible to presume that the trauma in the cervical compartment was caused by the inert force of the body itself, with a strong forward propulsion, while the head delays – the so-called called whip effect after crashing.

Both traumas are to be assessed as severe and even separately can cause a serious disability of the individual. It is most possible that both of them occurred simultaneously in the consequence of one event. After no possible industrial cause of such a trauma during the period, the most possible cause could be found in the accident by horse ridding, after a strong forward propulsion of the horse the rider falls and simultaneously could have had the right leg stuck in the stirrup, during the forward movement of the horse, while the rider's body rotates from the posterior to the anterior plane and after falling to the ground is dragged by the horse for some time, which together with the rotation movement leads to the hip dislocation.

Since the medieval Drastar was of a high importance as a river port a possibility of a sail accident could also be assumed. As legs have a small importance in direct working with boat ropes and tackle, it is most difficult to suppose a possible stable stuck of the leg in the ropes and simultaneous unstopping stretching force, without any mechanical equipment. In this case very special circumstances should be found which simultaneously could have caused the neck trauma or an independent incident should be proposed, before or after the hip trauma, which is difficult to support.

After the survived traumas, the individual was disabled. The trauma in the cervical compartment could have caused head ache and pain in the neck, as well as being highly dangerous and life threatening in any case of loading or incidental stress of this compartment of the spine column. The trauma at the hip joint caused its total immobilization. As the skeleton showed no evidence for development stress and distortion, it should be proposed that the tragic event in the individual's life occurred after the age of growth or after the age of 20 years. The course of stabilizing, clear adaptive changes point out that at the time when it occurred, the individual was in a good physical condition. In spite of the observed aging and adaptive changes the skeleton did not reveal the signs of stress markers and point out to the individual, who has not been exposed to heavy physical loads. It means that the individual was not involved in a working process, physical in the period, it could be explained with his disability. That points to the possible life period of the event in the young age or in the age of 20–30 years.

The inflammation changes in the left sciatic tuber should be explained with a long time sitting on hard surfaces. The changes in the vertebral column are to be explained with the incorrect posture during sitting and walking. Because of the lack in material changes in the left half of the skeleton – the left lower and the upper limbs could not be studied.

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ANTHROPOMETRIC ASSESSMENT OF ELDERLY WOMEN IN RELATION TO THE RISK OF CARDIO-VASCULAR DISEASES (EPIDEMIOLOGICAL STUDY OF FEMALE POPULATION AGED 65–74)

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ABSTRACT

The cross-sectional epidemiological study of the random sample from the Estonian Population Register of free-living population of the elderly of Tallinn was carried out in 2003–2004. In this paper the authors present the results of 190 females, aged 65–74, examined by means of standard epidemiological methods on cardiovascular diseases, including anthropometrical parameters (height, weight, BMI, skin fold thickness, waist, hip, arm and calf circumferences), MNA-test, arterial blood pressure, lipids (TC, HDL-C, Tg), glucose, albumin, creatinine and homocysteine in plasma.

Overweight by BMI (BMI ≥ 27 kg/m³) was registered in 63.7% among elderly women, by that in 25.3% estimated as obesity class I (BMI ≥ 30–35 kg/m³) and in 14.2% as obesity class II (BMI ≥35). Opposite the risk to underweight (BMI ≤ 21kg/m²) was established only in 5.3%. Estimated by MNA (Mini Nutritional Assessment) malnutrition status (MNA ≤ 17 points) was estimated in 2.2% and risk to malnutrition (MNA 17–23.5 points) – in 21.8%, well nourished (normal and overweight) was 76%. The comparison of MNA results with BMI values showed that MNA was detected more often and the risk of malnutrition was earlier. MNA is recommended to use for estimating the nutritional status of aged people.

Hypertension (SBP/DBP ≥ 140/90 mm Hg) appeared in 82% of women and it is twice higher than in the female population of the age 50–54 years. Significant correlation has been found of anthropometrical parameters with blood pressure for weight, BMI, waist and hip circumference. Hypercholesterolemia (TC ≥ 5.2mmol/l) was found in 77%, hypo-HDL-cholesterolemia, (HDL-C < 1 mmol/l) in 18.6%, hypertrigyceridemia (Tg ≥ 1,6 mmol/l)- in 31.4%, hypertiglucemia (glu ≥ 6.1 mmol/l) – in 24%. Atherogenic changes in metabolism of lipids (decrease of HDL-cholesterol, increase of triglycerides and glucose) were connected with the excess of fat in the body and especially in the abdominal region of the body.

Key words: anthropometrics, body fat, BMI, WHR, MNA, hypertension, blood lipids, glucose, albumin, creatinine, elderly, aging

BACKGROUND AND THE AIM OF THE STUDY

Aging of population and connected with it the life quality has become one of the greatest challenges for the most European countries. That is why the research and preventive measures of aging grow more perspective and have a higher priority in health care and social maintenance.

Statistical data show that the proportion of older persons (over 60 years old) in the total population of Estonia is increasing very rapidly (women twice more than men): the prognosis for the year 2030 of the population over 60 years old increases from 18.9% (estimated on the census data of 1989) to 19.5% in 2005 and to 24.72% in 2030 (by the UN medium scenario). The projection produced at the Estonian Interuniversity Population Research Centre was even higher (21.35% and 17%, respectively) [1]. The predominance of women increases with every age group: their share grows from 60% in the 60–64 age group to about 80% for those aged 85 and over.

Our earlier investigations of the nutritional assessment and metabolism of the elderly (E. Vagane, M. Saava, V. Pauts, 1977, 1981, 1982) have been made on the materials of residents of nursing homes (Iru, Merivälja). [2, 3, 4]. In 1995 the researchers were studied home-living retired people in Tallinn as the socially vulnerable group of population. The results of the study, compared to our former data, have been reported at the European Congresses of Nutrition and Health of Elderly (2ndCongress in Denmark, Elsionore, 1995; 3rdCongress in Madrid, 2000) [5, 6].

The nutritional status of the elderly is affected by the number of changes in the aging organism and depending on psychosocial conditions (low income, isolation). In the course of the design of the current project, the literature about older population studies on nutritional assessment and health (including EuroNut, Seneca) has been gathered [7, 8, 9, 10, 11].

OBJECTIVES OF THE STUDY

- The anthropometrical assessment of the elderly women of the randomly selected cohort from the Estonian Population Register (300 persons aged 65–74 in Tallinn). Statistical analyses include the calculation of percentiles of indices for this age group.
- The assessment of the nutritional status with the Mini Nutritional Assessment test, comparing it with the Body Mass Index, fat mass and other anthropological parameters. The aim is to improve the methodology for estimating the risk of malnutrition in the older age groups and to determine the health risks connected with the changes in the body weight.
- To determine some biochemical indices that is connected with aging and the nutritional status (cholesterol, triglycerides, glucose, homocysteine, creatinine and albumin in plasma).
- To determine the associations between anthropometrical data and the main risk factors of cardiovascular diseases (hypertension, plasma lipids, glucose a.o.).

MATERIALS AND METHODS

The randomly chosen cohort of the elderly (aged 65–74 years), consisting of 300 women, has been formed (from the Population Register with birth dates 1928–1937 and living in Tallinn) and had been invited by post to visit the department of preventive cardiology. 190 women responded (63.3%) and the following procedures and methods of investigation were carried out:

- anthropometrical measurements: height, weight, body mass index (BMI), hip and waist circumferences, waist-hip ratio (WHR), skin fold thickness over triceps muscle and subscapular, circumferences of arm and calf;

- hands' muscle-power (kg) measurement was done with a dynamometer;
- measurement of body fat mass (in kg and%) with the Omron fat-monitor;
- the nutritional status was estimated by the Mini Nutritional Assessment (MNA) that consists: some anthropometrical measurements (weight, height, BMI, weight loss during the last 3 months; arm and calf circumference); a short dietary questionnaire (related to the number of meals, food and fluid intake, the autonomy of feeding); questions related to lifestyles, medication and mobility; subjective assessment of self-perception on health and nutritional status [12];
- blood pressure – systolic and diastolic (SBP, DBP) – measurement (mm Hg) was done twice on the right arm with a mercury sphygmomanometer;
- venous blood samples (EDTA-plasma) after a fast of 12 hours were performed for biochemical analyses to the Tallinn Diagnostic Centre and the Laboratory of Tallinn Central Hospital, were blood glucose and serum cholesterol (TC, HDL-C), triglycerides (Tg), albumins (Alb), creatinine (Cre) and homocysteine (Hcy) determinations have been carried out by enzymatic and routine clinical methods with Immunolite-20000 analyser;
- the estimating of results has been computed by the SPSS with the IBM Compatible PC with standard MS packets (Windows1998, MS Office 2000).The statistical processing included the calculation of means and standard deviations and the errors of the means, percentiles, inter-group comparisons (by the Student's t-test) and the Pearson correlation coefficients were used to determine the relationship between variables.

RESULTS AND DISCUSSION

The means and medians of data together with their percentiles are presented in Table 1 and the frequencies of BMI and MNA values with the criteria of over- or undernutrition are in Table 2.

Overweight by BMI (BMI $\geq$27 kg/m^3) was registered in 63.7% among elderly women, by that in 25.3% estimated as obesity class I

Table 1. Anthropometrical, blood pressure and biochemical data (mean, standard deviation and procentiles) of the population sample of the females aged 65–74 in Tallinn 2003–2004.

Variables	Mean	SD	Procentiles						
			5	10	25	50	75	90	95
Anthropo-metry (n=190)									
Height (cm)	158.5	6.39	148	150	154	158	163	168	169
Weight (kg)	73.3	14.6	53.3	56.5	62.1	71.8	81.8	92.3	99.5
BMI (kg/m²)	**29.2**	**5.38**	20.7	**22.7**	**25.2**	**28.7**	**33.1**	**36.2**	**38.7**
Waist circumference (cm)	88.5	12.6	69	72	79	88	97	104	111
Hip circumference (cm)	106.1	11.2	91	94	99	105	111	122	127
Waist/Hip (WHR)	**0.83**	**0.07**	**0.71**	**0.74**	0.79	**0.83**	**0.88**	**0.92**	**0.95**
Arm circumference (cm)	30.8	3.67	25	26	28	31	33	36	37
Calf circumference (cm)	35.2	3.21	31	31	33	35	37	39	41
Tricepc skinfold (mm)	29.0	6.85	19	20	23.5	29	34	37.5	40.7
Subscapular skinfold (mm)	24.5	8.55	11.5	14	16.5	24.5	30.5	36	40
Body fat (%)	40.3	4.98	31.8	33.3	36.6	40.4	44.1	46.0	47.8
Body fat mass (kg)	29.9	8.64	18.3	19.4	23.1	28.6	35.9	41.9	45.6
MNA score (n=183)	**25.8**	**3.53**	**19**	**20.2**	**24**	**26.5**	**29**	**29.5**	**30**
Dynamometry (kg)									
Right hand	20.0	4.74	12.6	14.0	17	20	23	26	28
Left hand	18.4	4.61	12.0	12.6	16	18	21	24	28

Table 1. Continuation

Variables	Mean	SD	Procentiles						
			5	10	25	50	75	90	95
Blood pressure *(n=190)*									
Systolic BP (mmHg)	157.1	26.0	120	125	139	153	172	191	207
Diastolic BP (mmHg)	82.9	12.6	65	69	74	82	90	99	105
Heart rate (per min)	70	11.9	56	60	60	68	76	84	96
Biochemical indices (**n=185**)									
TC (mmol/l)	6.08	1.16	4.1	4.5	5.3	6.0	6.8	7.7	8.2
HDL-C (mmol/l)	1.38	0.35	0.9	1.0	1.1	1.4	1.6	1.9	2.0
Tg (mmol/l)	1.5	0.62	0.8	0.9	1.0	1.4	1.8	2.44	2.97
Glucose (mmol/l)	5.87	1.84	4.5	4.8	5.1	5.5	6.0	6.65	8.6
Albumin (g/l)	47.8	5.3	40	42	45	48	51	54	55
Creatinine (umol/l)	79.8	16.7	61	65	69	78	86	97	111
Homocysteine (umol/l)	11.3	5.2	6.1	7.0	8.2	10.5	12.9	17.3	19.2

Table 2. Frequency of overweight and malnutrition by several anthropometrical measures and biochemical data in comparison with BMI and MNA values.

Parameter	Class	Criteria for estimation	Frequency (%)
BMI (kg/m²)	Risk to undernutrition	≤19	1.1
	Begins risk to underweight	≤21	5.3
	Normal weight range	21–27	31.0
	Overweight	≥27–30	24.2
	Obese class I	>30–35	25.3
	Obese class II	≥35	14.2
Waist (cm)	Increased	≥90	47.4
		≥95	31.0
		≥100	18.9
Waist/Hip ratio (WHR)	Increased	≥0.90	16.3
	Very high	≥0.96	4.3
MNA score	Malnourished	≤ 17	2.2
	Risk to undernutrition	17–23.5	21.8
	Well-nourished	≥24	76.0
Very low albumin	Undernourished	≤36 g/l	0.5
low (5% percentile point)	Undernourished	≤40 g/l	4.9
(25% percentile point)	Risk to undernutrition	≤45 g/l	22.2
Low creatinine			
(5% percentile point)	Undernourished	<60 umol/l	3.8
(25% percentile point)	Risk to undernutrition	≤70 umol/l	24.3

(BMI ≥30–35) and in 14.2% as obesity class II (BMI ≥ 35). Opposite the underweight (BMI≤21kg/m²) was established only in 5.3%. In comparison of overweight in the age 65–74 with the epidemiological study (Volozh O., Abina J, Solodkaya E. et al., 1999–2000) in the younger female population the prevalence of overweight was lower in the age group 50–54 years – 48.5% and obesity class I+II – 30.1%, respectively [13, 14, 15].

The estimated by MNA malnutrition status (MNA≤17 points) was estimated in 2.2% and the risk to malnutrition (MNA 17–23.5 points) – in 21.8%. If to try to estimate malnutrition by albumin in plasma, then only some cases (0.5%) had a very low albumin level (≤ 36 g/l), 5.4% had it under 40 g/l. The average normal level of albumin (48 g/l) shows that the expressed malnutrition is no problem on the whole population level, it is exceptional. At the same time, the risk to the beginning malnutrition might exist already by the normal albumin level in plasma.

Special tests are recommended for the assessment of the nutritional status of the elderly that differ from the tests for younger people (BMI). It is important to mention that MNA-test gives already to BMI ≤ 23 one point less and to BMI ≤21 two points less in calculating of the overall score. BMI may not show a real overweight in many elderly persons because of the decrease in stature as a result of morphological changes in the vertebral column. Because of that, BMI might be estimated differently at older than at younger ages; BMI criteria are taken higher for estimating overweight. The conclusion of these comparisons is that BMI gives overestimated results for the normal and overweight status of the elderly people and so the risk to malnutrition is non-existing. For the real assessment of the nutritional status in older age, it is better to use MNA-test, as it is validated and recommended, because MNA takes into account more parameters than BMI [11, 12].

The Mini Nutritional Assessment test (MNA) has been validated before by us with the elderly at the University of Third Youth in Tallinn (1998) and at the nursing home Merivälja (2000) together with the dietary calculations by menus during 10 days of two periods [6]. The risk of malnutrition was found with the same frequency (1/5 to 1/4) in the elderly living freely at home or in the nursing house. In the present population study the percentage of risk to malnutrition of the elderly women by MNA-test was the same. Malnutrition is a serious problem in other countries as well [8, 9]. Because of that, the short MNA-test is recommended and used internationally for the assessment of the nutritional status in the elderly, especially for early the detection of malnutrition symptoms depending on dehydration, muscle mass decrease and the changes of fat distribution in the body.

The criterion of hypertension was taken SBP/DBP ≥140/90 mmHg. By this criterion in the present study of the elderly female population, aged 65–74, hypertension represents a very great risk (in 82.1%) and compared with the younger age-group the frequency of hypertension has doubled (BP was elevated in 40.8% of women, aged 50–54, investigated in Tallinn in 1999–2000) [14, 15]. Even by the higher criterion (SBP/DBP ≥160/95 mmHg) 50.5% of women aged 65–74 were hypertensive; only 17.9% of women had the values of BP < 140/90 mm Hg, by that 90% of women with hypertension answered that they were aware of their hypertension before, 70% had taken even drugs, but without any stable effect.

Blood pressure had significant positive correlations with anthropometrical indices (Table 3): the highest correlation coefficients were found for systolic and diastolic blood pressure with hip and waist circumferences (but not with WHR), with weight and BMI values. SBP had a positive association with the glucose level in blood.

The heart rate reached in 80 and more beats per minute in 19% of participants; the negative correlation to MNA points ($r=-0.207$, $p<0.01$) and nearly significant correlation of the heart rate to the glucose ($r=0.161$, $p<0.05$) level in blood appeared.

The dynamometric measurement showed that the mean strength of hands was 18–20 kg and the variations were from 4 to 36 kg with no significant differences between the right and the left hand. As the correlation coefficients show (Table 3), the dynamometric values decreased with growing of age (correlation with age was negative), it shows the decline of muscle strength with age. The positive correlation of the arm and the calf circumference (best indicators for the muscle mass of the elderly) to the level of plasma creatinine (being the indirect metabolic variable for the muscle mass in the body) speaks about the lean body mass decline in the elderly (from 64 to 75 years) as well. At the same time, the anthropometrical variables connected mainly with the fat mass in the body had no significant correlation with the age from 65 to 74 years, neither increase nor decrease.

From the studies on the body's fat distribution in the elderly it is clear that significant changes occur in the body's composition with aging. The intra-abdominal fat (waist circumference) tends to increase and subcutaneous fat on the limbs tends to decrease. Among the elderly the loss of the lean body mass may be a more significant problem than a slight overweight, because of that all the elderly should be encouraged to increase physical activity and eat more proteins to maintain or increase lean body mass [16].

In our study, the level of physical activity was quite low: only 12.6% were somehow active every day, 38.4% – twice or three times

Table 3. Correlation coefficients between anthropometrical parameters, blood pressure, plasma lipids and other biochemical indices of females aged 65–74 years ($p \geq 0.01$* ; $p \geq 0.001$**).

	Coefficients of correlation									
	SBP	DBP	TC	HDL-C	Tg	Glu	Alb	Cre	Hcy	Age (y)
Height	–0.26	0.048	0.001	–0.133	0.124	**-0.210***	-0.06	0.112	0.006	0.015
Weight	0.163	**0.217***	–0.044	**–0.883****	**0.244****	0.116	0.011	0.151	0.111	–0.008
BMI	**0.19***	**0.218***	–0.045	**–0.354****	**0.209***	**0.226***	0.040	0.109	0.115	–0.021
Waist circumference	**0.201***	**0.214***	–0.046	**–0.386****	**0.285****	**0.247****	0.048	0.103	0.102	0.001
Hip circumference	**0.22***	**0.305****	0.044	**–0.354****	0.184	0.118	0.015	0.098	0.078	–0.02
Waist/Hip ratio	0.076	–0.003	0.013	**–0.234***	**0.267****	**0.283****	0.072	0.060	0.077	0.034
Arm circumference	0.180	0.144	0.013	**–0.312****	0.159	0.167	0.055	**0.223***	0.084	–0.002
Dynamometry, right	0.085	0.034	0.041	–0.009	0.043	0.044	–0.10	0.103	0.054	**-0.28****
Dynamometry, left	0.102	0.087	0.085	–0.070	0.071	0.141	–0.10	0.09	0.069	**-0.23***
Calf circumference	0.084	0.146	–0.04	**–0.318****	0.113	0.089	0.088	0.159	0.032	–0.016
Triceps skinfold	0.075	0.048	0.005	**–0.242****	0.183	0.134	0.092	**0.210***	0.060	–0.08
Subscapular skinfold	0.183	0.157	0.028	**–0.320****	**0.316****	**0.310****	0.042	0.136	0.070	–0.12
Body fat (%)	0.112	0.175	–0.056	**–0.282****	**0.206***	0.192	0.097	0.084	0.070	0.09
Body fat mass (kg)	0.124	0.182	–0.036	**–0.374****	**0.282****	0.156	0.029	0.114	0.105	0.009
MNA score	0.081	0.069	**0.222***	**–0.267****	**0.194***	0.131	0.021	0.029	–0.02	0.02
Heart rate (per min)	0.046	0.091	–0.048	0.168	0.060	0.161	0.116	0.051	0.008	0.03
Systolic BP	1.0	**0.605****	0.081	–0.128	0.120	**0.197***	0.133	0.059	0.056	–0.03
Diastolic BP	**0.605****	1.0	0.064	–0.181	0.051	0.024	0.116	0.059	0.059	0.01

a week; 36.5% did gymnastics and only 3% were engaged in some sports (on average 2 hours a week). Daily physical activities declined with age: 43% women of the age 64–69 and 55% of the age 70–74 did not do any physical exercise at all; the number of persons doing gymnastics decreased with age from 42% to 31% respectively. Because of that, the rapid increase of overweight and a high prevalence of obesity with synchronous lean body mass decline are the most important anthropometrical risks in the aging women in comparison with the younger ones. On the metabolic level it appears as the hypertrigyceridemia (+low level of HDL-cholesterol) and hyperglycaemia, in the clinical part – the very high prevalence of hypertension (82%) and other cardio-vascular diseases (myocardial infarction – in 4%, severe ishaemia – in 38% i.e.).

Comparing the data of blood plasma lipids with the normal ranges showed that the mean levels of TC and Tg in the elderly female were high (average 6.1 mmol/l, 1.5 mmol/l); HDL-cholesterol level was 1.4 mmol/l. The mean of glucose was 5.9 mmol/l. Hypercholesterolemia (TC $\geq$ 5.2 mmol/l) was in 77.3%, low levels of HDL-C (hypo-HDL-cholesterolemia, HDL-C $<$ 1 mmol/l) in 18.6%, hypertrigyceridemia (TG $\geq$ 1.6 mmol/l) – in 31.4%. Severe hyperglucaemia (glu $\geq$ 6.1 mmol/l) appeared in 23.9%; in addition to so high values the glucose level between 5.5 and 6.1 mmol/l have been determined in 27.7% of women, at that most of them were not aware about it before, high glucose levels were detected for them for the first time. It shows how important regular consulting of aging population was in the proper time with the aim of prevention or the treatment of chronic diseases.

Correlations between anthropometrical parameters and blood lipids (Table 3) assured that the total cholesterol had no correlation to anthropometrical data (except the positive association with MNA score). Triglycerides and glucose in plasma had a positive correlation to many anthropometrical variables: fat (%, kg), skin folds thickness, waist, WHR, weight, BMI and MNA ($p<0.01$). At the same time, HDL-cholesterol in plasma had a negative correlation to the same anthropometrical variables (weight, body fat, skin folds, hip, waist, arm and calf measures, WHR, BMI) and to the diastolic blood pressure as well ($p<0.05$). That means, that the metabolic syndrome with hypertension, atherogenic changes in the metabolism of lipids (the decrease of HDL-cholesterol, the increase of triglycerides) and a high glucose level are connected with the excess of fat in the body and especially in the abdominal region of body.

CONCLUSIONS

Anthropometrical parameters together, characterized as overweight and obesity, fat accumulation in body, especially in the abdominal region of body, have a certain impact on blood plasma lipids, glucose and blood pressure, that is why they are the main risk factors for the very frequent prevalence of hypertension, the ischaemic heart disease and diabetes.

The muscle mass and the strength of limbs are declining with age and fat accumulation in body trunk and abdominal region are characteristic rebuilding signs that will be manifested through a metabolic syndrome as diabetes or a cardiovascular disease.

The certain part (24%) of the elderly free-living female population estimated by MNA test, are at the risk of being undernourished and have to be under special medical follow-up before at more intensive ailment.

BMI is not very adequate for estimating the nutritional status in all the aspects in the aged people. MNA is a better tool for this purpose, because MNA detects in right time the malnutrition risks in right time.

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TYPOLOGY OF A BODY BUILD OF THE ADULT POPULATION OF BELARUS

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ABSTRACT

The new method for drawing up of normative scales with the point ratings of anthropometrical indices was developed taking into account sex and age with the purpose of constitutional type definition for children (Salivon, Polina, 2003). The method was used by the author in working out of similar normative scales for women and men of young (till 35 years), average (36–55 years for women and 36–60 years for men) and senile (above 55 years for women and 60 years for men) age periods. The efficiency of usage of the given method was shown on a concrete example of the constitutional type definition in the Belarus people investigated before the Chernobyl disaster.

Key words: adults, constitutional diagnostics, somatotype, complex of anthropometric indices.

INTRODUCTION

The peculiarities of a body build of a separate man and the distribution of types of a body build among sex and age, ethnic and territorial, professional, sports and other groups of the people represent both theoretical and practical interest at the study of the population's adaptive reactions, the process of formation of somatic peculiarities in ontogenesis, at the solution of ergonomic tasks, at the formation of the assortment of clothes in the industry, at the professional and sports orientation and so on.

At the solution of concrete practical tasks in constitutional diagnostics the set of indications appropriate to this tasks, describing some singularities of the body shape is considered. For example, the constitutional features of a pelvis structure proper to the female organism are important in obstetrical-gynaecological practice. At sports selection, depending on the kind of sports, the correlation of body proportions, defining bio-mechanical peculiarities of the organism are of essential importance, and during sports monitoring the fixation of dynamics of the relation of adipose and muscle components in body composition is important.

Offered by domestic and foreign anthropologists, various schemes of somatotyping (the definition of a body build type) of adults and children are considered in the monograph by A.I. Kliorin and V.P. Chtetsov [4]. However, it is necessary to notice that any of the classification schemes, based as on a visual estimation of somatotype, and on a totality of quantity indicators, is not able to reflect all the variety of the body shapes and transmutations between them because of a continuity of morphological variability. All the offered methods allow us only schematically, conditionally pick out the definite variants on the basis of the totality of those or other features, characteristic of the definite type of a body build. In the theoretical development of domestic anthropology the classification schemes of the visual definition of variants of a body build at women, offered I.B. Galant in 1927 [3] and at men, developed V.V. Bunak in 1940 [1] and 1941[2], are most frequently used. However, because of the subjectivity of the visual estimations the degree of comparability of the data by different authors is insignificant.

According to a new technique of somatotyping of adults, developed by V.P. Chtetsov and colleagues for men [7] and women [8], the convenient for the users normative tables of point estimations of anthropometric indications, depending on a degree of their expressiveness, were composed. In the presence of doubtless virtues of the offered approach to the definition of the body build type in the normative tables, such age morphological changes stipulated by the ontogenetic hormonal reorganization as, for example, the increase of a degree of subcutaneous fat deposit, the drop of a turgor of soft tissues, the tonus of the sceletal muscular system, the increase of the degenerative changes of the skeleton were not taken into account.

In connection with the sharp aggravation of the ecological situation in a considerable territory of our republic after the Chernobyl disaster, there was a necessity for the tight cooperation of physicians and anthropologists for the detailed elaboration of the typological peculiarities of the morphofunctional reactivity of an organism on the increased anthropogenous loads of habitat. For this purpose we developed a new approach for the creation of the normative scale of point estimations for a small complex informative anthropometric indices, first of all, for the most ecosensitive part of the population – children – in view of the age variability of a developing organism [6].

MATERIAL AND METHODS

The application of the same methodical approach with the use of the uniform complex of the indications for somatotyping of adults gives us an opportunity to trace the population dynamics in the distribution of body build types during all the life cycle. The uniform methodology of distinguishing of somatotypes among children and adults is based on a determinant forming of the genetic constitution of an individual. Therefore. the given method was used also during the definition of body build types as investigated by the author in 1970–1980 of the native agricultural population (the Belarus). Because of the fact that clear age changes in the body build of adults of Belarus [5] were detected, the data are distributed into 3 age cohorts according to «The Scheme of age periodization of the human ontogenesis», accepted in 1965 at the 7-th All-Union Conference on the problems of age morphology, physiology and biochemistry of NPA of the USSR. These three cohorts are: cohort 1 – young age till 35 years (the indices are rather stable), cohort 2 – mature age from 36 till 55 years at females and till 60 years – at males, cohort 3 – senile age higher than 55 years at females and 60 years at males.

The scheme of somatic typifying included 5 indices. They were: **WLI – weight-length index** (ratio of body mass in kg to body length in cm, multiplied by 100); **IFT – index of the form of a thorax** (ratio of a sagittal diameter in mm to a transversal diameter in mm, multiplied by 100); **AMS4 – average magnitude of 4 skinfolds** – on triceps, front thigh, subscapular and abdominal ones (in mm); **AMTD – average magnitude of transversal diameters of distal epiphysises of a humerus and femur** (in mm); **AMG – average magnitude of girths of a forearm and crus in the narrowest places** (in mm).

While compiling normative scales, standard deviations for each of the selected indices were taken into account (Tables. 1 and 2), and the somatotype of an individual was diagnosed according to the sum of points in the five magnitudes indicated.

Table 1. Norms of point ratings of morphological indices for the Belarus women of different somatotypes

Indication	–2	–1	0	1	2
	from (M – 2SD) to (M – 1,5SD)	**from (M – 1,5SD) to (M – SD)**	**M ± SD**	**from (M + SD) to (M + 1,5SD)**	**from (M + 1,5SD) to (M + 2SD)**
			Women up to 35	**N = 583**	
WLI	26.5–29.8	29.9–33.2	**33.3–46.8**	46.9–50.2	50.3–53.6
IFT	59.5–61.9	62,0–4,4	**64.5–74.4**	74.5–76.9	77.0–79.4
AMS4	7.6–10.9	11.0–14.3	**14.4–28.0**	28.1–31.4	31.5–34.8
AMTD	69.0–70.8	70.9–72.8	**72.9– 80.7**	80.8–82.7	82.8–84.6
AMG	173.8–180.4	180.5–187.1	**187.2– 214.1**	214.2–220.8	220.9–227.5
			Women of 36– 55	**N = 749**	
WLI	29.7–33.4	33.5–37.1	**37.2– 52.2**	52.3–56.0	56.1–59.7
IFT	61.0–63.9	64.0–66.8	**66.9–78.8**	78.9–81.7	81.8–84.7
AMS4	9.1–12.8	12.9–16.5	**16.6–31.5**	31.6–35.3	35.4–39.0
AMTD	70.3–72.3	72.4–74.5	**74.6–83.1**	83.2–85.3	85.4–87.4
AMG	176.5–183.9	184.0–191.4	**191.5–221.3**	221.4–228.8	228.9–236.2
			Women higher than 56	**N = 185**	
WLI	27.1–30.7	30.8–34.3	**34.4–49.0**	49.1–52.7	52.8–56.3
IFT	70.3–72.2	72.3–74.3	**74.4–82.6**	82.7–84.7	84.8–86.8
AMS4	7.1–10.9	11.0–14.7	**14.8–30.1**	30.2–34.0	34.1–37.8
AMTD	70.0–72.0	72.1–74.2	**74.3–82.9**	83.0–85.0	85.1–87.2
AMG	167.2–175.6	175.7–184.1	**184.2–218.1**	218.2–226.6	226.7–235.1

Table 2. Norms of point ratings of morphological indices for the Belarus men of different somatotypes

Indication	−2	−1	0	1	2
	from (M – 2SD) to (M – 1.5SD)	from (M – 1.5SD) to (M – SD)	M ± SD	from (M + SD) to (M + 1.5SD)	from (M + 1.5SD) to (M + 2SD)
			Men up to 35	**N = 582**	
WLI	31.1–33.5	33.6–36.0	**36.1–46.1**	46.2–48.6	48.7–51.1
IFT	57.9–60.9	61.0–63.9	**64.0–76.2**	76.3–79.3	79.4–82.3
AMS4	2.7–4.9	5.0–7.3	**7.4–16.8**	16.9–19.2	19.3–21.6
AMTD	76.9–78.8	78.9–80.8	**80.9–89.0**	89.1–91.0	91.1–93.0
AMG	183.7–189.6	189.7–195.6	**195.7–219.7**	219.8–225.7	225.8–231.6
			Men of 36–60	**N = 684**	
WLI	28.6–32.0	32.1–35.4	**35.5–49.5**	49.6–53.0	53.1–56.5
IFT	61.6–64.5	64.6–67.5	**67.6–79.4**	79.5–82.4	82.5–85.3
AMS4	2.6–5.1	5.2–7.8	**7.9–18.4**	18.5–21.0	21.1–23.6
AMTD	76.9–78.8	78.9–80.9	**81.0–89.0**	89.1–91.0	91.1–93.0
AMG	177.7–184.7	184.8–191.8	**191.9–220.2**	220.3–227.3	227.4–234.4
			Men higher than 61	**N = 80**	
WLI	28.3–31.2	31.3–34.1	**34.2–46.0**	46.1–48.9	49.0–51.9
IFT	65.0–68.1	68.2–71.3	**71.4–84.2**	84.3–87.4	87.5–90.5
AMS4	2.9–5.3	5.4–7.7	**7.8–17.7**	17.8–20.1	20.2–22.6
AMTD	78.1–79.7	79.8–81.5	**81.6–88.6**	88.7–90.4	90.5–92.2
AMG	171.8–178.8	178.9–185.9	**186.0–214.5**	214.6–221.6	221.7–228.8

Depending on the massiveness of a skeleton and the development of soft tissues, 7 variants of a body build are chosen: AstL – asthenized leptosome, L – leptosome, ML – mesoleptosome, M – mesosome; MH – mesohypersome; H – hypesome and AdH – adipose hypersome.

Somatotype	Range of points
	total points
Asthenized leptosome (AstL)	less then **–4**
Leptosome (L)	from **–3 to –4**
Mesoleptosome (ML)	from **–1 to –2**
Mesosome (M)	**0**
Mesohypersome (MH)	from **1 to 2**
Hypersome (H)	from **3 to 4**
Adipose hypersome (AdH)	more than **4**

RESULTS AND DISCUSSION

The standards reflect the age variability of anthropometric indices selected for the definition of body build. With age for males IFT increases because of the thorax volume increase; the range of AMS4 variability increases, which means that up to the middle age subcutaneous fat deposit increases, and up to senile age reduces; WLI and also AMG decrease, the possible reason for this is the gradual diminution of water content in soft tissues and decrease of their turgor.

For females in mature age WLI increases because of hormonal modifications, which influence gradual augmentation of subcutaneous fat deposit (AMS4). Both indices become less in senile age. In the middle age AMTD and AMG also increase. However, as well as for males, the last index in the senile age decreases. The age variability of the distribution of somatotypes is of interest (Figure. 1).

At women from the first to the third age cohort the frequencies of mesosome (M) and adjacent mesoleptosome (ML) and mesohypersome (MH) types gradually decrease due to the increase of the portion of asthenical leptosome (AstL), properly leptosome (L) and hypersome (H) types. The portion of the extreme hypersome variant – adipose hypersome (AdH) – remains the same. At men the frequencies of AstL and L variants, as well as AdH and MH, remain in all the age cohorts approximately on the same level. To senile age percentage of M-type decreases considerably due to ML and H percentage increase.

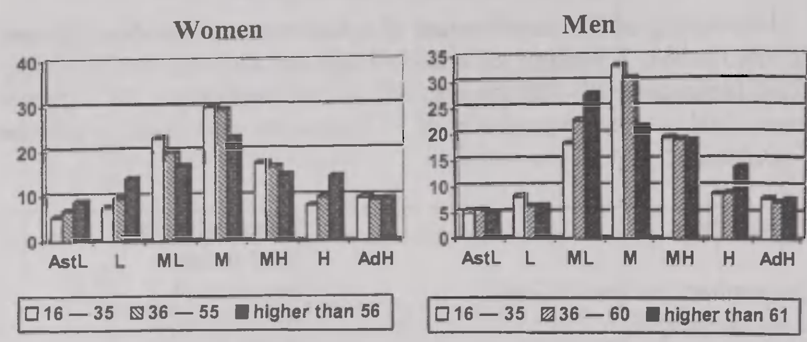

Figure. 1. Age variability of the percentage distribution of somatotypes at women and men in Belarus before the Chernobyl disaster
Somatotypes meanings: AstL – asthenized leptosome, L – leptosome, ML – mesoleptosome, M – mesosome; MH – mesohypersome; H – hypersome and AdH – adipose hypersome.

The variability of the average magnitudes of anthropometric indices, calculated for each variant of the somatotype in three age cohorts for men (Table 3) and women (Table 4) is illustrated by the regularities described above.

Considered here, three age cohorts represent a kind of three generations, in which the gradient of the increase of body length from older generations to younger reflects the consequences observed within the last century process of acceleration on the one hand, and the outcome of modification in the senile age of spine and supporting-motor apparatus as a whole owing to the involution processes – on the other hand. The degree of expressiveness of intergenerational differences on the body length among the men and women depends on the somatotype.

The body mass of the leptosome men (AstL, L, ML) gradually decreases with age, at M it is rather stable, and among hypersome (MH, H, AdH) it is a little enlarged in the average age, then at MH it is slightly reduced in the senile age. The given tendency is more expressed at H and AdH.

Table 3. Variability of the main statistical parameters of morphological indications at the Belarus women depending on the somatic type

	Body build type													
Indication	AstL		L		ML		M		MH		H		AdH	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Women up to 35													
Number of investigated	31		44		133		174		101		45		55	
Body length (cm)	156.02	4.52	161.21	5.37	160.11	5.22	160.65	4.71	160.20	6.12	161.25	5.10	162.24	4.81
Body weight (kg)	47.69	3.97	53.97	5.75	58.16	6.51	63.38	6.21	66.89	6.48	75.24	6.48	86.06	8.68
WLI* (kg/cm)	30.57	2.49	33.48	3.35	36.31	3.75	39.45	3.67	41.76	3.78	46.65	3.68	53.09	5.68
Thorax circumference (mm)	785.74	38.94	811.48	46.52	836.46	46.55	863.88	45.23	886.94	48.01	937.33	53.87	997.75	71.36
Biacromial breadth (mm)	347.29	14.32	354.30	18.09	355.68	15.18	359.01	14.28	358.65	13.50	363.13	15.58	371.25	13.11
Bicristal breadth (mm)	271.03	12.52	282.73	15.97	284.83	16.49	290.09	14.81	297.04	17.46	308.71	17.83	320.49	13.78
Thorax transversal diameter (mm)	246.42	16.77	250.68	16.15	252.56	14.77	255.20	12.44	256.60	15.59	270.89	17.96	282.33	21.85
Thorax sagittal diameter (mm)	164.77	8.69	165.82	9.35	170.45	9.64	176.36	7.83	184.50	9.50	193.89	10.00	200.78	13.34
IFT**	67.16	5.67	66.46	6.19	67.65	4.54	69.19	3.18	72.08	4.52	71.86	5.79	71.38	5.62

Table 3. Continuation

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Distal epiphyses breadth (mm):														
of a humerus	58.39	3.15	61.50	3.23	62.43	3.35	63.43	2.76	65.14	3.22	65.98	3.00	69.76	3.90
of a femur	82.61	3.75	86.25	3.64	87.83	3.51	89.38	3.52	91.39	4.55	92.58	5.43	96.95	5.12
AMTD*** (mm)	70.50	2.84	73.88	2.62	75.13	2.64	76.41	2.15	78.26	2.84	79.28	3.09	83.35	3.27
Girths in the narrowest places (mm):														
of a forearm	153.39	7.80	159.59	8.28	165.77	9.32	171.07	8.43	174.04	9.74	181.87	9.79	194.07	10.71
of a crus	206.42	12.08	217.20	12.79	223.29	11.63	228.90	11.47	235.70	13.94	240.51	14.39	250.93	15.91
AMG**** (mm)	179.90	9.08	188.40	7.85	194.53	8.94	199.99	7.97	204.87	9.54	211.19	10.43	222.50	10.80
Skinfolds (mm):														
triceps	13.10	3.77	13.84	3.89	17.17	4.03	19.07	4.06	20.79	3.94	25.04	4.69	27.65	5.83
front thigh	11.84	4.00	13.95	4.39	16.06	5.72	18.26	5.22	20.72	5.44	23.33	5.52	26.67	6.67
subscapular	11.58	4.27	13.34	5.07	15.45	5.18	19.98	5.26	23.05	6.74	27.76	5.99	33.05	7.60
abdominal	15.19	6.25	17.75	7.56	19.91	7.27	26.22	6.98	28.43	8.69	36.36	8.54	40.60	8.33
AMS4***** (mm)	12.93	3.76	14.72	4.54	17.15	4.54	20.88	3.98	23.25	4.80	28.12	5.02	32.00	5.34

WLI* – weight-length index;); IFT** – index of the form of a thorax; AMTD*** – average magnitude of transversal diameters magnitude of transversal diameters of a humerus and femur; AMG**** – average magnitude of girths of a forearm and crus in the narrowest places; AMS4***** – average magnitude of 4 skinfolds

Table 3. Continuation

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Women of 36 – 55													
Number of investigated	51		70		147		219		123		72		67	
Body length (cm)	154.57	5.44	156.04	5.24	157.39	5.84	158.27	5.10	158.46	5.00	159.3	4.55	160.17	5.16
Body weight (kg)	51.30	4.41	58.68	7.05	64.56	6.51	70.48	6.78	74.78	8.89	81.97	7.73	93.15	9.17
WLI (kg/cm)	33.19	2.57	37.59	4.21	41.04	4.08	44.51	3.83	47.15	5.00	51.44	4.48	58.17	5.50
Thorax circumference (mm)	822.12	36.78	871.00	54.99	901.76	52.87	937.33	50.86	959.33	64.85	994.38	57.09	1042.82	64.73
Biacromial breadth (mm)	351.55	17.13	345.21	13.62	359.31	14.07	360.55	14.59	359.09	14.71	365.74	16.05	366.60	15.91
Bicristal breadth (mm)	286.71	19.22	290.49	15.04	298.94	14.21	304.57	14.85	309.71	16.36	317.96	15.32	328.03	18.86
Thorax transversal diameter (mm)	255.25	16.12	263.14	15.99	267.73	16.36	270.61	14.65	271.26	19.91	277.83	19.12	286.22	20.89
Thorax sagittal diameter (mm)	176.63	10.22	183.01	12.09	187.66	10.93	196.33	10.55	205.11	13.34	209.93	11.76	217.39	15.83
IFT	69.43	5.47	69.75	5.67	70.31	5.39	72.65	3.79	75.90	6.02	75.93	6.90	76.21	6.28
Distal epiphyses breadth (mm):														
of a humerus	61.71	3.48	63.6	2.93	65.08	3.29	66.62	3.12	68.09	3.49	69.65	3.20	71.73	4.08
of a femur	83.92	3.89	86.8	4.30	89.00	3.86	90.55	3.86	92.54	4.91	95.57	5.34	98.94	6.22
AMTD (mm)	72.81	2.99	75.2	2.96	77.04	2.72	78.59	2.36	80.32	3.15	82.61	3.08	85.34	4.04
Girths in the narrowest places (mm):														
of a forearm	159.88	8.11	166.44	10.01	173.89	9.24	180.45	9.45	182.96	10.48	190.26	9.52	202.12	13.30
of a crus	208.73	8.18	218.37	16.19	226.99	14.51	233.70	12.75	237.54	15.92	244.74	17.87	257.06	18.66
AMG (mm)	184.30	5.97	192.41	11.45	200.44	10.06	207.08	8.49	210.25	10.84	217.50	11.58	229.59	12.77

Table 3. Continuation

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Skinfolds (mm):														
triceps	13.71	3.13	16.60	4.91	19.46	5.05	21.72	4.42	24.04	4.78	26.24	5.13	31.12	5.24
front thigh	11.69	4.53	15.33	5.43	17.35	5.56	20.34	5.24	22.34	5.88	24.97	5.85	30.09	6.50
subscapular	11.35	4.48	15.86	6.19	18.58	6.59	22.02	6.52	25.07	6.97	27.33	7.21	32.73	8.22
abdominal	15.10	7.44	22.76	9.80	27.07	9.28	32.25	8.20	36.37	8.97	40.86	10.32	47.06	8.88
AMS4 (mm)	12.96	4.01	17.64	5.80	20.61	5.20	24.08	4.56	26.95	5.29	29.85	5.72	35.25	5.08
	Women higher than 56													
Number of investigated	16		26		31		42		27		26		17	
Body length (cm)	154.09	4.97	153.71	4.32	153.44	4.16	153.90	5.64	153.41	3.97	154.28	4.91	155.19	4.61
Body weight (kg)	48.72	5.00	57.80	8.77	60.19	8.13	63.67	9.29	67.96	8.56	70.85	9.03	81.15	11.10

Table 3. Continuation

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WLI (kg/cm)	31.59	2.77	31.45	4.40	39.20	4.98	41.31	5.38	44.27	5.26	45.85	5.05	52.38	7.65
Thorax circumference (mm)	817.25	35.13	866.55	59.57	892.68	58.59	908.83	53.54	942.63	57.28	951.35	52.21	997.53	74.28
Biacromial breadth (mm)	343.75	15.72	347.55	13.08	347.74	15.76	349.86	16.97	348.67	14.25	348.54	16.22	354.94	10.62
Bicristal breadth (mm)	289.88	15.71	299.9	16.05	295.65	15.41	305.36	15.96	307.07	17.73	314.92	10.97	325.47	12.81
Thorax transversal diameter (mm)	254.375	10.32	265.54	20.48	270.10	17.00	261.57	16.78	266.48	20.08	258.54	19.05	269.71	20.32
Thorax sagittal diameter (mm)	183.063	8.57	191.46	10.11	198.23	8.97	206.21	13.95	216.19	11.70	221.38	14.46	229.82	15.19
IFT	72.12	5.12	72.40	5.27	73.65	5.40	79.02	5.61	81.40	5.37	86.02	7.80	85.54	7.03
Distal epiphyses breadth (mm):														
of a humerus	63.563	3.10	65.81	3.36	66.87	3.26	66.69	3.58	66.70	3.53	69.38	3.85	71.00	4.39
of a femur	83.313	3.79	86.38	4.35	89.10	5.44	89.60	4.47	90.70	4.56	92.81	5.45	99.24	4.38
AMTD (mm)	73.44	2.39	76.10	2.99	77.98	3.69	78.14	2.93	78.70	2.43	81.10	4.23	85.12	3.85
Girths in the narrowest places (mm):														
of a forearm	153.00	6.40	168.62	11.73	172.06	10.19	174.95	12.45	176.78	12.94	184.73	11.25	197.12	20.39
of a crus	199.13	9.37	215.85	19.11	222.45	16.88	228.93	15.54	231.19	18.11	236.50	21.46	251.82	21.29
AMG (mm)	176.06	7.18	192.23	13.32	197.26	10.49	201.94	12.14	203.98	13.43	210.62	12.61	224.47	18.32
Skinfolds (mm):														
triceps	13.20	4.02	17.46	4.73	18.03	4.67	21.00	4.17	24.07	5.56	24.27	5.36	27.00	7.20
front thigh	8.40	4.34	14.85	5.10	14.32	3.66	17.67	4.82	19.33	5.71	20.23	5.51	28.12	9.18
subscapular	9.50	2.68	18.08	7.45	17.74	6.71	23.10	6.27	25.70	7.25	26.38	7.46	34.65	9.92
abdominal	11.70	5.11	23.27	10.09	24.58	9.15	29.40	8.73	33.30	9.61	36.58	10.35	42.88	12.46
AMS4 (mm)	10.70	3.28	18.41	5.60	18.67	4.98	22.79	4.89	25.60	5.52	26.87	5.95	33.16	8.17

Table 4. Variability of the main statistical parameters of morphological indications at the Belarus men depending on the somatic type

Indication	Body build type													
	AstL		L		ML		M		MH		H		AdH	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Men up to 35													
Number of investigated	30		47		106		192		112		50		45	
Body length (cm)	167.51	7.7	169.40	6.14	171.61	5.63	172.69	5.99	173.6	6.01	174.17	5.73	175.26	5.40
Body weight (kg)	60.29	7.02	62.94	6.66	67.03	5.93	69.98	6.28	73.99	7.61	77.70	10.45	84.32	12.19
WLI (kg/cm)	35.96	3.51	37.14	3.42	39.04	2.95	40.51	3.18	42.60	4.03	44.59	5.68	48.14	7.09
Thorax circumference (mm)	873.80	44.81	883.28	47.40	907.77	43.35	920.90	45.77	940.68	54.29	956.16	75.31	1001.93	78.72
Biacromial breadth (mm)	385.67	14.71	386.47	19.90	392.42	17.64	392.33	16.87	393.94	15.78	395.28	18.17	399.53	18.10
Bicristal breadth (mm)	278.67	21.97	277.74	16.90	284.84	17.26	288.17	14.94	288.38	16.64	297.88	20.93	299.71	16.49
Thorax transversal diameter (mm)	289.93	24.09	285.43	19.88	289.20	15.92	290.16	15.49	292.41	20.63	293.48	23.24	299.13	26.37
Thorax sagittal diameter (mm)	180.03	13.37	186.83	13.30	197.68	12.29	202.51	11.75	208.17	12.09	214.78	13.61	231.38	19.89
IFT	62.49	6.99	65.69	5.81	68.48	4.58	69.86	3.50	71.42	5.06	73.51	5.99	77.82	8.38

Table 4. Continuation

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Distal epiphyses breadth (mm):														
of a humerus	68.47	5.05	69.60	5.22	70.82	3.57	72.93	3.26	73.99	3.82	73.92	4.91	75.71	4.35
of a femur	91.73	5.10	93.23	5.26	95.59	4.45	97.11	3.77	99.54	4.62	99.88	4.39	102.56	5.16
AMTD (mm)	80.10	4.35	81.41	4.42	83.21	3.35	85.02	2.40	86.76	3.46	86.90	3.85	89.13	4.13
Girths in the narrowest places (mm):														
of a forearm	175.33	11.38	176.23	11.44	180.26	9.33	184.76	7.90	189.72	10.27	190.90	13.47	199.42	13.64
of a crus	216.29	14.75	217.85	12.29	222.89	10.91	230.49	10.00	234.62	12.28	237.28	14.90	247.16	17.19
AMG (mm)	195.81	12.40	197.04	10.36	201.58	8.88	207.63	7.25	212.17	9.45	214.09	13.11	223.29	13.67
Skinfolds (mm):														
triceps	7.53	3.20	8.06	4.01	7.93	2.64	9.06	2.54	9.89	3.41	11.48	4.32	13.51	5.45
front thigh	7.00	2.35	7.36	3.32	7.66	2.85	8.69	2.40	9.73	3.59	11.52	4.83	13.76	5.82
subscapular	10.37	3.15	10.47	3.67	11.01	3.40	12.30	3.27	14.61	5.04	16.48	6.69	19.82	8.66
abdominal	12.10	5.18	12.36	5.83	12.88	5.55	15.58	5.07	19.10	8.45	22.38	9.92	25.67	11.22
AMS4 (mm)	9.25	3.09	9.56	3.48	9.87	3.11	11.41	2.73	13.33	4.41	15.47	5.81	18.19	7.30

Table 4. Continuation

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Men of 36–60													
Number of investigated	39		43		154		209		129		60		48	
Body length (cm)	162.6	4.99	166.59	5.16	168.07	5.85	169.07	5.97	169.24	5.53	172.17	6.54	174.07	5.65
Body weight (kg)	52.77	5.89	60.08	6.32	65.03	6.91	70.25	6.92	76.08	7.26	85.51	8.35	98.94	5.53
WLI (kg/cm)	32.45	3.46	36.05	3.46	38.68	3.78	41.53	3.62	44.97	4.16	49.69	4.72	56.84	5.53
Thorax circumference (mm)	856.03	36.20	893.07	45.26	922.14	49.73	946.35	44.35	988.98	52.81	1039.32	53.51	1095.85	61.57
Biacromial breadth (mm)	366.62	15.04	377.12	14.39	383.64	15.92	384.35	15.66	388.58	16.07	395.97	21.54	404.15	15.84
Bicristal breadth (mm)	277.15	12.72	284.33	14.28	289.95	14.15	292.53	15.31	298.15	17.08	305.52	14.61	314.48	12.82
Thorax transversal diameter (mm)	272.67	15.78	286.37	22.28	289.95	17.28	292.80	15.62	301.74	18.21	312.28	23.42	324.81	15.97
Thorax sagittal diameter (mm)	195.10	11.94	198.81	12.47	204.01	12.43	215.79	12.18	228.82	12.82	236.48	19.19	246.10	14.18
IFT	71.76	5.78	69.80	6.75	70.57	5.58	73.80	4.16	76.05	5.51	76.08	7.66	75.92	5.35

Table 4. Continuation

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Distal epiphyses breadth (mm):														
of a humerus	67.92	3.37	70.12	3.65	71.97	3.37	73.67	3.16	75.02	3.39	76.80	3.71	79.02	3.76
of a femur	89.41	3.60	91.88	4.04	94.42	4.17	96.10	3.52	98.38	4.08	99.60	4.50	103.15	5.95
AMTD (mm)	78.67	2.60	81.00	3.19	83.19	2.91	84.88	2.45	86.70	2.80	88.20	3.21	91.08	3.82
Girths in the narrowest places (mm):														
of a forearm	165.38	7.59	173.74	8.54	181.05	8.78	185.87	8.21	191.05	10.33	195.95	10.89	207.73	10.27
of a crus	198.41	8.54	210.51	12.19	220.36	12.67	225.62	9.92	232.00	14.01	238.62	11.47	250.21	11.73
AMG (mm)	181.90	6.03	192.13	9.40	200.71	9.16	205.74	7.29	211.53	10.39	217.28	9.67	228.97	9.66
Skinfolds (mm):														
triceps	5.72	1.69	6.47	2.10	7.90	2.71	9.18	2.47	10.63	3.01	12.80	3.06	15.08	3.88
front thigh	5.38	1.66	6.70	2.34	7.68	2.80	8.70	2.48	10.63	3.45	12.83	3.85	16.48	4.98
subscapular	8.15	3.08	10.19	4.28	11.98	4.35	13.73	3.94	17.64	5.33	21.08	5.31	25.98	5.42
abdominal	8.87	4.48	11.09	5.08	13.88	6.41	17.05	5.87	22.02	7.48	26.83	8.00	32.15	8.19
AMS4 (mm)	7.03	2.40	8.61	3.03	10.36	3.56	12.16	2.97	15.23	4.20	18.39	4.31	22.42	4.25
	Men higher than 61													
Number of investigated	4		5		22		17		15		11		6	
Body length (cm)	155.23	4.7	160.08	6.69	164.77	5.85	166.95	5.73	166.83	4.13	166.85	5.55	168.83	5.47
Body weight (kg)	50.18	4.03	53.84	3.31	60.00	5.94	67.65	7.38	68.88	7.18	75.25	8.24	85.00	3.76

Table 4. Continuation

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WLI (kg/cm)	32.37	3.02	33.69	2.62	36.50	3.24	40.47	3.57	41.32	4.53	45.18	5.28	50.37	2.30
Thorax circum-ference (mm)	870.25	59.34	861.00	34.04	913.59	35.09	923.06	65.75	968.67	50.50	992.18	54.05	1064.00	39.93
Biacromial breadth (mm)	347.50	8.66	366.00	21.02	371.55	14.84	372.88	16.35	378.53	15.76	388.82	19.10	391.83	8.38
Bicristal breadth (mm)	268.50	17.97	288.60	12.48	295.45	16.16	297.35	13.22	302.47	14.87	303.45	16.35	308.33	8.07
Thorax transversal diameter (mm)	271.75	18.79	273.00	11.42	281.77	15.76	287.29	12.62	292.93	15.93	300.36	23.04	318.83	11.29
Thorax sagittal diameter (mm)	199.00	23.34	212.20	10.85	215.77	11.22	220.76	15.60	236.80	10.04	233.73	16.03	247.00	16.89
IFT	73.20	6.27	77.97	7.33	76.80	5.80	76.90	5.15	81.09	6.04	78.30	8.61	77.58	6.51
Distal epiphyses breadth (mm):														
of a humerus	67.50	1.73	72.80	2.49	73.27	2.88	74.82	2.83	74.13	4.00	77.91	3.11	78.83	3.54
of a femur	88.75	2.63	91.00	3.32	94.14	3.04	96.35	3.87	98.67	3.37	98.36	4.52	96.33	2.88
AMTD (mm)	78.13	0.63	81.90	2.27	83.70	2.46	85.59	2.65	86.40	3.33	88.14	2.79	87.58	2.56
Girths in the narrowest places (mm):														
of a forearm	163.50	5.20	173.20	21.23	174.95	9.73	179.00	10.86	183.73	8.22	192.00	18.47	203.50	10.43
of a crus	204.75	18.21	190.60	13.50	208.18	15.92	224.53	12.26	222.20	11.98	235.91	9.85	240.50	12.29
AMG (mm)	184.13	11.53	181.90	16.11	191.57	9.55	201.76	7.19	202.97	8.92	213.95	10.44	222.00	6.63
Skinfolds (mm):														
triceps	6.00	1.63	7.00	1.41	8.00	2.74	10.71	3.12	11.20	4.39	12.36	4.34	14.50	2.17
front thigh	5.75	1.71	6.60	1.14	7.05	2.61	8.59	3.37	10.47	3.96	12.91	6.04	15.83	3.54
subscapular	9.00	1.83	9.80	1.48	11.68	4.56	14.06	2.97	15.20	5.12	18.45	5.43	24.83	5.12
abdominal	10.75	2.36	10.00	1.58	12.64	5.46	17.59	5.20	18.13	8.11	23.45	7.76	27.17	2.23
AMS4 (mm)	7.88	1.64	8.35	0.78	9.84	3.28	12.74	2.80	13.75	4.73	16.80	5.14	20.58	2.38

At the women of all the variants of body build in the average age the body mass rises, being a little bit reduced in the senile. This tendency of age variability of body mass is more weakly expressed at all the leptosome women. The intensity of the decrease of body mass, owing to the involution processes, is more expressed at the MH men and women and at AdH especially.

The thorax circumference varies a little with age at men of the leptosome variants of body build. Only since M-type perimeter of thorax increases in the mature age (especially at hypersome), then in the senile age it decreases a little not reaching the level of the young.

Among women, common for all the types, the tendency of augmentation of the given size in the mature age is observed. This size remains almost invariable at all the leptosome types in the senile age. At M and all hypersome types, the thorax circumference becomes less in the senile age.

According to IFT, the shape of the thorax gains more spherical outlines at all leptosome variants of men in the mature and especially in the senile age. The same direction of age variability, but less expressed, is observed at the representatives of ML, M, MH and H, but at AdH remains almost invariable in all the age periods. The gradual ascending of the given index from the young to the senile age is peculiar to women of all somatotypes (especially of hypersome variants).

Taking into consideration the definite dependence of body mass and thorax circumference from subcutaneous fat deposit, the age variability of thickness subscapular adipose folds is considered. At the AstL-representatives of both sex some decrease of its thickness in the senile age is observed. This sign is rather stable at the L and ML men, at M is slowly enlarged with age, and at MH, H and AdH increases noticeably in the average age and reduces in the senile. At women of L, ML, M and MH types, the thickness of the given fold gradually increases from the young to the senile age, at H-type – progressively reduces from the young to the average and from the average to the senile age, and at AdH – subscapular fold is stable to the senile age, a little raising only in this period.

The offered method of somatotyping on uniform normative scales, elaborated for the given region, including a small set of the most informative anthropometric indices, can be used at the population monitoring in the ecologically unfavorable situation. It will allow us to estimate more precisely the typological peculiarities of the reactivity of the organism and to select groups of risk requiring special preventive measures.

The uniform methodological and methodical principles, put in a basis of development of normative scales of somatotyping for children and adults of Belarus, allow us to use the method, offered by us, at the study of typological peculiarities of the variability of a body build: on pre-definitive, definitive and post-definitive stages of ontogenesis; during several generations; in severely distinguishing ecological niches.

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RELATIONSHIPS BETWEEN SKINFOLD THICKNESSES AND HANDGRIP STRENGTH IN 7-YEAR-OLD CHILDREN

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ABSTRACT

The aim of this study was to investigate the relationships between handgrip strength, general anthropometric parameters and some skinfold thicknesses in 7-year-old non-athletic Estonian children. In total, 93 children (47 boys, 46 girls) participated in this study. Body height was measured by Martin metal anthropometer (0.1 cm) and body mass by medical electronic scale (0.05 kg). All children were at Tanner's [12] stage 1. In total, eight skinfolds (biceps, triceps, subscapular, supraspinale, suprailiac, medial calf, lateral calf, thigh) were measured. The maximal handgrip strength of the right and left hand was measured with a hand dynamometer. There were highly significant relationships between handgrip strength and body height both in boys (right hand – r = 0.620, left hand – r = 0.646) and girls (right hand – r = 0.564, left hand – r = 0.464). The relationship with body mass is high as well both in boys (right hand – r = 0.478, left hand – r = 0.478) and girls (right hand – r = 0.564, left hand – r = 0.499). The relationship between handgrip strength and skinfold thicknesses is statistically insignificant. It was concluded that the children's general development (growth) is highly influenced by the general muscle strength. "Passive" tissue (fat mass) is not influenced by handgrip strength.

Key words: handgrip strength, body height, body mass, skinfold thicknesses, children

INTRODUCTION

Because handgrip is critical to many daily activities, grip strength is frequently used in clinical settings as an indicator of overall physical strength and health [2,6]. Grip strength studies frequently test a few trials of one repetitive maximum grip (maximum voluntary contraction) and examine the effect of different variables such as age [12], gender [13], body build [8] and physical activity [9].

Normative dates of the handgrip strength for healthy children have been reported previously by several researchers from different countries [7,14,16]. Unfortunately, the norms for Estonian grammar school children are still absent. However, some results of handgrip strength have recently been presented for Estonian grammar school children by Jürimäe and Saar [4] and 11–17-year-old children by Jürimäe and Volbekiene [5]. Handgrip strength results in preschool children have been presented by Oja and Jürimäe [11].

Normally the handgrip strength in boys is stronger compared with girls of the same age [1], but frequently the difference is not statistically significant in grammar school children [16]. About 90% of the children have the right hand as the dominant one [16]. There are conflicting results about the differences between dominant and non-dominant handgrip strength in children. For example, Sartorio et al. [15] found a significant difference and on the contrary, Mathiowetz et al. [7] found insignificant differences between dominant and non-dominant handgrip strength in children.

In several studies, handgrip strength significantly correlated with general anthropometric parameters (body height, body mass) in children and adolescents [3,15]. Sartorio et al. [15] explained that from the body composition parameters, fat-free mass (FFM) highly influenced the handgrip strength in children – inter-gender differences are strongly related to changes of FFM values occurring during childhood. Nevertheless, to our knowledge, there are no studies of handgrip strength in relation to "passive" tissue of body composition, skinfold thicknesses in young children. We hypothesized that general body anthropometry (body height, body mass) is a stronger predictor of handgrip strength than skinfold thicknesses in children. The aim of this study was to investigate the relationships between handgrip strength, general anthropometric parameters and some skinfold thicknesses in 7-year-old non-athletic Estonian children.

METHODS

In total, 93 7-year-old Estonian schoolchildren participated in this study (47 boys and 46 girls). All children participated in compulsory physical education classes at school 2 times a week. All subjects were healthy and none of them was at that moment taking any medications and they did not experience any pain or disability in their upper extremities. All children and parents were thoroughly informed of the purposes and contents of the study and written informed consent was obtained from the parents or the adult subjects before participation. The study was approved by the Medical Ethics Committee of the University of Tartu (Estonia).

The children's body height was measured by Martin metal anthropometer (0.1 cm) and body mass by medical electronic scale (0.05 kg). All children were at Tanner's [17] stage 1, using pubic hair and pubic hair and breast development in boys and girls, respectively. In total, eight skinfolds (biceps, triceps, subscapular, supraspinale, suprailiac, medial calf, lateral calf, thigh) were measured using skinfold caliper. Children were dressed in light underwear during the measurements. Skinfold thickness measurements were performed by a well-trained anthropometrist.

The maximal handgrip strength of the right and left hand was measured with a hand dynamometer (Takei Scientific Instruments Co., Ltd tkk5001, Japan). Hand dominance was determined by asking for the hand used to hold a pencil and throw a ball [14]. The children were standing comfortably with shoulders abducted. The dynamometer was held freely without support, not touching the subjects' trunk. The position of the hand remained constant with the downward direction. The palm did not flex on the wrist joint. The children were required to exert maximal strength on the dynamometer (maximum voluntary contraction). All subjects performed three trials and the best performance was taken into account.

The statistical analyses were conducted using the SPSS version 10.0 statistical software program (SPSS Inc., Chicago, IL). Standard statistical methods were used to calculate mean ($\overline{X}$) and standard deviations (± SD). The paired t-test for dependent variables was used for determining the differences between boys and girls. Pearson correlation coefficients were used to determine the relationships between dependent variables. The effect of general body anthropometrical parameters (body height and body mass) and skinfold thicknesses on the handgrip strength was analysed using stepwise multiple regression analysis. The level of significance was set at $p < 0.05$.

RESULTS

The mean general anthropometric parameters and skinfold thicknesses in boys and girls are presented in Table 1. Boys were taller ($p < 0.05$) and heavier ($p < 0.05$) than girls. All the measured skinfold thicknesses were thicker in girls (Table 1). However, only in triceps and thigh were the differences between sexes statistically significant ($p < 0.05$). Mean handgrip strengths are also presented in Table 1. In boys, mean results were higher compared with girls ($p < 0.05$). In the same sex, the differences betweeen right and left hand were not statistically significant ($p > 0.05$).

Table 1. Mean (± SD) general anthropometric parameters, skinfold thicknesses and handgrip strength in children.

	Boys (n = 47)	Girls (n = 46)	p
Age (yrs)	7	7	
Body height (cm)	126.0 ± 5.9	123.0 ± 5.2	< 0.05
Body mass (kg)	26.5 ± 4.1	24.0 ± 3.4	< 0.05
Tanner stage	1	1	
Skinfolds (mm):			
Biceps	5.02 ± 2.38	5.90 ± 2.61	NS
Triceps	9.47 ± 2.56	11.20 ± 2.73	< 0.05
Subscapular	5.76 ± 1.86	6.35 ± 2.61	NS
Supraspinale	5.16 ± 2.53	5.64 ± 2.51	NS
Suprailiac	7.39 ± 3.18	8.57 ± 3.18	NS
Medial calf	9.43 ± 3.25	10.57 ± 2.62	NS
Lateral calf	10.33 ± 2.47	10.84 ± 1.84	NS
Thigh	12.31 ± 3.41	14.29 ± 3.65	< 0.05
Handgrip strength (kg)			
Right hand	13.48 ± 3.09	10.16 ± 2.83	< 0.05
Left hand	12.68 ± 2.79	9.73 ± 2.56	< 0.05

NS – not significant

There were highly significant relationships between handgrip strength and body height both in boys (right hand – $r = 0.620$, left hand – $r = 0.646$) and girls (right hand – $r = 0.564$, left hand – $r = 0.464$). The relationship with body mass is high both in boys (right hand – $r = 0.478$, left hand – $r = 0.478$) and girls (right hand – $r = 0.564$, left hand – $r = 0.499$). In none of the groups was the relationship between handgrip strength and skinfold thicknesses statistically significant. Stepwise multiple regression analysis indicated that none of the skinfold thicknesses were included in the models.

DISCUSSION

The main conclusion of our study is that only the general anthropometric development of children (body height, body mass) is the main predictor that influenced the handgrip strength. The "passive" body tissue (fat tissue) is not influenced by handgrip strength in neither 7-year-old boys nor girls.

In our study, 36 of the 47 boys (77%) and 40 of the 46 girls (87%) were right-handed. This is similar to other studies [16]. It is difficult to compare the mean handgrip strength values because there are not standards available for Estonian children. However, our results are slightly higher than the values for 6-year-old Estonian children [11].

The relationship between general anthropometric parameters (body height, body mass) is high both in boys and girls (see Table 1). This is in agreement with other studies [3]. This means that the total growth (biological development) is the most important factor influencing the general muscle strength in children. This means that prepubertal children who are taller and whose body mass is higher have more handgrip strength. However, fat tissue (skinfold thicknesses) is not a factor that increased strength. This is again a confirmation of the results of Sartorio et al. [15] that from the body composition parameters, the most important is the fat-free mass, which influenced handgrip strength.

Our conclusion is that the children's general development (growth) is highly influenced by the general muscle strength (handgrip strength). "Passive" tissue (fat mass) is not influenced by handgrip strength.

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COMBINED ASSESSMENT OF PROFICIENCY IN THE GAME, ANTHROPOMETRIC VARIABLES AND HIGHEST REACH TESTS RESULTS IN A BODY BUILD CLASSIFICATION AT GIRLS' YOUTH EUROPEAN VOLLEYBALL CHAMPIONSHIP 2005 IN TALLINN

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ABSTRACT

The paper analyses, based on registration sheets, the height, weight, BMI, results of spike test and two-hand block tests of the teams of 12 countries (ages 14–17 years, n=144) who participated in Girls' Youth European Volleyball Championship in Tallinn from 29 March to 3 April 2005. The data were analyzed in a body build classification that divided the girls into types based on height and weight: (1) small, (2) medium, (3) big, (4) pycnomorphous, (5) leptomorphous. Height and weight differed significantly between the classes; the results of the spike test and two-hand block tests were the best in classes 3 (big) and 5 (leptomorphous). The teams' ranking depended most significantly on how many members belonged to class 3 and, thereafter, to classes 4 and 5.

Key words: young female volleyball players' anthropometry, body build classification, volleyball performance.

INTRODUCTION

Compared to elite female volleyballers, the body build peculiarities of adolescent female volleyballers have until now received relatively less attention [1, 4]. However, ball handling skills as well as physical and psychophysiological abilities are known to be in close correlation with the girls' age-related constitutional peculiarities [3, 5, 10]. Therefore, in order to improve adolescents' volleyball coaching, it would be necessary to make use of all opportunities to relate young female volleyballers' results at competitions with their individual body build and physical abilities.

One of the problems that hinders the application of anthropometric data is the fact that until now most researchers have not used a classification that would be suitable for simultaneous comparison of the main characteristics – height and weight. Usually, these are still assessed separately. This, in its turn, makes it difficult to assess which somatotypes – which relations between height and weight – the most promising players should have.

The authors of the article have been engaged in detailed anthropometric research of young female volleyballers for a considerable time [6, 8]. We have studied the regularities of young female volleyballers' anthropometric body structure and found that it is a system consisting of a number of body measurements, all of which are in statistically significant correlation, but primarily they are correlated with height and weight. Thus, height and weight are the leading characteristics of the system and determine more than 50% of the variability of all the other characteristics. At the same time, each variable is also a part of the system as it does not represent only one concrete measurement of the body but always also represents the body as a whole. The authors have shown that, therefore, the body as a whole would be best described in a height-weight classification as this enables us to systematize all the other length, breadth and depth measurements and circumferences.

The authors have also used this classification to systematize, in addition to body measurements, the results of physical abilities tests [9].

In cooperation with the staff of the Centre of Physical Anthropology of the University of Tartu [2], the authors have established that the body build structure of adolescent female volleyballers is similar to the body build structure of all schoolgirls of the same age. To study the latter, the same height-weight classification was used.

In the present study, the authors used the body build classification in order to systematize the girls of 12 nationalities who participated in the Girls' Youth European Volleyball Championship into body types and to assess, along with anthropometric data, the results of highest reach jumping tests in body types and to analyse which body types were most successful at competitions.

MATERIAL AND METHODS

The present article analyzes, based on registration sheets, the body build, highest reach tests results and their correlation with competitions results of 12 teams (age 14–17 years) who participated at Girls' Youth European Volleyball Championship in Tallinn from 29 March to 3 April 2005. The 12 teams included 144 girls – 12 members in each team. The final ranking of the teams was the following: (1) Ukraine, (2) Russia, (3) Italy, (4) Croatia, (5) Germany, (6) Belarus, (7) Austria, (8) the Czech Republic, (9) Serbia and Montenegro, (10) Turkey, (11) Estonia, (12) Hungary.

The data for analysis were taken from the teams' registration sheets that included the age, weight (kg), height (cm) and data on highest reach tests results for the members of all the 12 teams.

The jump tests included a spike test with one hand in centimetres and block test with two hands in centimetres. In addition, the authors calculated the body mass index of each player.

Statistical analysis

The data were analyzed using the SAS system. The mean and SD values of age, weight, height, BMI, spike test and two-hand block test were calculated for the whole sample and for all the 12 teams according to their results (place 1–12) (Table 1). In addition to finding the mean data of teams, analysis was also performed in the body build classification.

The basis for creating the body build classification of girls with different age was the mean height, weight and their standard deviations for the whole sample. To create a 5SD classification, first a classification was formed of 3×3=9 SD classes of height and weight (small, medium, big). From this classification, we took three classes

Table 1. Mean anthropometric values and highest reach test results in 12 teams (12 players in each team) according to their ranking in Girls Youth European Volleyball Championship 2005

Variable	Mean		1st place	2nd place	3rd place	4th place	5th place	6th place	7th place	8th place	9th place	10th place	11th place	12th place
n=144	$\bar{x}$ SD	Minimum Maximum	$\bar{x}$ SD	$\bar{x}$ SD	$\bar{x}$ SD	$\bar{x}$ SD	$\bar{x}$ SD	$\bar{x}$ SD	$\bar{x}$ SD	$\bar{x}$ SD	$\bar{x}$ SD	$\bar{x}$ SD	$\bar{x}$ SD	$\bar{x}$ SD
1. Age	16.64 0.71	14.0 17.0	16.67 0.49	16.67 0.65	16.83 0.39	16.83 0.39	16.75 0.45	16.50 0.91	16.50 0.80	16.92 0.29	16.25 0.87	16.67 0.78	16.33 1.07	16.75 0.87
2. Weight	65.94 7.69	48.0 89.0	65.00 9.62	68.92 4.87	68.50 6.91	69.58 9.10	66.67 4.91	67.92 6.13	53.00 2.17	64.67 3.80	67.33 5.76	68.75 4.65	68.92 7.39	62.08 8.55
3. Height (cm)	182.19 5.88	163.0 198.0	184.67 5.60	181.41 5.16	182.92 5.05	180.50 8.09	182.33 3.11	183.08 4.99	176.42 4.30	182.33 5.07	186.17 5.89	182.75 4.85	181.08 6.97	179.58 6.01
4. BMI	19.84 1.92	14.71 24.39	19.03 2.57	20.29 1.67	20.45 1.66	21.30 1.71	20.06 1.47	20.24 1.28	17.03 0.51	19.47 1.17	19.44 1.56	20.59 1.27	21.02 1.96	19.21 2.10
5.Spike (cm)	292.90 10.18	261.0 315.0	304.08 6.33	302.33 5.97	294.58 8.19	286.58 12.61	296.33 4.81	296.08 7.38	284.33 3.92	297.67 8.94	288.92 8.78	287.46 8.53	290.33 9.73	285.67 10.42
6. Two-hand block (cm)	279.94 11.34	246.0 305.0	298.33 5.77	290.58 3.66	277.25 7.53	274.17 13.54	281.50 4.12	285.92 8.13	268.33 2.84	281.00 8.06	276.08 10.80	274.00 7.97	279.17 9.66	272.42 10.44

of concordant height and weight (small height – small weight; medium height – medium weight; big height – big weight). The remaining six classes were joined into two classes of disconcordant height and weight (big weight and small height – pycnomorphs; small weight and big height – leptomorphs; see Fig. 1).

Weight classes				
		Light	***Medium***	***Heavy***
Height classes	***Short***	**Small**		**Pycno-**
	Medium	**Lepto-**	**Medium**	**morphic**
	Tall	**morphic**		**Large**

Fig. 1. Body build classes

Thus, the five height-weight SD classes were created according to the following rules:

Class 1 (small)
weight < $\bar{x}_w$ – 0.5 SD_w and height < x – 0.5 SD_h

Class 2 (medium)
$\bar{x}_w$ – 0.5 SD_w ≤ weight ≤ + 0.5 SD_w and $\bar{x}_h$ – 0.5 SD_h ≤ height < 0.5 SD_h

Class 3 (large)
weight ≥ $\bar{x}_w$ + 0.5 SD_w and height ≥ $\bar{x}$ + 0.5 SD_h

Class 4 (pycnomorphs)
weight ≥ $\bar{x}_w$ – 0.5 SD and height < $\bar{x}_h$ – 0.5 SD_h or
weight ≥ $\bar{x}_w$ + 0.5 SD and height < x + 0.5 SD_h

Class 5 (leptomorphs)
weight < $\bar{x}_w$ – 0.5 SD and height ≥ $\bar{x}_h$ – 0.5 SD_h or
weight < $\bar{x}_w$ + 0.5 SD and height ≥ x_h + 0.5 SD_h (see Fig. 1).

Girls of different ages (14–17 years) were placed into the classes of a common height-weight classification according to their individual height and weight. Thereafter the average ages of girls of all classes were compared, and, as no statistically significant differences were revealed between the classes, the application of such a common classification was found to be justified (Stamm et al. 2001, Kaarma et al. 2005).

Table 2. Mean anthropometric values and highest reach test results in body build classes in Girls Youth European Volleyball Championship 2005

	Class 1 Small n=25		Class 2 Medium n=23		Class 3 Large n=27		Statis-tics 1–3	Class 4 Pycnomorphic n=40		Class 5 Leptomorphic n=29		Statis-tics 4–5
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD	
Age	16.28	0.94	16.52	0.79	16.78	0.42	–	16.83	0.50	16.66	0.77	-
Weight (kg)	55.08	4.11	65.48	2.06	74.11	4.34	+	70.23	4.57	62.17	5.16	+
Height (cm)	174.32	3.49	182.52	1.76	188.89	2.59	+	179.83	3.80	185.72	4.24	+
BMI	18.14	1.45	19.66	0.84	20.78	1.22	+	21.71	1.15	18.01	1.19	+
Spike (cm)	281.56	8.03	293.39	8.08	300.19	8.55	+	291.51	8.31	297.38	8.24	+
Two-hand block (cm)	267.40	8.03	280.65	9.16	287.85	9.36	+	278.74	9.05	284.41	10.71	+

Table 3. Distribution of players between body build classes according to the ranking of teams

Ranking of teams	Body build classes					
	Class 1 Small n=25	Class 2 Medium n=23	Class 3 Large n=27	Class 4 Pycnomorphic n=40	Class 5 Leptomorphic n=29	Total
1	1 8.33%	1 8.33%	4 33.33%	2 16.67%	4 33.33%	12 100%
2	0 0.00	1 8.33%	5 41.67%	4 33.33%	2 16.67%	12 100%
3	2 16.67%	2 16.67%	3 25.00%	4 33.33%	1 8.33%	12 100%
4	3 25.00%	1 8.33%	3 25.00%	4 33.33	1 8.33%	12 100%
5	1 8.33%	2 16.67%	1 8.33%	5 41.67%	3 25.00%	12 100%
6	2 16.67%	4 33.33%	2 16.67%	3 25.00%	1 8.33%	12 100%
1–6 total	9 12.50%	11 15.28%	18 25.00%	22 30.56%	12 16.67%	72 100%
7	8 66.67%	0 0.00	0 0.00	0 0.00	4 33.33%	12 100%
8	1 8.33%	3 25.00%	1 8.33%	3 25.00%	4 33.33%	12 100%
9	1 8.33%	3 25.00%	3 25.00%	1 8.33%	4 16.67%	12 100%
10	0 0.00	3 25.00%	3 25.00%	4 33.33%	2 16.67%	12 100%
11	1 8.33%	2 16.67%	1 8.33%	7 58.33%	1 8.33%	12 100%
12	5 41.67%	1 8.33%	1 8.33%	3 25.00%	2 16.67%	12 100%
7–12 total	16 22.22%	12 16.67%	9 12.50%	18 25.00%	17 23.61%	72 100%

Among teams 1–6 there was a statistically significant difference between classes 1–4, 2-4 and 4–5.
Among teams 7–12 there was a statistically significant difference between classes 3–4 and 3–5. The difference in percentage was checked by z-test.

Then the means and standard deviations of age, weight, height, BMI, spike test and two-hand block tests were calculated in all the five classes. Using the Scheffé-test, the class means of all anthropometric data were compared between classes 1 and 3 but also between classes 4 and 5, using the significance level $\alpha = 0.05$ (Table 2).

The proportion of players with different body types in better and weaker teams differed. The difference in percentage was checked by z-test (Table 3).

The statistical analysis was performed by Säde Koskel M.Sc. from the University of Tartu.

RESULTS

Table 1 presents the basic statistics of all the data gathered. These are the means and standard deviations of height, weight, BMI, highest reach tests – spike and two-hand block in the order of places the teams achieved. The mean age of the subjects (n=144) was 16.63 years (minimum 14 and maximum 17 years).

The players' mean weight was 65.94 kg, varying from 48 to 89 kg. Their mean height was 182.19 cm (from 163 to 198 cm). The mean BMI was 19.84 (from 14.71 to 24.39).

There were no systematic changes in height and weight according to the teams' ranking from the 1st to the 12th place. Neither did linear correlation analysis show any significant correlations between age, height, weight and the teams' ranking.

The results of spike and two-hand block tests, however, seemed to have higher values in teams who achieved higher places, and this was confirmed by correlation analysis. Thus the spike test ($r=0.423$) and two-hands block test ($r=0.448$) were in significant correlation with the teams' ranking.

In addition to ranking, the tests results correlated significantly with height and weight. Age did not correlate with ranking, height and weight.

In order to compare girls of different nationalities simultaneously on the basis of anthropometric variables and test results, we divided the competitors into five height-weight classes (see methods). This classification divides the subjects into body types according to height and weight, differentiating between small, medium, large, pycno-morphous and leptomorphous types. The creation of a common classification for all girls was facilitated by the fact that age did not show any correlation with height, weight or highest reach jump tests.

Table 2 shows the mean values of height, weight, BMI, spike and two-hand block tests according to five body build types.

It was interesting to observe the jump tests results according to body build types (Table 2). The numerical values of jump tests results increase gradually from classes small to medium to large. There is an essential difference between the pycnomorphous and leptomorphous types, the latter achieving considerably better results.

As known, the jump tests results depend on arm length and on general physical development. The fact that the girls of class 3 – the big type – surpass the others by their body measurements as well as tests results refers to their better general physical abilities.

Next, we analyzed how the teams' ranking in competitions was influenced by the distribution of body types in teams.

For this purpose, we analyzed the distribution of body types in teams who achieved the 1^{st}–6^{th} place and the 7^{th}–12^{th} place (Table 3).

We found that the number of small players was smaller in the better group (n=9, 12.50%) and relatively high in the weaker group (n=16, 22.22%). The difference in the number of girls with medium build was smaller – 15.28% in the better group and 16.67% in the weaker group.

The greatest difference between the groups could be noticed in class 3 – big girls. In the better group 25% of players belonged to class 3; in the weaker group, however, only half of that – 12.50%.

The number of pycnics in the better group was the highest – 30.56% – and in the weaker group 25%. The percentage of leptosomes was 16.67% and 23.61% respectively.

Thus, we can conclude that proficiency in the game is primarily influenced by the percentage of players of class 3 in teams. In the better teams, their percentage was twice higher than in the less successful teams. The number of pycnics and leptosomes in teams is also significant. In the Ukrainian team who won the championship 10 girls out of 12 belonged to classes 3–5; in the Hungarian team who remained last, their number was only 6.

DISCUSSION

Research results showed that our classification suited for combined assessment of anthropometric data and highest reach tests results of adolescent female volleyballers of different nationalities. The classification divides girls into five types of body build, which enables us to assess the differences between body build types in performing jump tests.

It was essential for the present study that this kind of classification made it possible to assess the future prospects of girls with different body types as competitive players. Although each team included players with different body types, the analysis showed that the teams' success was primarily determined by the number of girls of the third type in the team, who were followed by pycnic and leptosomic players.

Connections between proficiency in the game and body build have earlier been demonstrated on a sample of young Estonians, using their basic anthropometric variables. The authors have shown in their earlier studies that, relying on 14 basic anthropometric variables of 32 young Estonian girls, it was possible to predict statistically significantly the efficiency of performance of serve, reception, block, feint and attack within 32–83% [5]. Studying the individual proficiency of young female volleyballers at Estonian championships for 13–16-year old players (n = 77, 14 anthropometric measurements) in 2004, the authors showed that with the exception of serve, the performance of all the other elements of the game correlated with body measurements. The players successful at attack, block and reception were taller and heavier; they had larger dimensions of the wrist and several other measurements [7].

Consequently, as the essential role of body build in proficiency in the game has repeatedly been confirmed, we are of the opinion that the types represented in the body build classification can be treated as types of morphological constitution, and in the future much more thoroughgoing constitutional studies of volleyballers should follow.

In conclusion, we can recommend such a body build classification for other authors in order to assess the body build of adolescent female volleyballers of either one nationality or different nationalities.

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SOMATOTYPE IN ADOLESCENTS FROM A BIG CITY AND A SMALLER TOWN

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ABSTRACT

The study includes data of 449 boys and 465 girls in Sofia and 169 boys and 192 girls in Smolyan aged 9 to 17 in the mid 1980s. A proper somatotyping schedule is used to trace the constitution and its changes in adolescence in Sofia the capital of Bulgaria and in the smaller town Smolyan. The suitability of this schedule is confirmed by a correlation analysis. In the investigated adolescents intersexual differences in somatotype are established already in the juvenile stage of development (higher mesomorphism in boys, higher endomorphism in girls). These differences persist and increase during puberty. At the same time significant differences are found in the somatotype of the adolescents in the capital and in Smolyan. The boys from the smaller town are more mesomorphic, and girls – more mesoendomorphic than the ones in Sofia ones. A probable reason of these differences is the higher physical activity in the smaller town, and the peculiarities in the way of nutrition.

Key words: Somatotype, adolescence, stage of maturation, city-town differences, intersexual differences.

INTRODUCTION

The constitution in adolescents and its relations with the processes of growth, physical and sexual maturation constitute the object of many studies [2, 3, 5]. In Bulgaria the somatotypes of adolescents until quite recently were studied mostly as conserns of the sport activity [8, 12, 15, 17]. However, since the development of the human organism in childhood and adolescence is under the influence of the social environment, we should expect social differences in the somatotype. Such differences were in fact established during the analysis of anthropological data about the physical development of adolescents from two urban settlements differing in the number of population and social characteristics in Bulgaria (the capital city Sofia and the rural town of Smolyan) [9, 10, 11]. In these studies, however, the differences in the somatotype are only shortly mentioned as a part of the physical development, without any numerical evaluation.

The aim of the present study is exactly to analyse in detailes the dynamics of the somatotype according the chronological age and the stage of sexual maturation in two settlements, different by their sociological characteristics.

MATERIAL AND METHODS

This study is based on the data from individual measurements of 449 boys and 465 girls in the city of Sofia and of 169 boys and 192 girls in the town of Smolyan, aged 9 to 17 years, investigated in 1984–1987. Some measurements, necessary for the evaluation of the somatotype after the most popular schedule of Heath-Carter [18], were ommited in the initial plan of the investigation. It is well known, however, that "almost every problem in anthropology needs for its solution an individual method or modification of methods in connection with its specificity. There are not any universal methods, every method has its own peculiarities and a specific area of application [6]. At the same time, in spite of the existance of numerous and various classifications of the constitutional types, in fact, the investigators determine three major types, named by different, i.e. synonymous terms [7]. For example, I. Salivon and N. Polina elaborate the modification of another popular schedule of the constitutional typology, the scedule of Chtetsov [14], for the needs of its adaptation to the materials from mass investigations of Belarussian schoolchildren [16]. In Bulgaria attempts to create their own somatotypological schedules have been made by D. Kadanoff and his students [7] and also by G. Angelov [1]. That was the reason to make an attempt to use a proper schedule of determination of the constitutional type, adapted to our material. In the schedule proposed here the particular components of the somatotype are determined on the basis of the same or analogical somatic parameters, as in the Heath-Carter schedule. Thus, the present schedule can be considered as a modification of the Heath-Carter`s one. The endomorphism is evaluated on the basis of the sums of the skinfolds on the extremities. The mesomorphism is evaluated on the basis of the relative biacromial width (biacromial index) and the relative upper arm (biceps) muscle circumference. The ectomorphism – on the basis of the body mass index. The standard deviation score method is used for the evaluation of these parameters. As a control (basis) sample, 199 boys of Sofia in the juvenile stage of development (mean age 11.2 years) are used (Table 1). The somatotype of this basic sample is accepted to be 3:3:3. The stages of sexual maturation are determined after Schwidetzky-Pavilonis [4, 11, 14].

Table 1. Mean values and their standard deviations of the anthropological parameters, which determine the somatotype in the basic sample (boys, Sofia, juvenilie stage of maturation).

	Sum of 4 upper arm skinfolds (Sua), mm	Sum of 4 thigh skinfolds (Sth), mm	Biacro-mial index (BI), %	Relative upper arm muscle circumference (RMCua), %	Body mass index (BMI), kg/sq. m.
N	180	180	194	176	195
M	45.58	81.43	21.04	12.53	17.67
SD	20.05	36.52	0.98	1.49	2.78

Formulae:

End = ½ . (((Sua – M(Sua))/SD(Sua)+(Sth-M(Sth))/SD(Sth)) +3

Mez = ½ . (((BI – M(BI)))/SD (BI) + (RMCua-M(RMCua)/SD(RMCua)) + 3

Ect= 3 – ½ . (((BMI-M(BMI))/SD(BMI)

Sua – Sum of 4 upper arm skinfolds

Sth – Sum of 4 thigh skinfolds

BI – Biacromial index (Biacromial diameter/height)

RMCua – Relative upper arm muscle circumference (upper arm muscle circumference/height), where the upper arm muscle circumference is evaluated after the formula

MCua = Cua – 3,14 /4 .Cua (Cua – upper arm circumference, MCua – upper arm muscle circumference).

BMI – Body mass index (weight/height in square)

M(x) и SD (x) – mean value and standard deviation of the parameter *x* in the basic sample.

RESULTS AND DISCUSSION

In the schoolchildren, investigated in Smolyan and in a part of Sofia schoolchildren, it was possible to use both schedules. The values, calculated after the proposed schedule values of the major components of the somatotype, show a high degree of correlation (0.58–0.87) with the corresponding components, calculated after the Heath-Carter methods (Table 2). The high level of statistical significance of this correlation (over 0.001) confirms the suitability of the modified schedule for the analysis of the somatotype.

Table 2. Correlations between the somatotype components, evaluated by the schedule, used in this study and the Heath-Carter schedule.

Sex	Investigated individuals and correlation coeeficient after the component		Sofia	Smolyan	Total
Males	N		172	168	340
	Component	I	0.743	0.755	0.711
		II	0.580	0.598	0.590
		III	0.801	0.794	0.805
Females	N		78	191	269
	Component	I	0.710	0.861	0.711
		II	0.702	0.674	0.683
		III	0.842	0.863	0.869

$P < 0.001$ for all correlations.

The numerical evaluations of the major components of the somatotype according the sex, the chronological age and the stage of sexual maturation are presented in Table 3 and Table 4. (Fig. 1 and 2). They show that the Smolyan adolescents are more massive (less ectomorphic) in all ages and the developmental stages. A digression can be observed only in the prepuberty. It can not be statistically vertified because of the small number of the investigated children in this stage. However, since it is observed in both sexes in the same stage of development (and only in it!) it has to be mentioned.

The higher massiveness of the Smolyan boys is a result of a strongly expressed mesomorphism. The level of their subcutaneous fat tissue, i.e. the endomorphism, is lower. In the Smolyan girls, however,

Table 3. Somatotype in adolescents in Sofia and Smolyan according the chronological age (means, standard deviations and significance of intersample differences).

Sex	Age, years at last birthday	Number		Endomorphism		Mesomorphism		Ectomorphism	
		Sofia	Smolyan	Sofia	Smolyan	Sofia	Smolyan	Sofia	Smolyan
FE-MALES	9–10	99–100	15	3.4	**3.8**	2.8	**3.1**	**3.0**	2.5*
				0.7	0.7	0.9	0.5	0.7	0.8
	11	65	22	3.5	**3.9***	2.7	**3.3*****	**2.8**	2.7
				0.7	0.5	0.6	0.6	0.9	0.6
	12	58	37	3.3	**4.0*****	2.6	**3.1*****	**2.5**	2.4
				1.0	0.8	0.8	0.7	1.2	0.9
	13	86	19–20	3.7	**3.8**	2.9	**3.2**	2.1	2.1
				0.7	0.7	0.7	1.0	1.3	1.3
	14	49	26	4.2	**4.4**	3.1	3.4	**1.8**	1.4
				1.0	0.6	0.6	1.0	1.0	1.2
	15	63	35	4.4	4.3	3.0	3.3	1.6	1.6
				0.9	0.7	0.9	0.7	1.2	0.8
	16	41	33	4.1	**5.2*****	3.1	**3.9*****	**1.8**	0.5***
				0.7	0.6	0.7	0.9	1.1	1.2
MALES	9-11	154–172	23	**3.0**	2.5***	3.1	**3.8*****	**2.9**	2.5*
				0.8	0.4	0.8	0.7	1.0	0.7
	12	65–72	46	**3.5**	3.0**	2.9	**3.8*****	**2.5**	1.9*
				1.2	0.8	0.9	0.7	1.2	1.3
	13	69	33–34	**3.4**	2.6***	3.0	**3.7*****	2.5	2.2
				0.8	0.8	0.9	0.9	0.9	1.1
	14	60	26	**3.1**	2.8	3.4	**3.9***	**2.0**	1.4
				0.9	1.1	0.8	0.9	1.0	1.7
	15	36	23	**3.5**	2.6*	3.9	**4.1**	1.6	1.6
				1.4	0.7	0.9	0.9	1.2	1.3
		29	15–16	**3.2**	2.3**	4.6	4.6	1.3	1.3
	16			**1.5**	0.4	1.0	0.8	0.9	0.8

*– p<0.05; ** p < 0.01, *** p < 0.001

Table 4. Somatotype in adolescents in Sofia and Smolyan according to the stage of sexual maturation (means, standard deviations and significance of intersample differences).

Sex	Stage of sexual maturatione	Number		Endomorphism		Mesomorphism		Ectomorphism	
		Sofia	Smolyan	Sofia	Smolyan	Sofia	Smolyan	Sofia	Smolyan
FE-MALES	Juvenilis –1	61–62	15	3.2	**3.5**	2.7	**3.1***	**3.4**	3.0*
				0.6	0.6	0.8	0.6	0.6	0.5
	Juvenilis –2	36	14	3.5	**4.0***	2.7	**3.2****	**3.1**	2.2***
				0.8	0.7	0.7	0.6	0.7	0.8
	Prae-puberitas	37	10	3.5	**3.9**	2.8	**3.2**	2.6	**2.8**
				0.8	0.7	1.0	0.6	1.1	0.8
	Phasis cetera	72	35	3.6	**4.0***	2.7	**3.1***	**2.6**	2.3
				0.9	0.8	0.7	0.9	1.1	1.2
	Phasis lenta	127	31	3.8	**4.1***	2.8	**3.1**	**2.1**	2.0
				0.8	0.5	0.7	0.8	1.0	0.9
	Post-puberitas	100	37-38	4.1	**4.2**	3.1	3.4*	1.6	**1.7**
				0.8	0.7	0.7	0.7	1.0	0.7
	Adultus	31	49	4.3	**5.0****	3.5	**3.8**	**1.3**	0.5*
				1.1	0.6	0.9	0.9	1.5	1.1
MALES	Juvenilis	176–199	43–44	**3.0**	2.5***	3.0	**3.7*****	**3.0**	2.7*
				1.0	0.6	0.8	0.7	1.0	0.9
	Prae-puberitas	30–31	22	3.4	2.8**	3.3	**3.5**	2.2	**2.4**
				0.8	0.6	1.0	0.7	1.2	0.8
	Phasis cetera	94	48–49	3.3	3.1	3.0	**3.7*****	**2.3**	1.6***
				0.9	1.0	0.8	0.8	1.0	1.4
	Phasis lenta	104	40–41	**3.2**	2.5***	3.7	**4.3*****	**1.8**	1.5
				1.2	0.6	1.0	0.7	1.0	1.2
	Post-puberitas	15 21	11 13	**3.5**	2.5	4.7	4.7	**1.1**	0.8
	Adultus	6	2						
				2.2	0.8	1.1	1.2	1.0	0.9

* – p<0.05; ** – p<0.01; *** – p<0.001

Fig. 1

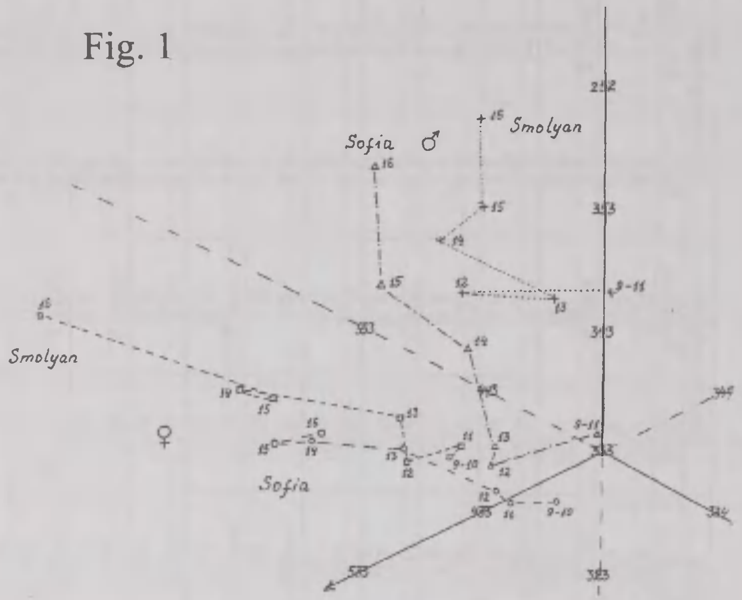

Fig. 1. Somatotype in adolescents in Sofia and Smolyan according the chronological age.

Fig. 2

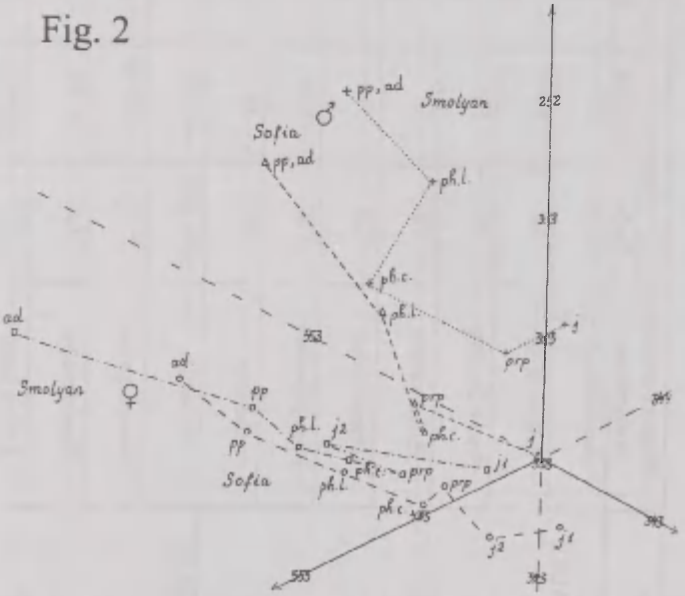

Fig. 2. Somatotype in adolescents in Sofia and Smolyan according the stage of sexual maturation.

the massiveness is a result of a more developed fat tissue (higher endomorphism) and only in the second place – of a higher mesomorphism. The analysis of the separate parameters shows, that, in fact, the Smolyan girls present a higher biacromial index than the Sofia ones, but their relative muscle upper arm circumference is even lower [9]. The analysis of some additional somatic parameters confirms that the Smolyan boys are more mesomorphic (athletic) and the Smolyan girls – more mesoendomorphic than the Sofia ones [11]

As for the intersexual differences, girls are manifestly more endomorphic than boys, and boys – more mesomorphic than girls in both settlements. These differences can be observed already in the juvenile stage and rise during the puberty, because in girls the endomorphism increases more quickly than in boys, and in boys – the mesomorphism increases more quickly than in girls. The ectomorphism decreases in both sexes and is approximately on the same level in boys and girls.

It is difficult to make a comparison with other studies, since in Bulgaria the human constitution has not been studied in dependence upon the level of urbanization. Foreign data tell us for a higher body mass index in the adolescents with a lower social status (analogically to the case with the Smolyan adolescents). Usually the explanation is a more developed subcutaneous fat tissue [13]. Our data show that at least in boys the reason can be a higher development of the osteomuscular system, may be because of a higher physical activity in childhood and adolescence in the smaller settlements.

In conclusion, the study confirms the suitability of the proposed modified somatotypological schedule in analysing the intersexual and social differences in constitution and their age dynamics during adolescence. Additional studies (new investigations and also an analysis of already yet published, but not analysed data) are necessary to establish if the established city-town differences were typical of the whole country and if they persist until now.

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PERINATAL MORTALITY OF VERY LOW BIRTH WEIGHT INFANTS IN ESTONIA IN THE PERIOD 1992–2002

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ABSTRACT

The aim of the study was to investigate the perinatal mortality of very low birth weight (VLBW) infants in Estonia from 1992 until 2002. All the infants (n=1582), with the birth weight < 1500 g born during 1992–2002 in Estonia were studied retrospectively. The data were received from the Estonian Medical Birth Registry. Among the VLBW infants there where 1,169 live births, 413 stillbirths and 402 early neonatal deaths. The perinatal mortality rate, the stillbirth rate and the early neonatal mortality rate were estimated for boys and for girls, for infants < 500 g at birth, for those weighing 500 to 749 g, for those 750 to 999 g, for those 1000 to 1249 g and for those 1250 to 1499 g.

In 1992–2002 the average perinatal mortality rate of VLBW infants in Estonia was 515/1000. The perinatal mortality rate was higher for boys (543/1000) than for girls (487/1000) and was caused by the boys' higher mortality in the first 7 days of life. The perinatal mortality rate decreased with birth weight and was 917/1000 for infants < 500 g at birth, 856/1000 for those weighing 500 to 749 g, 668/1000 for those 750 to 999 g, 447/1000 for those 1000 to 1249 g and 271/1000 for those 1250 to 1499 g.

From 1992 to 2002, the perinatal mortality of VLBW infants decreased significantly. In 1992, the perinatal mortality rate was 743/1000, in 2002, 336/1000. This decrease in perinatal mortality was caused both by a decrease in the stillbirth rate and by a decrease in the early neonatal mortality rate, but the early neonatal mortality rate decreased more than the stillbirth rate. By birth weight, the decrease in the mortality rate was the greatest for infants weighing 1000 to 1249 g at births.

Key words: Perinatal mortality, stillbirths, early neonatal mortality, VLBW infants

INTRODUCTION

Perinatal mortality has been used for international comparisons as an indicator of national health and social development. Advances in obstetrical and neonatal care have decreased the mortality of very low birth weight (VLBW) infants, defined as infants weighing <1500 g at birth, in many populations [2, 5, 6]. However, VLBW children have had higher mortality rates than normal birth weight (>2499 g) children.

The aim of this study was to investigate the perinatal mortality of VLBW infants in Estonia from 1992 to 2002 when major political, economic and health care changes took place in the country.

MATERIAL AND METHODS

All the infants (n=1,582) with the birth weight <1500 g born during 1992–2002 in Estonia were studied retrospectively. The data were received from the Estonian Medical Birth Registry [8]. Among the VLBW infants there were 1,169 live births, 413 stillbirths and 402 early neonatal deaths. 87% of the VLBW infants were very preterm (gestational age < 32 weeks). *A live born infant* was a newborn with at least one characteristic of life. A newborn with a birth weight of at least 500 g, carried to the 22^{nd} week of pregnancy and without the characteristics of life was considered *stillborn*.

The perinatal mortality rate, the stillbirth rate and the early neonatal mortality rate were estimated for boys (n=805) and for girls (n=777), for infants <500 g at birth (n=12), for those weighing 500 to 749 g (n=257), for those 750 to 999 g (n=394), for those 1000 to 1249 g (n=409) and for those 1250 to 1499 g (n=510). To calculate the perinatal mortality rate, the number of infants who died in the perinatal period (from 22 full-weeks of pregnancy until 7 days after birth) during the year was divided by the annual number of all the births and multiplied by 1000. To calculate the stillbirth rate, the number of infants born dead during the year was divided by the annual number of all the births and multiplied by 1000. For calculating the early neonatal mortality rate, the number of infants who died in the early neonatal period (from birth until 7 days after birth) during the year was divided by the annual number of live births and multiplied by 1000.

RESULTS AND DISCUSSION

In 1992–2002 the average perinatal mortality rate of VLBW infants in Estonia was 515/1000. The perinatal mortality rate decreased with the birth weight and was 917/1000 for infants < 500 g at birth, 856/1000 for those weighing 500 to 749 g, 668/1000 for those 750 to 999 g, 447/1000 for those 1000 to 1249 g and 271/1000 for those 1250 to 1499 g. The perinatal mortality rate was higher for boys (543/1000) than for girls (487/1000). The stillbirth rate during the same period was 261/1000 (260 for boys and 263 for girls) and the early neonatal mortality rate 344/1000 (383 for boys and 304 for girls). Thus, the higher perinatal mortality for boys was caused by their higher mortality in the first 7 days of life (Figure 1). This result confirms that early survival is greater for female than for mail VLBW infants [1, 3].

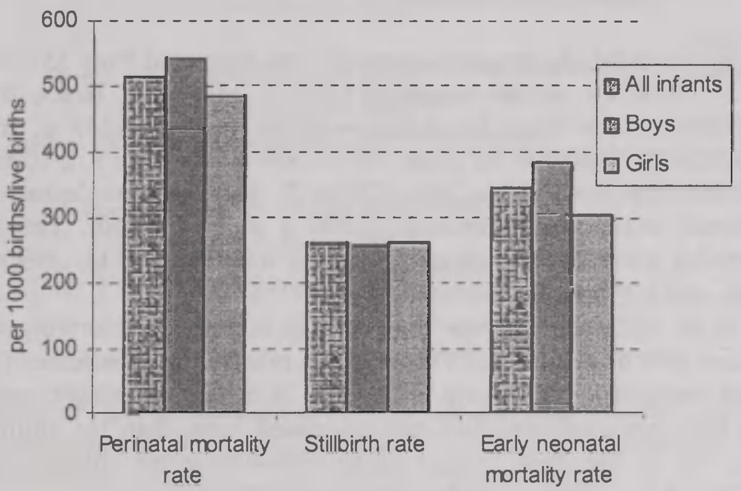

Figure 1. The average perinatal mortality of VLBW infants in Estonia by gender, 1992–2002

From 1992 to 2002, the perinatal mortality of VLBW infants in Estonia decreased (Table 1). In 1992, the perinatal mortality rate was 743/1000, in 2002, 336/1000. This decrease in perinatal mortality was caused both by a decrease in the stillbirth rate and by a decrease in the early neonatal mortality rate, though the early neonatal mortality rate decreased more (from 617/1000 to 198/1000) than the stillbirth rate (from 329/1000 to 172/1000).

Table 1. The perinatal mortality of VLBW infants in Estonia, 1992, 1998–2002

	1992	1998	1999	2000	2001	2002
Number of perinatal deaths	156	48	69	52	36	39
Perinatal mortality rate per 1000 births	743	384	479	364	275	336
Number of stillbirths	69	28	39	22	23	20
Stillbirth rate per 1000 births	29	224	271	154	176	172
Number of early neonatal deaths	87	20	30	30	13	19
Early neonatal mortality rate per 1000 live births	617	206	286	248	120	198

By birth weight, the perinatal mortality rate decreased from 537/1000 to 176/1000 for infants weighing 1250 to 1499 g at births, from 673/1000 to 167/1000 for those weighing 1000 to 1249 g, from 923/1000 to 269/1000 for those 750 to 999 g and from 972/1000 to 792/1000 for those 500 to 749 g (Table 2). There was no decrease in perinatal mortality for infants < 500 g at birth. Thus, perinatal mortality decreased 3–4 times for infants weighing 750 to 1499 g at birth, and 1.2 times for those weighing 500 to 749 g .

In all the weight groups the decrease in perinatal mortality was caused both by a decrease in the stillbirth rate and by a decrease in the early neonatal mortality rate (Figure 2). In most birth weight groups the early neonatal mortality rate decreased more than the stillbirth rate, but in the birth weight group 500–749 g the stillbirth rate decreased more than the early neonatal mortality rate.

Table 2. The perinatal mortality of VLBW infants in Estonia by birth weight, 1992, 1998–2002

Birth weight (in grams)	1992	1998	1999	2000	2001	2002
< 500*	0	1000	1000	500	0	1000
500–749	972	778	800	762	556	792
750–999	923	531	517	452	351	269
1000–1249	673	367	421	342	226	167
1250–1499	537	71	283	157	133	176

* There were no infants with the birth weight < 500 g in 1992 and 2001

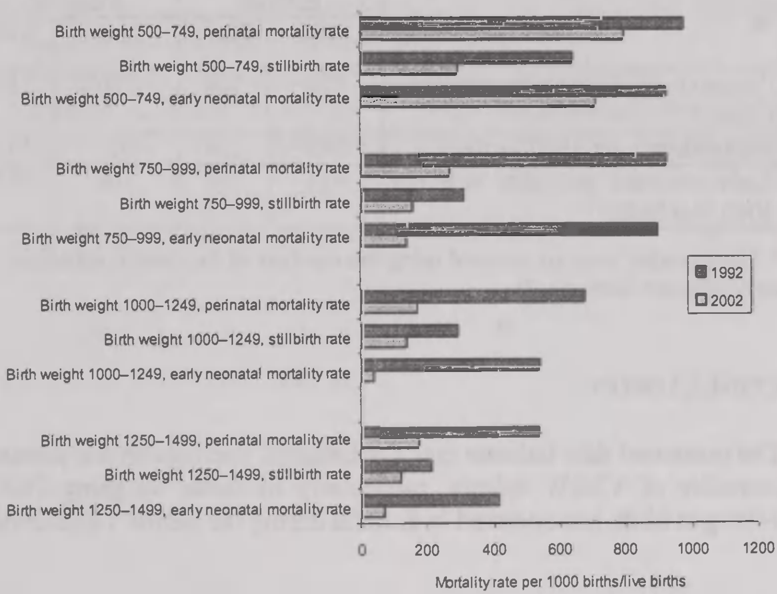

Figure 2. The perinatal mortality rate, the stillbirth rate and the early neonatal mortality rate of VLBW infants in Estonia by birth weight, 1992 and 2002

From 1992 to 2002 the proportion of VLBW infants from all the births in Estonia decreased. In 1992, VLBW infants made up 1.2% of all the births, in 2002, 0.9% [8]. Among the VLBW infants, the proportion of stillbirths decreased (from 33% to 17%) and the proportion of live birth increased (from 67% to 83%). Therefore, for the further decrease in the perinatal mortality of VLBW infants, the continuous reduction of the early neonatal mortality, it means the mortality in the first 7 days of life is important.

The comparison of the perinatal mortality of VLBW infants in Estonia with its economically more developed neighbouring country Finland showed higher mortality rates in Estonia (Table 3). These higher perinatal mortality rates were caused, first of all, by the higher early neonatal mortality rates. Thus, there is a capacity for the further decrease in the perinatal mortality of VLBW infants in Estonia by the reduction of the mortality of these infants in the first 7 days of life.

Table 3. The perinatal mortality of VLBW infants in Estonia and Finland

	Estonia		Finland*	
	1994	2000	1994	2000
Perinatal mortality rate per 1000 births	616	364	376	288
Stillbirth rate per 1000 births	342	154	207	194
Early neonatal mortality rate per 1000 live births	417	248	214	116

* The mortality rates are counted using the numbers of live births, stillbirths and early neonatal deaths [4, 7].

CONCLUSION

The presented data indicate that a substantial decrease in the perinatal mortality of VLBW infants, particularly of those weighing 750 to 1499 g at birth, has occurred in Estonia during the period 1992–2002.

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THE INFLUENCE OF SHORT-TERM GROWTH PATTERN ON ANNUAL WEIGHT GAIN IN NORMAL CHILDREN

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ABSTRACT

Objective: We have shown previously that the amount grown through the year is related to short term changes in height and weight: good growth during the year was related to large but frequent gains in weight and large individual spurts in height. We have now analysed the relationship between annual weight gain (expressed in ΔWeight SD score) and short-term growth pattern in height and weight in 43 schoolchildren (17 boys, 26 girls) aged 5.7–7.7 years.
Methods: Height and weight of each child was measured three times per week over one academic year. A timed overnight urine was collected for urinary GH (uGH) excretion. Individual height and weight velocity curves were derived using locally-weighted, least-squares, kernel regression analysis. Urinary GH data were expressed as a daily average.
Results: Weight velocity curves were characterised by 2–5 periods of weight gain, each lasting a mean 66 days, separated by 1–4 periods of weight loss, each lasting a mean 27 days. Δ Weight SD score was negatively correlated to mean uGH excretion (r=–0.43, p<0.005). In stepwise regression analysis, annual weight gain (Δ Weight SD score) was influenced by 5 factors: number (–) and mean length (–) of weight loss, mean (+) amplitude of weight gain, mean length of height velocity peak (+) and mean weekly uGH excretion (–), accounting for 58% of it's variability.

Conclusions: We conclude that weight gain during a year is related mainly to short-term changes in weight but also to changes in height. Good weight gain during the year is related to large pulses of weight gain separated by infrequent short-lasting periods of weight loss and prolonged pulses of height gain. Additionally weekly uGH excretion, as a short-term marker of GH secretion, is low in those with good weight gain over the year. These data emphasise the close relationship between short-term changes in weight, height and GH secretion and their contribution to longer-term growth performance.

Key words: growth, weight, short-term, growth hormone, weight gain

INTRODUCTION

Growth rate in childhood is determined by a complex interaction of physical, endocrine and nutritional factors, of which growth hormone (GH) and nutrition are the key determinants of mid-childhood growth [4, 5]. However, as seen from normal height velocity curves, annual growth rates vary from 4 to 8 cm per year in a 5-year old girl [16]. A subnormal growth rate can be associated with low GH secretion, while normal growth rates can occur over a wide range of GH output [5]. Normal or increased growth rates have been seen in obese children, who in fact exhibit low GH secretion [8]. Thus the amount of GH alone cannot explain the variation in growth rates in non-GH deficient children. We have shown that the pattern of height and weight velocity from week to week has itself an impact on height gain: good growth during the year was related to large but frequent gains in weight and large individual spurts in height [19]. However most studies have focused solely on height gain, without considering weight gain. We have now analysed how individual changes in height and weight may influence the annual weight gain of a child. In addition, we have studied the relationship between daily changes in urinary growth hormone excretion and weight gained over a year.

MATERIALS AND METHODS

Forty-three schoolchildren (26 girls, 17 boys) aged 5.7–7.7 years were measured 3 times per week over one academic year, September through to July the following year. Children were not measured during holiday periods. The children were volunteers and parental consent was obtained for the study. The study was approved by the Salford Health Authority ethics committee. Height and weight were measured at the same time of day by two observers using a free-standing Magnimetre (Raven Instruments, England) and electronic weighing scales (Soenhle, Germany) with measuring intervals of 50g. A mean interobserver difference between two observers was 0.04 cm. The standard deviation of the differences between "blind" triplicate height measurements of the same 25 children for the two observers was 0.13 and 0.15 cm.

Height and weight were measured on 94 occasions, the median for one subject being 89 (range 60–94). Auxological characteristics of subjects are given in Table 1. Weight and height standard deviation score (SDS) at the beginning of the study (SDS_1) and at the end of the study (SDS_2) were calculated from 1990 UK standards [1]. Weight gain through the study period was expressed as weight SDS (weight SDS_2-weight SDS_1) and height gain through the study period as height SDS (height SDS_2-height SDS_1).

Table 1. Auxological characteristics of subjects

	Mean	Range
Age (year)	6.7	5.7 to 7.7
Height SDS1	0.0	–2.9 to + 2.3
Height SDS2	+0.2	–2.7 to + 2.5
Δ height SDS	+0.2	–0.2 to + 0.7
Weight SDS1	0.0	–3.1 to + 2.5
Weight SDS2	–0.1	–3.3 to + 2.3
Δ weight SDS	–0.1	–0.8 to + 0.5

Statistical analysis

To assess changes in growth (height and weight) as a function of time we have used smooth estimates of individual height and weight velocity profiles. These were constructed using locally-weighted least-squares kernel regression analysis [13], with a bandwidth of 118 days for weight velocity and 60 days for height velocity. The bandwidths were chosen by a predicted squared error criterion [10]. This provides an objective data-based method of choosing an appropriate bandwidth.

Weight gain was defined as any period in which weight velocity curve above 0 g/day and weight loss as any period with weight velocity curve falling below 0 g/day. If there was a major fluctuation in weight velocity during a period of weight gain such that the minima between two maxima fell towards 0 grams per day (with the minimum to fulfil the requirement being defined arbitrarily as less than half of the smaller maximum), then this was classified as two periods of weight gain (see Figure 1 for explanations). A constraint was placed on the height velocity curves that did not allow negative velocities (ie loss of stature). Growth spurts were identified by using local maxima and minima in the velocity curves. In keeping with our previous study [19], growth stasis was defined as any period in which the height velocity curve fell below 0.007 cm/day (0.049 cm/week). Twelve different characteristics were collated from the height and weight velocity curves of each child (Figure 1): a) **number** of height velocity peaks, growth stases, periods of weight gain and periods of weight loss; b) **mean length** of height velocity peak, growth stasis, weight gain and weight loss (days); c) **mean amplitude** of height velocity peak (cm/day), weight gain (kg/day), weight loss (kg/day) and mean total weight velocity amplitude (kg/day). Stepwise regression analysis with all 12 characteristics derived for each child were used to define the determinants of annual weight gain (Δ weight SDS). Linear regression and Pearson correlation coefficients were used to define bivariate relationships.

A timed overnight urine was collected for urinary GH excretion. GH was measured by two-site immunoradiometric assay as previously described [14]. The intra-and interassay coefficients of variation were 6.6–8.8% and 8.8–10%, respectively. The results of total urinary GH (ng) excreted overnight were expressed as a daily average through the study period.

RESULTS

Weight velocity

Weight velocity curves of all children were non-linear. Weight velocity curves for the group were characterised by 2–5 periods of weight gain, each lasting a mean 66 days (range 36–113), and 1–4 periods of weight loss, each lasting a mean 27 days (range 12–56). The mean amplitude of weight gain was 0.02 kg/day (median 0.017, range 0.01–0.05) and the mean amplitude of weight loss 0.009 kg/day (range 0.002–0.022). As expected, children with 1–2 periods of

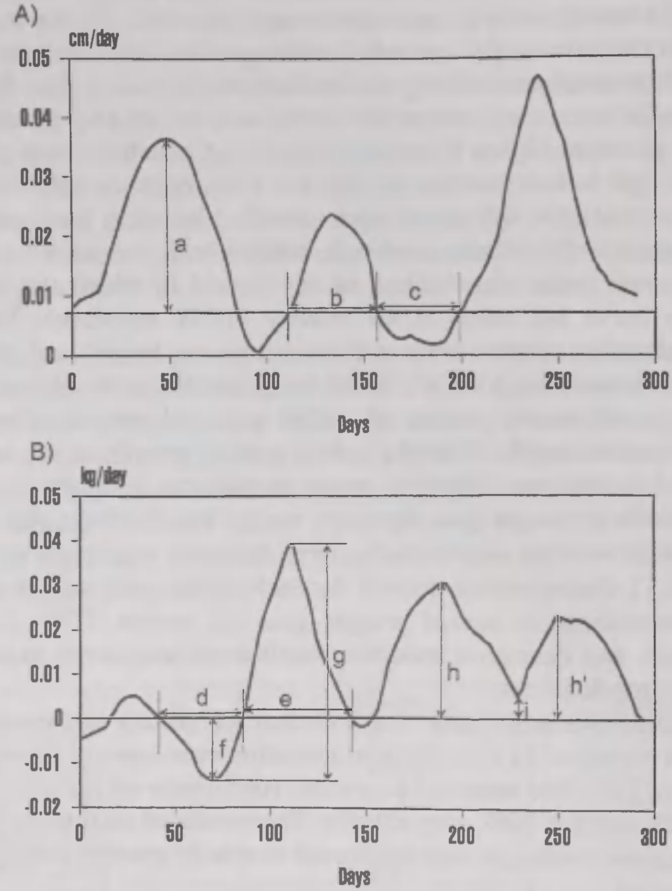

Fig. 1. Schematic explanation of the characteristics of the height (A) and weight (B) velocity curves. Arrowed lines indicate the amplitude of a height velocity peak (a), length of a height velocity peak (b) and length of a stasis (c) in panel A. Length of weight loss (d), length of weight gain (e), amplitude of weight loss (f), total amplitude of weight velocity (g) and amplitude of weight gain (h) are shown by arrowed lines in panel B. If the minimum between two peaks (i) was less than half of the amplitude of the smaller peak (h'), then two separate periods of weight gain were identified. Reproduced with permission from Pediatric Research (Tillmann et al. 1998).

weight loss (n=18) gained significantly more weight than those with 3–4 periods of weight loss (n=25) (0.01 ± 0.28 SDS vs. –0.2 ± 0.22 SDS, p = 0.01), whereas the length of weight loss, the amplitude of weight gain and loss were similar. Thus the weight gained over the year was achieved mostly by longer periods of weight gain (73 vs 61 days; $p < 0.05$).

Urinary GH excretion

Daily average urinary GH excretion was 3.2 ng (range 1.0–6.4). Children with 1–2 periods of weight loss (n=18) tended to have lower uGH than those with 3–4 periods of weight loss (n =25), but the difference was not statistically significant (2.8 ± 1.1 vs. 3.4 ± 0.9 ng; p = 0.09). Annual weight gain (Δ weight SDS) was negatively correlated to uGH ($r = -0.43$; $p < 0.005$) (Figure 2).

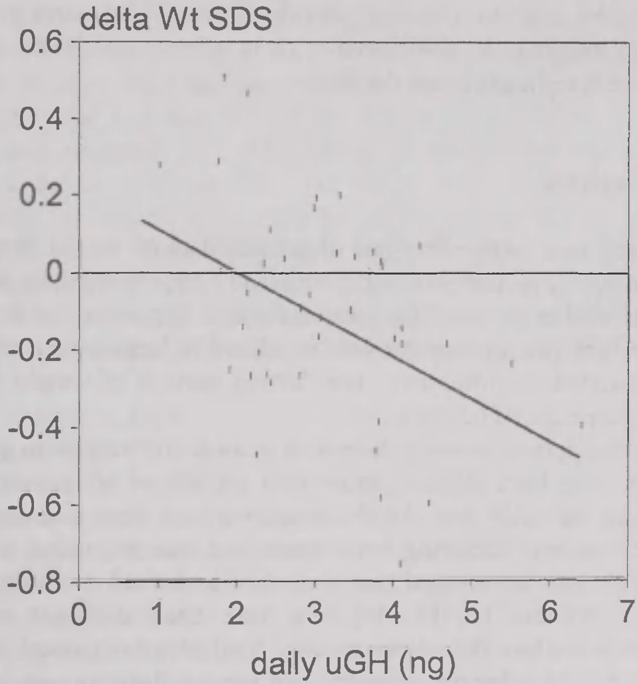

Fig. 2. The correlation between annual weight gain (delta Wt SDS) and daily urinary GH excretion (uGH) ($r = -0.43$; $p < 0.05$).

Determinants of annual weight gain

Neither weight SDS_1 or weight SDS_2 were significantly correlated to Δ weight SDS. Twenty seven children had a negative Δ weight SDS i.e. gained less weight than average. However, the majority of this group (n=26) grew at an above average rate, i.e. their Δ height SDS was positive. Weight gain through the year, Δ weight SDS, was influenced negatively by the number of periods of weight loss ($p < 0.0001$), negatively by the mean length of weight loss ($p < 0.0001$), positively by the mean amplitude of weight gain ($p = 0.01$), positively by the mean length of height velocity peaks ($p = 0.004$) and negatively by the mean daily urinary GH excretion ($p = 0.02$) with $r^2 = 58\%$. The regression equation was estimated as: Δ weight SDS = 0.37–0.14 (number of wt loss) – 0.016 (length of wt loss) + 9.56 (amplitude of wt gain) + 0.0065 (length of ht peak) – 0.065 (urinary GH). Thus good weight gain during the year is related to large pulses of weight gain separated by few short-lasting periods of weight loss and prolonged pulses of height gain. Additionally, daily urinary GH is low in those with good weight gain over the year.

DISCUSSION

This study is a further analysis of growth data of the 43 prepubertal children we have previously described [17,19]. In keeping with our previous studies we used the same statistical approach and found that good weight gain during the year is related to large pulses of weight gain separated by infrequent short-lasting periods of weight loss and prolonged pulses of height gain.

The distinction between short-term growth and long-term growth is arbitrary. We have defined short-term growth as all growth events within one calendar year. As clinicians, we have been interested more in growth events occurring over weeks and months, rather than over days. This has determined our choice of statistical methods. In our previous studies [17, 18, 19], we have used different statistical methods to analyse short-term growth. Analysis of empirical estimates of daily height velocities revealed two normal distributions, with one narrow distribution centred close to zero and the other wider distribution centred at 0.046 cm/day [17]. This analysis suggested that growth was comprised of two distinct phases, one of stasis and the other of continuous growth over a wide range of growth velocities. In the same study we did not find that growth consists only of saltations i.e. rapid daily growth increments, a model proposed by Lampl [6]. Saltatory increments occurred in the majority of children, but they accounted for only a small amount of the total annual growth [17]. Our own growth model, based on locally-weighted least-squares kernel regression analysis, describes growth as a biphasic process characterised by growth spurts and stases (losses) in both height and weight [17, 19]. This is a nonparametric technique, which generates velocity curves without imposing a particular form to the growth process, which would result from the use of a linear, polynomial, or step function. However, this method needs a smoothing function. As the choice of bandwidth has an impact on curve characteristics, the bandwidths were determined by a predicted squared error criterion, an objective data-based method of choosing an appropriate bandwidth.

We used different characteristics of each velocity curve (the number, length, amplitude of height/weight changes) to describe the growth process. Weight velocities showed a biphasic pattern in all 43 children, characterised by periods of weight height gain lasting an average 66 days separated by periods of weight loss. Similar patterns of weight gain, although at slightly shorter intervals (54 days) were shown in a subgroup of 7 of the children, whose data were analysed by time series analysis [18]. As time series analysis is highly dependent on data density, only the children with the most growth data were used. These 3 different methods (analysis of empirical estimates of daily height velocities, kernel regression analysis and time series analysis) all indicate that the biphasic pattern of growth is a true phenomenon and not determined by statistical methodology [17, 18, 19].

An average child in our study spent 25% of the time in periods of weight loss and 75% in periods of weight gain. Thus in a full year (our study lasted 10 months) one child should have an average of 3 periods of weight loss each lasting about 4 weeks and 4 periods of weight gain each lasting 8–10 weeks. A pulsatile weight velocity pattern has been found in very low birth weight babies appropriate for gestational age with 9–11 day cycles [2] and in children with coeliac disease during catch-up growth with a mean inter-peak interval of 57 days [3]. In both these studies there were no data about the periods of weight loss (weight velocity < 0 g/day). However these subjects were experiencing intense periods of weight gain over the study; this probably explains the shorter interval between weight peaks than that found in our study (93 days).

Weight gain over the study period was influenced by five factors: the number of periods of weight loss, the mean length of weight loss, the mean amplitude of weight gain, the mean length of height velocity peaks and the mean daily urinary GH excretion. Thus poor weight gain is related to small pulses of weight gain separated by frequent long-lasting periods of weight loss and short pulses of height gain. It is noticeable, that in spite of the negative Δ weight SDS in 27 children, 26 of them gained height i.e. Δ height SDS was positive. These data indicate that weight gain during the year is related mainly to short-term changes in weight, but also to changes in height.

In addition, we found a negative correlation between daily urinary GH and Δ weight SDS: urinary GH excretion is low in those with good weight gain over the year. A negative relationship between body mass index and GH secretion has been seen in normal prepbertal children as well as in obese children [7, 9, 11]. The fact that GH secretion increases after weight loss suggests that reduced GH level is a result of obesity rather than a cause.

Obesity is a common and rapidly increasing health problem around the world [12, 15]. Current recommendations to control weight gain in children are to increase physical activity and eat a healthy diet. The outcome if patients follow these recommendations, however, is very variable. The majority of patients achieve only temporary weight loss (or reduction in weight gain). However, according to our data, these temporary short lasting periods of weight loss are important determinants of longer-term weight gain. From the regression model of our 43 children, we could theoretically estimate that by increasing the number of periods of weight loss from 3 to 4 and the mean length of weight loss from 4 to 6 weeks, the annual weight gain should decrease by 0.36 SDS i.e. about 1.1 kg. Further studies are necessary to clarify how manipulation of a child's individual week-to-week weight pattern might influence their long term weight gain.

These data emphasise the close relationship between short-term changes in weight, height and GH secretion and their contribution to longer-term growth performance. Non-linear changes in these parameters appear to be the hallmark of satisfactory growth, and imply that manipulations of short-term growth itself (such as the periods of weight loss) may have important implications to long-term growth.

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BLOOD PRESSURE OF 12- TO 15-YEAR-OLD ESTONIAN ADOLESCENTS OF DIFFERENT HEIGHT-WEIGHT CATEGORIES

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ABSTRACT

The article describes systolic and diastolic blood pressure of 357 healthy schoolboys aged 12–15 years from secondary schools of Tartu in respect of the height-weight category where they belong.

In each age group the data were systematised into 5 height-weight SD-classes according to the correspondence between body height and weight.

The medium class lies between –0.5 SD and 0.5 SD of the respective age group mean (M±0.5 SD); the other classes contain the respective outer values. All the subjects were assigned into one of the following five categories: three height/weight-concordant categories: I – small (small height – small weight), II – medium (medium height – medium weight), III – large (big height – big weight) and two height/weight-discordant categories: IV – the so-called pyknomorphous, V – the so-called leptomorphous.

Though no differences were in the mean age of height-weight categories these body build categories had significantly different mean SBP and DBP as they also differ in their body height, weight and BMI. The highest SBP and DBP values were in the boys of *large* category and the boys of height-weight discordant categories. In conclusion the results of this study highlighted that height-weight categories have a small but significant impact on the BP.

Key words: blood pressure, height-weight classification, schoolboys

INTRODUCTION

The Centre for Physical Anthropology (PA) at the University of Tartu has been studying body structure for a long time [4, 5, 6, 10, 12, 13, 20]. A conclusion has been reached that the whole body anthropometric system is formed by statistically well-correlated characteristics, where the leading measurements are body height and weight. Body height and weight account for 50% of the variability of all the other measurements, while individual variability makes up another 50% [4]. This whole body model based on a bivariate body height-weight classification has been used to study the changes in different anthropometric characteristics. The Centre for PA has used such a classification for the data of neonates, schoolgirls and -boys aged 12–15 and 15–18 and young women aged 18–25, and it has been found that in such a way it is possible to systematise the prevailing body measurements, body proportions and the characteristics of the body composition.

This approved multidimensional statistical model of body build has been suggested for the use of systematising and comparing morphological variables with other assessed characteristics in different applied studies, for example, physiological, sociological, psychological, or nutritional.

A great number of risk factors for the diseases of the cardiovascular system occurred in the Estonian youth [3, 14, 17, 18].

Hypertension is one of the most common and powerful risk factors for CVD [7]. It is known that a significant percentage of children and adolescents with high blood pressure develop stable hypertension in adulthood [8].

The obese children and the children with a family history of hypertension are at the highest risk for maintenance or developing hypertension at a later date [22]. The prevalence of the elevated blood pressure levels has proved to be highest in the Estonian children and adolescents who sustained the family history of CVD [3, 17, 18].

In the present cross-sectional study we are going to reveal whether there are differences in blood-pressure among the boys of different height-weight categories in the age 12 to 15.

Correspondingly the present overview had the following specific aims:

1) to characterize BP status of the studied children;
2) to examine BP values of the boys of different height-weight categories;

3) to assert height-weight categories where most boys are with the elevated BP.

MATERIAL AND METHODS

Study subjects

A cross-sectional sample consisting of 357 boys was randomly selected from different schools of Tartu, Estonia. All the subjects were in the age range of 12 to 15 years, Estonians in origin. The parents or guardians of children and the children themselves gave their oral permission for voluntary testing. The study was approved by the Medical Ethics Committee of the University of Tartu.

Methods

Measurements were performed in the morning at schools with the subjects's bladder emptied. Children did not exercise before testing. Stature was measured using a Martin metal anthropometer in cm (±0.1) and body mass was measured with medical scales in kg (±0.05 kg), body mass index (BMI (kg/m^2)) was calculated.

Blood pressure measurements (systolic blood pressure (SBP) and diastolic blood pressure (DBP)) were obtained on the subjects' right arm in a relaxed, sitting position using a standard mercury sphygmomanometers. The mean of the two trials was used in the analysis.

Assessment of height-weight categories.

In all the age groups both body height and mass values were divided into 3 SD-classes (Figure 1). The medium class lies between –0.5 SD and 0.5 SD from the respective age group mean (M±0.5 SD), the other classes contain the respective outer values. All the subjects were assigned into one of the following five categories: three height/ weight-concordant categories: I – small (small height – small weight), II – medium (medium height – medium weight), III – large (big height – big weight), and two height/weight-discordant categories: IV – the so-called pyknomorphous, V – the so-called leptomorphous. Categories IV and V thus contained three height/weight subclasses each, as shown in Figure 1.

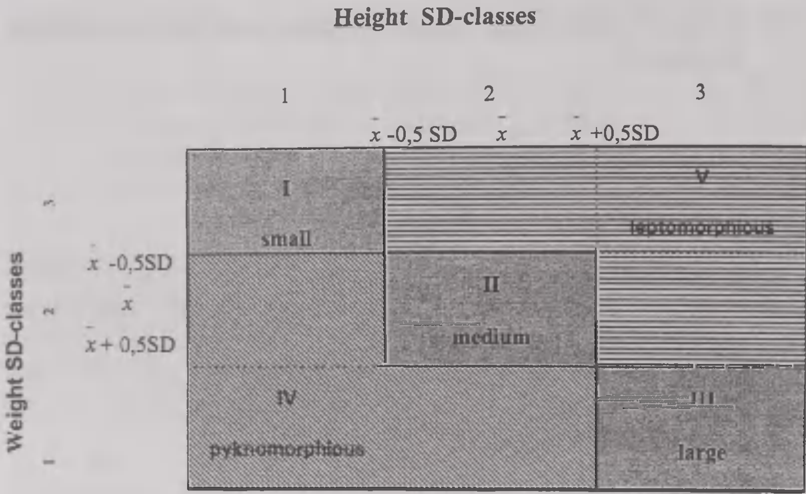

Figure 1. Classification of 12-15-year-old boys by 5 height-weight classes.

Statistical analysis

Statistical analysis was performed using the SAS statistical package (version 6.12). Standard statistical methods were used to calculate the mean (M) and standard deviation (SD), median (Med) and the coefficient of variation (CV) of parameters and percentages.

The statistical comparisons of parameters between different height-weight categories were made using two-way ANOVAs. The Scheffe's test as a posteriori test was applied to study in which group means were significantly different ($p \leq 0.05$).

The correlation analysis was performed to establish significant relationships ($p<0.0001$ and $p<0.05$)) between systolic and diastolic blood pressure and age, body weight and height, BMI and height-weight category (HW categ).

RESULTS

The SBP and DBP of boys showed big variability within the age groups (Table 1–2). As could be expected, with an increase in age a gradual increase of the mean blood pressure values appeared within categories I–III. The means of SBP and DBP revealed statistically significant differences (p<0.0001) between the boys aged 12 and 15 (in SDP also between ages 14 and 15). Differences within each category from age 12–15 were statistically significant (p<0.05) for SBP in HW categories I, III and V; for DBP in HW categories I, IV and V.

Table 1. Systolic BP in different age groups of boys

Age (years)	n	Systolic BP (mmHg)					
		M	SD	Med	Min	Max	CV
12	66	102.39	9.36	103	80	120	9.14
13	98	106.82	11.93	104	87	140	11.17
14	101	108.00	10.86	108	80	135	10.05
15	92	113.98	10.23	112	94	150	8.97
Total	357						

Table 2. Diastolic BP in different age groups of boys

Age (years)	n	Diastolic BP (mmHg)					
		M	SD	Med	Min	Max	CV
12	66	58.48	8.01	58	40	80	13.70
13	98	62.11	8.88	60	45	95	14.30
14	101	63.34	8.76	60	48	86	13.84
15	92	66.77	8.37	68	50	90	12.54
Total	357						

The correlation coefficients between SBP and DBP, age, body height, weight and BMI were all positive and mainly higly significant (Table 3). The main determinants of SDP and DBP were body weight, height and BMI. The influence of age on blood pressure was less pronounced. The height-weight category was relatively weakly, though significantly associated with SDP and DBP (Table 3).

The mean and median values of SBP and DBP obtained for five body build categories in the studied age groups are presented in Table 4. The highest arterial blood pressure values were in the boys of *large* category and in the boys with height-weight discordant body build (*pyknomorphous* and *leptomorphous* boys). Differences between height-weight categories were statistically significant (p<0.0001) in both SBP (F=19.71) and DBP (F=10.19). By the Sheffe's test statistically significant differences in SBP were between all the height-weight categories except the discordant body-build categories (HW categ IV and V) as also between HW categ II and IV, as also II and V. The differences of DBP of the weight-height categories were statistically significant ($p<0.0001$) only between categories of *small* and *large*, as also *medium* and *large*. At the same time boys of different height-weight categories were not distinct in their mean age (13.58; 13.64; 13.95; 13,53; 13.65 respectively), but differed in their body weight and height except HW categ II and IV; II and V. BMI differences were significant between all the height-weight categories except I and V; III and IV.

Table 3. Pearson correlation coefficients between parameters in 12–15-year-old boys

	HW categ	Weight	Height	SBP	DBP	BMI
HW categ	1.00					
Weight	**0.27**	1.00				
Height	**0.35**	**0.87**	1.00			
SBP	**0.21**	**0.57**	**0.51**	1.00		
DBP	0.16	**0.43**	**0.43**	**0.53**	1.00	
BMI	0.16	**0.87**	**0.44**	**0.47**	**0.37**	1.00
Age	0.01	**0.54**	**0.71**	**0.33**	**0.29**	**0.24**

$p<0.0001$ for numbers in bold and $p<0.01$ for gray numbers

Table 4. Systolic blood pressure by height-weight categories in 12–15-year-old boys

Category group	n	%	Systolic BP (mmHg)					
			M	SD	Med	Min	Max	CV
I – Small	79	22.13	100.63	9.62	100	80	124	9.56
II – Medium	82	22.97	108.45	9.84	110	80	132	9.08
III – Large	63	17.65	115.97	9.17	116	93	150	7.90
IV – Pyknomorphous	50	14.01	109.88	10.32	110	92	135	9.41
V – Leptomorphous	83	23.25	108.16	12.25	108	80	140	11.33
Total	357	100.0						

Table 5. Diastolic blood pressure by height-weight categories in 12–15-year-old boys

Category group	n	%	Diastolic BP (mmHg)					
			M	SD	Med	Min	Max	CV
I – Small	79	22.13	58.96	6.53	58	40	72	11.07
II – Medium	82	22.97	62.31	8.06	60	48	80	12.93
III – Large	63	17.65	68.05	8.52	70	52	90	12.52
IV – Pykno-morphous	50	14.01	63.86	8.44	62	48	80	13.21
V – Lepto-morphous	83	23.25	63.13	10.53	60	45	95	16.67
Total	357	100.0						

Differences of categouries IV and V in SBP and DBP were statistically significant only in the age of 15.

Small-medium-large categories were statistically significantly different from each other in height, weight, BMI and also in SBP and DBP. We could not find significant mean blood pressure differences between discordant HW categ IV and V.

In the studied age the mean SBP of category I (mean age 13.58) could not reach the mean of 12-year-olds. The mean SBP of *large* boys (mean age 13.95) exceed the mean of 15-year-olds.

Table 6. Eleveted systolic blood pressure (SBP) among different height-weight categories

Category group	n	SBP above 120 mmHg		SBP above 125 mmHg		SBP above 130 mmHg	
		n	%	n	%	n	%
I – Small	79	1	1.3	0	0	0	0
II – Medium	82	8	9.8	4	4.9	1	1.2
III – Large	63	17	27.0	8	12.7	2	3.2
IV – Pykno-morphous	50	9	18.0	3	6.0	2	4.0
V – Lepto-morphous	83	11	13.3	7	8.4	4	4.8
Total	357	46	12.9	22	6.2	9	2.5

The main part of boys with elevated blood pressures belonged to the *large* category and to the categories of discordant body build (IV and V) (Table 6 and 7). The highest SBP values were in *leptomorphous* boys and the percentage of *leptomorphous* boys with highest DBP values was even higher than *pyknomorphous* boys.

Table 7. Eleveted diastolic blood pressure (DBP) among different height-weight categories

Category group	n	DBP above 75 mmHg		DBP above 80 mmHg	
		n	%	n	%
I – Small	79	0	0	0	0
II – Medium	82	6	7.3	0	0
III – Large	63	12	19.1	2	3.2
IV – Pyknomorphous	50	6	12.0	0	0
V – Leptomorphous	83	13	15.7	3	3.6
Total	357	37	10.4	5	1.4

DISCUSSION

Blood pressure (BP) values of the studied Tartu boys were significantly lower than in the same age boys of Lithuania (Tutkuviené 1995) or Belarus (Skrigan 2005) or some other Estonian investigations, for example, the boys of Southern-Estonia [3] or the Tallinn boys measured in 1984–1986 and 1998/99 [9, 16], but higher than the SBP and the DBP values of the Tallinn boys measured in 1971 [14] (Fig. 3 and 4). The reasons for the higher blood pressure values of other contemporary studies could be different: other studies are conducted in bigger cities than Tartu is or in Southern-Estonia the rates of prevalence of hypertension were the highest among Estonian children found [16]. In previous Estonian studies the design of the study or the age group assessment have been different (instead age groups the differences of BP of various school grades have been studied or the studies were carried out in medical institutions with the aim of examining adolescents with preceded hypertension) or the study groups have been relatively small or blood pressure measurements have been done with different test devices. Differences in BP values of different studies are in concordance with the claim of Suurorg and Tur [16] that large regional differences excisits in systolic and diastolic hypertension (0–18.2% and 0–13.6% respectively) among Estonian children. We should also mention that sexual maturation of Tartu children was also relatively late in comparison with other studies [21].

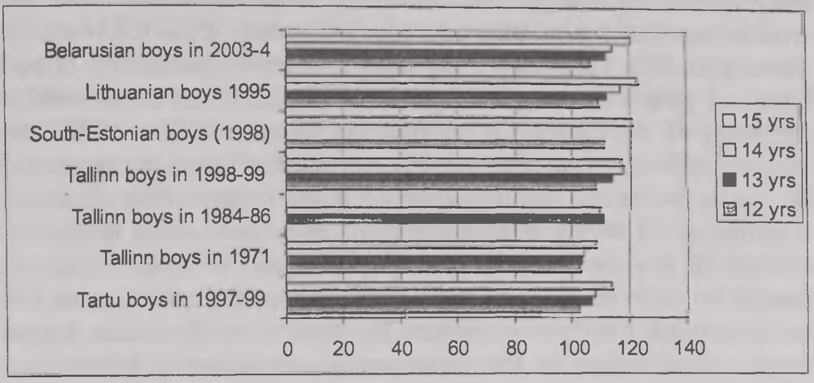

Figure 2. SBP of 12 to 15-year-old boys by different studies ((Grünberg 1998; Lilienberg, Saava 2002; Silla, Teoste 1989; Suurorg,Tur 2001; Tutkuviené 1995; Skrigan 2005; current study).

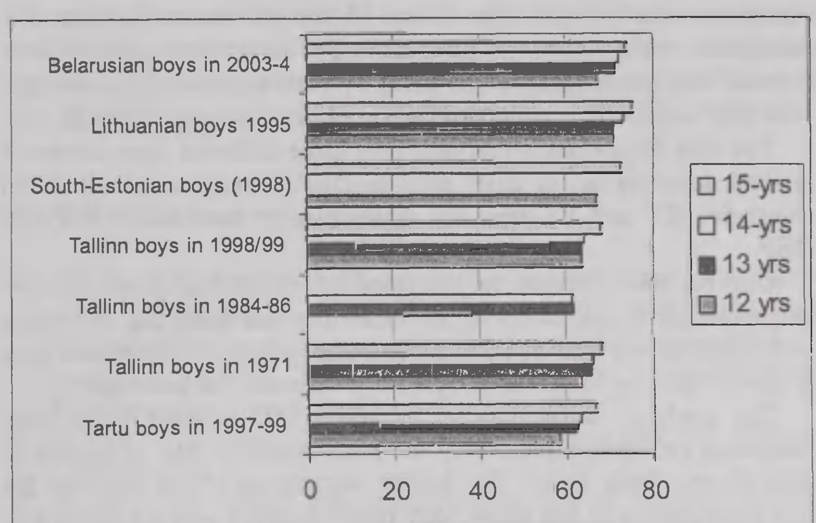

Figure 3. DBP of 12 to 15-year-old boys by different studies ((Grünberg 1998; Lilienberg, Saava 2002; Silla, Teoste 1989; Suurorg,Tur 2001; Tutkuviené 1995; Skrigan 2005; current study).

Age, sex and body size (height and weight) have been considered to be important determinants of blood pressure in childhood and adolescence [1, 11, 16]. Similarily to our study other authors [9, 16] have also revealed significant positive correlations between SBP and body height and weight and similarily have found that SBP was weaker correlated with BMI and age. Differently from the results of Suurorg and Tur [16] (they bring total correlation coefficients of both boys and girls with the mean ages of 10±1, 12±1 and 15±1 years) in our study all the correlation coefficients between SBP and DBP and weight and height were higher. The constantly increasing amount of data in medicine and health promotion urgently demands multivariate systematisation of the characteristics of body as a whole in order to include all the necessary clinical, physiological or biochemical data needed by different researchers. The height-weight classification was recommended for these purposes. The use of the five-class height-weight classification for the simultaneous comparison of different age groups allowed us to analyse whether the differences in distinct persons are related to their body build as a whole or not, when arterial blood pressure values of these persons are studied.

Though differences in the BP of age groups were statistically significant only between ages 12 and 15, the differences between HW categories were more pronounced. The correlation coefficients showed that the height-weight category was significantly associated with SDP and DBP though correlations were not strong (Table 3).

The first three classes that represent three different sizes showed a gradual increase as in SBP also in DBP. Discordant body build categories (IV and V) were not distinctive by their mean SBP and DBP.

Our results indicated to the need of somewhat more detailed height-weight classification as the variability was quite big, especially in *leptomorphous* and *pyknomorphous* categories of adolescent boys (Table 4–5). Also Maiste et al. [10] have affirmed the same need.

The study of differences of adolescent BP in five body build categories revealed expressively the main trends of BP in respect to their diverse body build. The higher occurrence of the elevated BP was associated with the *large* body build category and the discordant body build categories. The examination of the distribution of boys with elevated blood pressure helped additionally to clarify the relations of arterial BP and body peculiarities. Surprisingly, among *leptomorphous* boys there was even a stronger tendency towards the highest values of SBP and the higher DBP values than in *pyknomorphous* boys. This finding is different from the data available in literatury. In available literature mainly higher BMI levels, overweight and obesity have been shown to be associated with the elevated blood pressure [3, 17]. Thus our data are in agreement with the studies confirming that different persons have elevated SBP and elevated DBP [9]. Likely inconsistency in the hypertension prevalence among Estonian children is not because of the criterion differences only. Body build differencies could also play an important role. In our study the proportion of *leptomorphous* boys was the biggest. *Leptomorphous* body build (or ectomorphy) is characteristic of Estonian adolescence (Veldre 2003), and if this body build is associated with the elevated blood pressure, then it is better to understand why in Estonia CVD showing the increasing incidence rate and the number of premature death since the early 1990s [2, 3] though due to changes in nutritional situation underweight is becoming a problem in Estonia [9].

In conclusion the results of the current study highlighted that height-weight categories have a small but significant impact on the BP. Our study suggested that the screening of blood pressure of *large* boys, as also boys of discordant height-weight categories and especially *leptomorphous* boys could be advisable. Future longitudinal studies with more detailed height-weight classification could shed light on the issue whether, for example, extreamly leptomorphs are at the higher risk of elevated SBP or DBP or not.

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PREDICTION OF THE FOETUS' AND NEWBORN BABY'S WEIGHT BY USING ULTRASOUND EXAMINATION MEASUREMENTS

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Key words: weight of the foetus, birth weight of the newborn baby, models

INTRODUCTION

The prediction of the newborn baby's body measurements is required in obstetrics. Weight, height and other birth data of the newborn baby provide an overview of its development and the state of health. The body measurements of newborn babies are approximately proportional, though it is not exactly known how such a phenomenon persists throughout the embryonic development of the foetus. Ultrasound examinations of the foetus have increasingly been used over the last decades with the aim of predicting the baby's birth weight. Such examinations have been carried out in Estonia for over ten years, however, the formulas used in Estonian hospitals have not been calculated on the basis of the examinations of Estonian children and their accuracy has not been checked. The data from the ultrasound examinations have undergone relatively little statistical research in Estonia. The topic has been handled by statisticians from a number of European countries, and also from China, who have presented several mathematical models for forecasting birth weight by using the foetus' ultrasound examination measurements. As people of different countries differ from each other by build (e.g. the Estonians are rather tall compared to some other peoples), it can be assumed that newborn babies differ as well, and consequently the forecast formulae from other countries cannot be efficiently applied in the case of Estonian children.

Another inhibiting factor in the use of ultrasound data in forecasting is their potential inaccuracy and frequent gaps in data (e.g. if a physician failed to register a particular measurement).

The article provides an overview of some of the author's papers and examines how well the forecast models of the foetus and the newborn baby suit for theuse with Estonian newborn infants. It also works out the best possible forecast models of the foetus' and the newborn baby's weight based on the Estonian data that were compiled using different models suggested by various authors.

MATERIAL AND METHODS

The article uses empirical data from ultrasound foetus measurements and concomitant children's birth weights recorded in the Women's Hospital of the University of Tartu in the years 1995 and 1998. There are data on 1,930 live-born babies. All the foetuses were measured twice, firstly, on average, on the 140th day of pregnancy and secondly, on the 240th day.

This analysis uses the following ultrasound examination foetus measurements: biparietal diameter of head, femur length, abdominal breadth and abdominal depth. The ultrasound examination is used to assess the age of the foetus i.e. the so-called *ultrasound age*. The ultrasound age is usually measured in weeks based on the foetus' measurements, in this paper, however, the ultrasound age is the number of days from the first day of the last menstruation to the day of the ultrasound examination (both variables recorded with an exact date). Such an age measurement is used as it gives a result which is independent of the ultrasound measurement, and which should be more accurate than the age assessment based on the ultrasound examination measurement. Because of the fast growth rate of the foetus, the age is calculated in days. There are two ultrasound ages, as the foetuses were measured twice during pregnancy, *IUHp* and *IIUHp*. In addition, the time variable *DUS* is used, which represents the number of days between the two ultrasound examinations. Regression analysis is used to make predictions and forecasts.

Even though the foetuses under research were generally measured twice, the data contain a number of blanks, especially in the case of the first examination. Imputation of the missing values is one of the most essential issues in modern applied statistics. The author has treated the issues more profoundly in her previous article [18]. That paper also focuses on a methodological aim – how to render large data sets with many missing values usable and how to evaluate the credibility of results retrieved on the basis of data with blanks.

The use of ultrasound examinations of the foetus to predict the birth weight

The Estonian authors have conducted research concerning the body structures of non-pregnant and pregnant women and newborn babies [4], the relation between the body structure, clinical-anthropological data, and the course of pregnancy, and its effect on the Apgar score in the first minute of life [17]. Thorough research has been conducted on the basis of anthropometric measurements to predict the size of the newborn infant's head [5]. The aim of the above surveys was to provide the most objective overview possible of the relations between anthropometric measurements, their changes during pregnancy, and their effect on the newborn baby's measurements, including the birth weight.

To predict the child's birth weight, the mother's anthropological measurements can be used. To predict the newborn baby's weight, the Zordania formula [16] is commonly used in practice, where the newborn baby's weight is expressed as the height of the fundus of uterus multiplied by the circumference of the abdomen. Ultrasound measurements have been conducted in the Women's Hospital of the University of Tartu since the 1980s. The formula developed in the Karolinska Hospital, Stockholm, is used for the prediction of the foetus' weight and it is used in Tartu in the course of mutual assistance. Unfortunately, neither the author nor the practical users of the formula have any data concerning the surveys or publications of the formula.

A survey conducted in China [15] presents a correlative relation between the ultrasound measurements of 300 babies and their birth weight (biparietal diameter, cerebellar circumference, femur length, abdominal circumference). The results show that the foetus' abdominal circumference was strongly correlated to the birth weight ($r = 0.87$) and statistically significant. The summary of the article gave no further information on other measurements. The authors state conclusively that the abdominal circumference gained in the ultrasound measurement is a simple and valuable index for predicting the foetus' weight.

A number of authors have derived mathematical models for the prediction of the foetus' weight. British researchers [7], in the course of a retrospective survey using ultrasound measurements from 29 foetuses conducted in the 24–40th weeks of pregnancy and at least 10 days before delivery, found a model for the prediction of the weight of twins (Femur 4). This model uses only the femur length and abdominal circumference for the weight prediction and the result is better than the models of Campell [1], Shepard [14] and Hadlock [3], which require complicated measuring of the head, something which is very troublesome in the cases of multiple pregnancy. The author suggested a model in her earlier article [12] which proved somewhat better than the model of Hadlock or the others.

There are quite a number of sources concerning the reliability and validity of ultrasound measurements. The British researchers [2] examined the suitability of formulas (Aoki, Campell, Shepard, Hadlock models) for predicting the foetus' weight using ultrasound measurements:

Aoki: $EFW=1.25647 * BPD^3+3.50665*FAA*FL+6.3$

Campell and Wilkin: $\ln(EFW/1000)=-4.564 + 0.282*AC-0.00331*AC^2$

Shepard *et al*: $\log_{10}EFW=1.2508+0.166*BPD+0.046*AC-0.002646*AC*BPD$

Hadlock *et al*: $\log_{10}EFW=1.304+0.05281*AC+0.1938*FL-0.004*AC*FL$.

The following abbreviations are used: EFW – estimated foetus' weight (g); BPD^3 – biparietal diameter at rank three (cm^3); FAA – indicator characterising the foetus' abdominal area (no further explanations in the article); FL – femur length (cm); AC – abdominal circumference (cm).

Fifty pregnant women were examined and the measurements required for the model were taken up to one week before delivery. The foetus' weight was calculated and 25 grams for each day remaining until delivery were added. The estimated daily growth originates from an earlier research by the authors [11], which established that the average increase in weight in weeks 37–40 of pregnancy was 25 grams per day. The final findings showed that the birth weight predicted in this way was lower than the actual birth weight for all the formulas. The smallest average weight difference occurred in the formulas of Shepard (51.4 g) and Aoki (60.5 g). The Hadlock and Campell formulas displayed considerably larger differences (190.7 g and 141.8 g). The confidence interval of the average weight difference was the smallest (–324.2–445.2g) in the Aoki formula, and the widest (286.5–570.1 g) in the Campell formula. The research concluded that ultrasound measurements are fairly reliable for the prediction of the foetus' weight. It also proves an assumption that the values of the model parameters depend on race, social and cultural environment and time, which suggests that the compilation of "national" models is currently relevant.

A joint survey from Great Britain and Peru [6], which researched how biometric indicators of the foetus relate to altitude in Peru and compared pregnant women at the height of 4,300 m (in the settlement of Cerro de Pasco) and at sea level (Lima), proved this as well. The research did not find any differences in foetuses developing at different heights until the 25th week of pregnancy but in the later stage of development the measurements of the foetuses at greater heights were statistically noticeably smaller. The models presented for the measurements of the foetuses developed at sea level were as follows:

$$BPD = -14{,}43395 + 24{,}34002*GA^2 - 12{,}77063*GA^2*\log(GA)$$
$$HC = -57.20661 + 89.83847*GA^2 - 47.43493*GA^2*\log(GA)$$
$$AC = -130.2058 + 147.6567*GA^2 - 1.800975*GA^2*\log(GA)$$
$$FL = -104.8855 + 98.01394*GA^2 - 0.3105365*GA^2*\log(GA)$$
$$EFW = 12842{,}6 + 52806{,}21*GA^{-2} - 51276{,}29*GA^{-1}$$

where EFW – estimated foetus' weight (g); BPD – biparietal diameter (cm); FL – femur length (cm); AC – abdominal circumference (cm); HC – circumference of foetus' head (cm) and GA is stage of pregnancy in weeks.

A survey was conducted in Singapore [8] aimed at compiling a standard description of the growth of the foetus' weight in terms of the stage of pregnancy determined in the ultrasound examination. An essential role in compiling the standard was played by a relative growth curve where the weight of the foetus is presented as a ratio of the final result, i.e. of the birth weight, and that ratio (expressed as a percentage) is described in the following model:

$$\%wt = 208.53 - 23.09*GA + 0.82253*GA^2 - 0.0078279*GA^3$$

where GA is the stage of pregnancy in weeks [9].

After some calculation it was evident that quadratic and higher terms are not essential in the model and therefore the model of the foetus' weight can be presented as follows:

$$\text{foetus' weight} = 181.37*GA - 3742.12$$

The authors finally state that a normal foetus' growth should be increasing linearly with the stage of pregnancy in the last trimester. They also state that the foetus' weight should be calculated either using the stage of pregnancy determined by the ultrasound examination or using the foetus' body proportions, but not from the time of the last menstruation, as that is not as precise as the time determined by the ultrasound examination.

The aim of the above surveys is similar: as precise as possible a prediction of the weight of the foetus, in order to use its changes to forecast the course of delivery. The creation of the standards of the foetus' growth helps detect possible deviations and make conclusions concerning the development of the foetus.

Models and the description of their compilation

The Estonian data described the data for live newborn babies and the prediction did not include foetus' weight in the initial data, and thus it was not possible to find parameters of similar models for the Estonian data, but it was obvious when using the models of different authors [10, 3] that it is not expedient to use the so-called Karolinska formula, which has been in use in the Women's Hospital of the University of Tartu over a longer period. Adding the models of other authors [2] to the formulas used in the article [12], the result is the change in the foetus' weight during pregnancy as described in Figure 1.

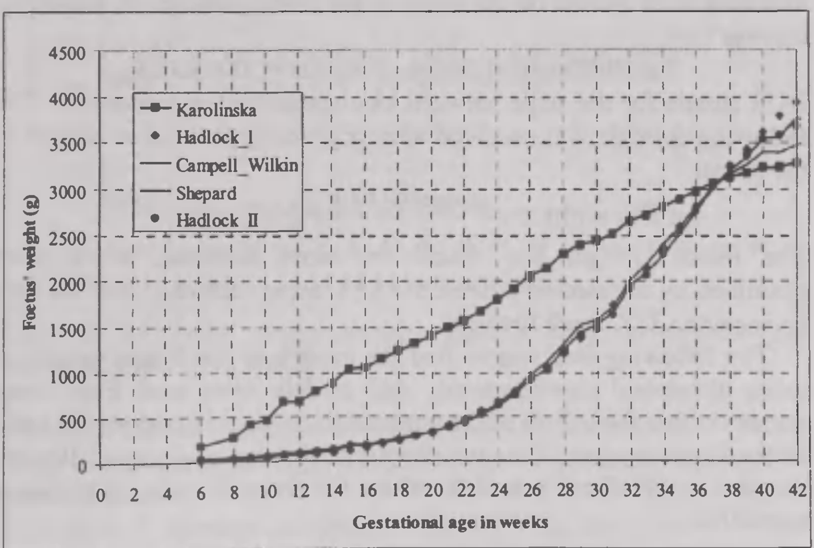

Figure 1. The foetus' weight during pregnancy using models of various authors

Even though Figure 1 does not clearly display the change in the foetus' weight separately for different models, we can clearly see that the weight from the Karolinska formula is completely different from that from other formulas in the figure. The Singapore model [8] only describes the most intensive growth period and it is linear, the others, however, are meant for predicting the weight logarithm and are suitable for a longer period as well. All the models, except for the Karolinska and Singapore models (which joins the rest in the 24th week), present similar results between weeks 6 and 38 of pregnancy, thereafter some differences occur. The Shepard model and the Hadlock's second model are the closest to a real newborn baby's birth weight, according to the Estonian data, and probably the foetus' weight and also the newborn baby's weight should be calculated with these models in the future. The Karolinska formula overlaps with the help of the other models only in week 38. Uneven weights of the foetus in the last weeks of pregnancy, as shown in Figure 1, probably occur because pregnancy normally ends in about week 40 and only a few foetuses are measured then.
In order to assess the parameters of the models in the above sources against the data of Tartu, the foetus' weight was derived by using the available birth weight on the basis of the model evolved in the earlier surveys [13]:

$$\text{Ln NbWeight}=1.0009\ln \text{FWeight}+0.0043\text{DUS}.$$

DUS stands for the days between two ultrasound examinations. The following formula was received after expressing the foetus' weight in the model:

$$\text{Ln FWeight} = e^{-0.004296DUS} * \text{NbWeight}^{0.999}.$$

The foetus' weight was found for those foetuses, which were examined by ultrasound at least 50 days before delivery, and the data set included 1373 such foetuses.

The following step was to find the models of the foetus weight by using ultrasound measurements, and models were used from those sources where the values of the parameters were predicted on the basis of the Estonian data. Thus we receive analogues of Campell-Wilkin, Shepard and Hadlock's models, where the determination multiplier is over 50%.

$$CW = 1.4 + 0.09 * AC - 0.00076 * AC^2 \quad R^2 = 0.52$$

$$SHEPARD = 2.53 + 0.06 * BPD + 0023 * AC - 0.001 * BPD * AC \quad R^2 = 0.53$$

$$HADLOCK = 2.557 + 0.018 * FL + 0024 * AC - 0.0015 * FL * AC \quad R^2 = 0.53$$

hese three models were selected because they had used different ultrasound measurements and in prediction did not use a time variable which is frequently determined at a certain remove in ultrasound examinations.

The graphs of the foetus' weight with the foetus' weight calculated on the basis of the Karolinska formula are shown in Figure 2.

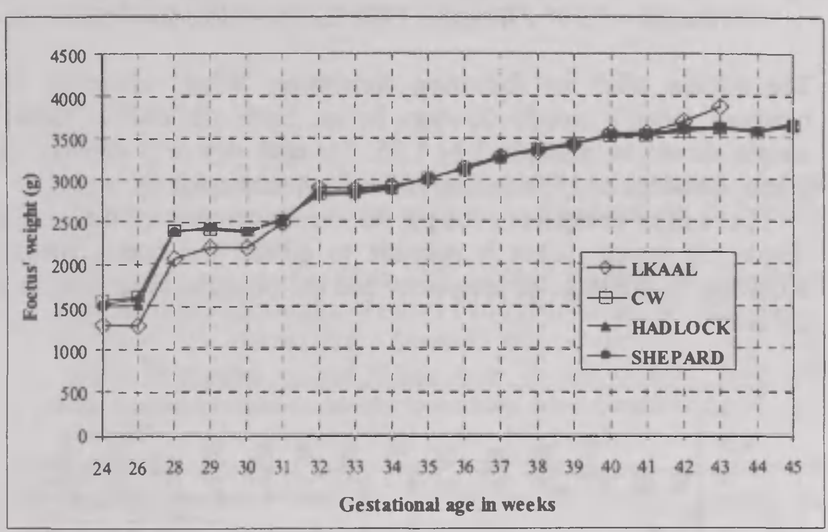

Figure 2. The foetus' weight during pregnancy using models of various authors and data from Tartu.

Where the foetus' weight was calculated for the foetuses examined up to 50 days before delivery, the graph shows the stage of pregnancy from week 24.

Figure 2 displays predictions as well as the foetus' weight calculated using the birth weight from the predictions. As can be seen, all the predictions in weeks 32–40 are relatively similar but the weight of the foetus examined in weeks 24–30 calculated from the birth weight is smaller than that predicted on the basis of ultrasound measurements. The actual weight of the foetus at the end of pregnancy is bigger than predictions, and this is evidently due to the small number of the subjects.

Once the foetus' weight was predicted, it became possible to predict the newborn baby's weight bearing in mind the presumed number of days until delivery. The following are the models for predicting the newborn baby's weight (*NbWeight*) based on the foetus' weight (*FWeight*) models referred to above:

According to the Shepard's model and time until delivery:

$$NbWeight = 1.25 * FWeight + 21.23 * DUS - 913.605 \quad R^2=0.68$$

According to the Hadlock's model and time until delivery:

$$NbWeight = 1.26 * FWeight + 21.4 * DUS - 952.191 \quad R^2=0.69$$

According to the Campell-Wilkin model and time until delivery:

$$NbWeight = 1.19 * FWeight + 19.28 * DUS - 688.347 \quad R^2=0.66$$

The models offer the following conclusion. When predicting the newborn infant's weight 50 days before birth, the current foetus' weight should be multiplied by 1.25. For each day until delivery 21 grams are added and 930 grams, on average, subtracted.

The author compiled a graph for the better use of the results (Figure 3) which makes it possible to predict the foetus' weight according to the stage of pregnancy and the potential birth weight of the baby.

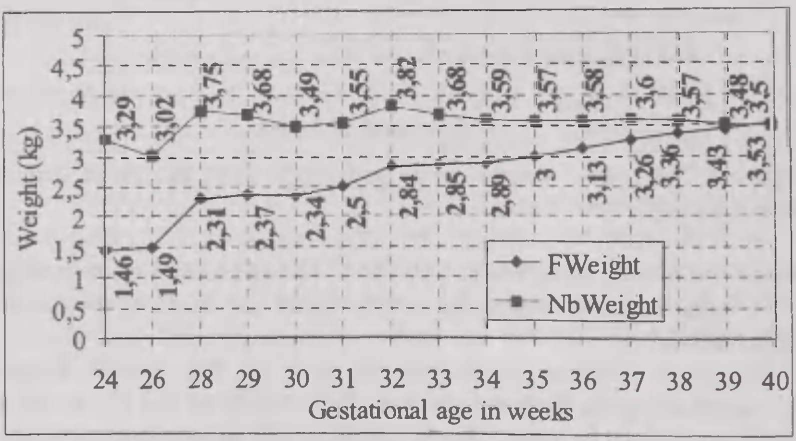

Figure 3. Prediction of the foetus and its birth weight according to the stage of pregnancy.

Figure 3 shows that the predicted birth weight of the newborn baby ranges between 3.29–3.5 kg and the predicted foetus' weight ranges between 1.46–3.53 kg. The instability of the curve of both predictions until the 30th week of pregnancy occurs because the foetus was measured too early, as for the foetus younger than 30 weeks the prediction margin of error can be too large.

DISCUSSION

The article gave an overview of the author's work and compiled models for the prediction of the foetus' weight. The practical outputs of the paper are average predictions of the foetus' weight and newborn baby's birth weight according to the stage of pregnancy and the models used in the article.

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