Papers on Anthropology

XVI

PAPERS ON ANTHROPOLOGY
XVI

Prof. Juhan Aul
15.X.1897–28.VIII.1994

UNIVERSITY OF TARTU
CENTRE FOR PHYSICAL ANTHROPOLOGY

PAPERS ON ANTHROPOLOGY

XVI

The collection is dedicated to the 110th birth anniversary of Professor Juhan Aul

TARTU 2007

The collection is indexed in BIOSIS, SPORTDiscus,
Anthropological Index Online,
EBSCO Publishing, CABI International,
Index Copernicus, Estonian Database Ester

The publication of the collection has been supported by
the Institute of Anatomy, University of Tartu

ISSN 1406–0140

Tartu University Press
www.tyk.ee
Order No 372

PREFACE

With the current collection, we celebrate the 110^{th} birth anniversary of Juhan Aul. It is difficult to overestimate Juhan Aul's merits. He was the founder of the Estonian school of anthropology, organizer of large-scale anthropometric studies of men, women and school students. As early as in 1942, he stated that Estonia was one of the anthropologically best-researched countries in the world, and, in order to preserve the identity of the Estonian nation, he asked for continuation of these studies.

We have been trying to preserve his heritage and follow his guidelines and the anthropological research method recommended by him has found application in biology, medicine, health promotion and nutrition.

The advantages of using the anthropological method of research are, on the one hand, the availability of the classical measuring technique by Martin and, on the other hand, the existence of regularities of the anthropometric structure of the body as a whole.

For the last decade, the anthropologists of Tartu have been studying the latter. The body as a whole has been found to consist of mutually correlated variables with height and weight as the leading characteristics.

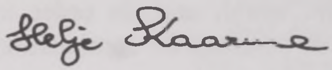
Thus, height and weight determine up to two thirds of the variability of all the individual characteristics and each individual characteristic does not express only a concrete numerical value but also represents the body as a whole. Like in pycnics and leptosomes, in the general sample, too, the basis for multivariate variability is the value of height and weight and their ratio.

Therefore, it is understandable why, by using the anthropological method of research, positive correlations with body build are achieved if only a few body measurements are used in correlation and regression analyses, or if only height, weight, body mass index are applied or if, for simultaneous systematization of many body measurements the Heath-Carter system or the 5 SD classification recommended by us is used.

Thus, the anthropometric method of research has a firm theoretical basis, and therefore it can lead us closer to the ultimate aim of theoretical biology and medicine – establishment of the constitutional peculiarities of healthy and ill subjects.

J. Aul started regular publication of collections of articles on anthropology as early as in 1964. This tradition has continued to the present. We are happy to thank all our current and future authors for their contributions to *Papers on Anthropology*.

Thank you all.



Prof. Helje Kaarma

CONTENTS

J. Kasmel, T. Kasmel. How Juhan Aul became an anthropologist (for Prof. J. Aul 110th birth anniversary 9

L. Kongo. On Juhan Aul and his students in anthropology 20

M. Lintsi, L.Kongo, H. Kaarma, M. Aunapuu, A. Arend. Founders of Section of Anthropology at the Estonian Naturalists' Society and their biographies and scientific bibliographies 30

M. Aunapuu, M. Pilmane, M Ots, A. Arend. Ultrastructural analysis of the human kidney biopsies 49

M. Bronikowski, R. Ślebóda, E. Szczepanowska, A. Kantanista, M. Bronikowska. Daily physical activity of Polish youth 56

Z. Cēderštrēma, J. Vētra, I. Duļevska. The absolute and relative growth rate of the longitudinal measurements in Riga school-age boys 70

I. Duļevska, S. Umbraško, Z. Cēderštrēma, J. Vētra, U. Teibe. Changes in body proportions during growth of Latvian girls in Riga 80

A. Gocentas, A. Landõr, A. Juozulynas. Recovery after repeated sprints associated with aerobic capacity in basketball players (recovery after sprints in basketball players) 92

E. Godina, V. Batsevich, O. Yasina, A. Prudnikova. Abkhazia revisited: Secular changes in the two generations of rural children 100

R. Jankauskas, Ž. Palubeckaitė-Miliauskienė, A. Barkus, A. Urbanavičius. Military stature variations during the 19th century: Napoleonic versus German soldiers of World War I 122

L. Heapost. 55 years of historical research at the Institute of History 132

H. Kaarma, M. Lintsi, L. Saluste, S. Koskel, A. Arend. Estonian national norms of height, weight and body mass index for men and women aged 20–70 years 139

L. Kalichman, E. Kobyliansky. Body composition: variations during the life-span and association with manifestations of aging 147

D. Kažoka, J. Vētra. Relationship between age at menarche and adult body mass index (BMI) 170
J. K. Lutskaya, N. V. Novak. Significance of morpho-functional particularity of the tooth in practical odontology 180
B. Neruda. Results of current and some older studies on the estimation of stature 186
A. Oginska, J. Vētra, M. Pilmane. Latvian infants' cephalic index change during the first year of life 198
M. Ojamaa, A. Landõr, M Ignatjeva, J. Maaroos. Physical examination parameters and health-related behaviours among Tartu University students (anthropometric parameters in students) 210
Ž. Palubeckaitė-Miliauskienė, R. Jankauskas. Dental status in two military samples: soldiers of Napoleon's Great Army and German soldiers in World War I 235
L. Pļaviņa. Characteristics of physical preparedness and physical fitness of the military officers and soldiers 237
M. Prokopec. Understanding human growth (Prague longitudinal study 1956–1981) 244
E. Szczepanowska, K. Jarska, M. Chudecka, E. Sieńko. Application of a vibraplate to shape body mass components in regular exercises 257
R. Stupnicki, P. Tomaszewski, K. Milde. Contributions of age, body height and body mass to the total variance of an example physical fitness variable 266
G. A. Tóth, B. L. Buda. Study on the physique of 60–80-year-old Hungarian women at the beginning of the 21^{st} century 273
M. Toomsalu. 110 years since the introduction of boiled rubber gloves into surgical practice 278
S. Umbraško, J. Vētra, I. Dulevska, S. Boka, L. Gavricenkova, R. Zagare. Specificities of foot growth among schoolchildren of Riga and Latvian regions 283

Papers on Anthropology XVI, 2007, pp. 9–19

HOW JUHAN AUL BECAME AN ANTHROPOLOGIST (FOR PROF. J. AUL'S 110TH BIRTH ANNIVERSARY)

Jaan Kasmel, Tiiu Kasmel

Centre for Physical Anthropology, University of Tartu, Tartu, Estonia

During almost eighty years, more than a hundred publications have appeared about the life and work of Professor of Zoology Juhan Aul, the founder of Estonian anthropology, the pioneer of our biometry and data processing, one of our first palaeoanthropologists and a long-time staff member of the University of Tartu [19]. The following overview about how Juhan Aul became an anthropologist attempts to be an addition to what has been published earlier.

Professor, Doctor of Biology Juhan Aul was born as a son of a farmhand in Are commune, Pärnu County, on 15 October 1897. His education began at the local Suigu commune school. He continued his studies in Taali ministry school in the neighbouring Tori commune, which he completed in 1912. Thereafter, for one year, he helped his father in fieldwork. His studies continued at Pärnu municipal school until 1915 when he had to leave as the family was in straitened circumstances. He took up a job as an assistant to the commune clerk [10].

Thirst for education made the future professor an autodidact who devoted his entire free time to studies. J. Aul paid special attention to languages; despite the difficult economic situation, he even took language classes in Pärnu. In his childhood, up to the municipal school, J. Aul was particularly fascinated by the Estonian language. For the time being, he did not show any special interest in natural science [19].

From 1 December 1916, at the age of 19, he became a teacher at Uulu three-year commune school; from the following autumn, however, at Suigu, where he worked until 1 August 1921 [10]. In this job, he also issued his first publication – "What should our secondary school be like" – in Issue 3 of *Kasvatus* (Education), the journal of the

Estonian Association of Teachers. This happened even before he had acquired secondary education himself. Next year the same journal published his articles "Sequence of themes in the course of botany" and "Natural science rooms in primary school" [19].

He continued his education while working as a teacher, and in spring 1920 a board at Tallinn School of Teacher Education awarded him qualifications of subject teacher (and home tutor) of natural science and Estonian. In June of the following year, he took secondary school final examinations as an external student [10].

In the autumn of 1921, J. Aul became a student of zoology at the Faculty of Mathematics and Natural Sciences at the University of Tartu. His life at the university was not easy. In order to earn his living and pay for tuition, he worked for a year and a half as a teacher of natural science at Tartu Night Primary School, for two years at Tartu School of Teacher Education and lectured for several years at the Folk High School of the Education Association [10].

Quite at the beginning of his university studies, J. Aul published his first book *Experimental and Observational Botany. Work- and Textbook for Primary School* (1922). When writing it, he made use of the experience he gained at teaching this subject at commune school [19].

When coming to the university, J. Aul's main interest area was human and animal physiology [7]. J. Aul had only become interested in nature as a young teacher, when pondering on the contradictions between the Bible and the evolutionary theory. Later, he was guided by J. Piiper's *Biological Letters*, popular scientific publications of the Estonian Students Society and his own lectures on human anatomy and physiology at the Folk High School. As he organised field trips, he had to learn to know plants and animals. This brought about the wish to become a physiologist [19].

In his first year at the university, J. Aul studied human anatomy under an extremely exacting and demanding professor – A. Sommer. From the autumn of the second year, he could attend the lectures of human physiology by Prof. A. Lipschütz, whose lectures were highly appreciated. During the spring term, J. Aul already became an "insider" at the Institute of Physiology. Soon the professor advised him to conduct an experimental study on the development of frog tadpoles in alcoholised environment. Having agreed, J. Aul first read pertinent literature, began his experiments in the spring term of 1923 and completed the work by the autumn. Even the professor was amazed by the very interesting results [7]. On the university's anniversary, J. Aul's research paper *Development of frog tadpoles in alcoholised environment* on 39 pages (with 41 figures, 13 microphotos, 7 protocols and 7 tables) won the First Prize, which was accompanied by 10,000 marks donated by the Estonian Temperance Association [19]. With this paper, J. Aul gained his first experience as a researcher and experimenter; this was the beginning of his career as a scientist.

From 1923–1924 J. Aul worked as a voluntary demonstration assistant for Prof. Lipschütz [10]. Two years later, the professor left Tartu for Chile. He was replaced by A. Fleisch, whose research interests were quite different (physiology of blood circulation and respiration, which was accompanied by creation of original apparatus) [10, 20]. As J. Aul's interests were different, he distanced himself from physiology [7].

Still, he did not remain alone in his scientific quests. Encouraged by his friend, student of botany J. Karu (1897–1923), he had meanwhile read abundant literature on genetics and acquired considerable knowledge in this field; he even published two lengthy overviews.

On the recommendation of J. Tork, Director of Tartu School of Teacher Education, J. Aul became interested in comprehensive studies of twins. For this purpose, he had to acquire the technique of anthropometric measuring as twins always had to measured when studied. Here he found help from H. Madisson MD (the later adjunct professor of eugenics) who had acquired these skills in Helsinki during the Christmas holiday of 1920 under the supervision of the well-known Finnish anthropologist Prof. Y. Kajava [19].

J. Aul managed to collect anthropological data on 40 pairs of twins. When analysing the material, he realised that the existing data were still too scanty for a proper anthropological research paper [7].

From here, it was not a long step into "big anthropology", which became J. Aul's main area of scientific research.

To overcome the scantiness of data, it was necessary to collect new material for further studies. Here the question arose, where and based on which features the sites for collecting new anthropological data should be selected.

J. Aul acquainted himself with pertinent literature, among which he particularly liked the Finnish anthropologist K. Hildén's studies on the anthropology of Siberian peoples. J. Aul came to the idea that, in Estonia too, anthropological investigation might be carried out on the population of a smallish isolated area. His choice was the peninsula of Sõrve in Saaremaa island. This region could be considered a relatively remote and isolated, and therefore its population could also differ anthropologically [7].

On 4 February 1926, the student of zoology J. Aul, who had been hatching those plans, and three other students of zoology were elected active members of the Estonian Naturalists Society [16]. By that time, the society had been working for nearly 75 years, and 13 reports on anthropology had been made at its meetings [18], which constituted less than one per cent of all presentations. Thanks to J. Aul, in the following years this number began to increase [11].

In the 1920s joint expeditions to several places by representatives of different sciences began to be organized in Estonia. Thus, J. Aul had the opportunity to include his anthropological study in the programme of geological, geomorphological and zoogeographical research of Sõrve peninsula, planned by Raimla Students Society [15].

About the beginning of his first anthropological expedition, J. Aul writes the following, "On the afternoon of a hot day in mid-June 1927, having walked more than 30 kilometres, I crossed the little bridge of the Salme River and stepped on Sõrve peninsula that I had already carefully studied on the map... I cherished the hope that racially the people of Sõrve might be one of the most interesting groups of people in Estonia – Sõrve peninsula is one of the western borders of the settlement area of Finno-Ugric peoples; at the same time it is one of the places where the western peoples gained foothold during their migration across the sea to the east... Which peoples have had greater racial influence on Sõrve – eastern or western? These were the questions for the solving of which data had to be collected..." [1].

This time, the measurements in Sõrve lasted for three weeks. Every single farm and house was visited and all the people at the age from 18 to 50 years measured. J. Aul writes that the people were kind and helpful; only the fleas were annoying; there were so many of them that he was covered with bites all over.

Despite difficulties, he continued measurements in Sõrve in the following summer and finally managed to collect the necessary material. Its analysis remained in the time after graduation [7].

In 1928 J. Aul graduated from the university with the degree of Master of Zoology. As his Master's thesis, he presented the experimental study conducted some years ago under the supervision of Prof. A. Lipschütz, for which he had been awarded the first prize [19]. From 1 September, he was appointed for four months to the post of acting junior assistant at the Institute and Museum of Zoology. Next he was elected to the post of senior assistant at the same institution until 1 January 1933 [10].

Already in 1929, Master of Zoology J. Aul published the main results of the anthropological research conducted in Sõrve during two summers in the *Reports of the Naturalists Society* (Loodusuurijate Seltsi Aruanded) [7]. From him had become one of the pioneers of Estonian biometry and data processing.

J. Aul's first paper on anthropology was briefly reviewed by the leading figure of Soviet anthropology Prof. V. Bunak, head of the Department of Anthropology at the University of Moscow, in issue 1/2 1930 of the journal *Russkij antropologicheskij zhurnal* [9].

The analysis of Sõrve data showed that anthropological analysis of the population of such a small area did not yield any essential results when broader background material was missing. Therefore, a similar overview of the whole Saaremaa would have been needed [7].

J. Aul would not have been able to collect such amount of data alone. He decided to employ measurers from among students of medicine and natural sciences. To conduct his research in the following years, he received funding from the Estonian Naturalists Society, the University of Tartu and the Cultural Endowment of Estonia [10]. In three years, the necessary material was collected. Still, it turned out that the measurers had made a number of mistakes. However, by that time J. Aul had gained sufficient experience to find the errors relatively quickly. Although he thought he had instructed his assistants thoroughly enough, this did not suffice. From that time onwards, he always emphasized that anthropometric measuring should always be taught properly and the requirements strictly followed [7].

From this material, only the data collected from Muhu island were published in print under the title *On the anthropology of the inhabitants of Muhu* (*Muhulaste antropoloogiast*, 1932) where the measurement errors could have been rather small [19]. Later he used the materials of the whole Saaremaa County in his habilitation thesis for determining age-related changes in anthropometric characteristics [12].

When working in Saaremaa, he had already in 1928 noticed an interesting phenomenon: in the parishes of western Saaremaa the percentage of illegitimate children had grown significantly in the years of World War I (particularly in 1917). In Jämaja parish on Sõrve peninsula they constituted even 52%. The results concerning the whole Saaremaa proved to be very interesting [7]. In 1934 he published them under the title *On the anthropological influence of the World War on the inhabitants of Saaremaa* (*Maailmasõja antropoloogilisest mõjust saarlastele*). A short summary of it was also published abroad [19].

Analysis of the collected material revealed that, in order to interpret the anthropological phenomena of Saaremaa County, similar data from the mainland were needed, and the pertinent research should have a much more extensive basis.

From that time onwards, the aim of Juhan Aul MSc was the compilation of *Anthropologica estonica* that would embrace the whole territory of Estonia. To this end, it was necessary that the sample measured should be proportional to the number of population in a certain parish or county, and that the subjects measured should be of the same age and without changes due to aging. J. Aul came to the fortunate idea to carry out this kind of studies on men who were leaving military service. Thus, from 1932–1936, he measured nearly 15,000 men of nearly the same age, receiving data on young men's anthropology from the whole of Estonia [8].

For this purpose, he visited military units all over country twice each year. He measured only the soldiers of older age class so that the data would mostly reflect fully-grown persons. It also happened that he measured at day and at night travelled to the following location [7]. Later, a factor conducive to such large-scale research was the university's homeland scholarship on anthropology that he received for two years [19]. J. Aul has also thankfully mentioned that the army administration was very obliging, which made his work considerably easier. It might be added that J. Aul himself had gone through four months of mandatory military service in 1924 as a private in the railway company of the Pioneer battalion [10].

After completing the measurements in the army, because of the abundance of dates, he decided to analyze them gradually.

The overwhelming majority of anthropological studies in the world are based on male material. On the women of many nations there are absolutely no anthropological data, or they are sporadic or reflect only a few characteristics. Sometimes the data are based on a too small sample, are selective, date back to very different periods, or are not comparable to males' data of the same period. Even today, anthropology can be considered men's anthropology rather [4].

J. Aul had realized by the initial year of his anthropological studies that Estonia needs women's anthropology as well, as by that time Estonian women's descriptions from the anthropological viewpoint were too scanty or random. He began the anthropological research of Estonian women on Sõrve peninsula in 1927 along with measuring the men; the results on women were published in J. Aul's first anthropological paper along with men's data [7].

From 1932 J. Aul MSc launched an extensive programme of collecting anthropological materials from schools all over Estonia and continued this work until 1940. Because of time restrictions, collection of material was sporadic and random [6]. An overview of this work was published as late as in 1973 [19].

In the 1930s young Estonian anthropologists became interested in the anthropological characterization of three Neolithic skeletons that were very well preserved. J. Aul was approached for help. He became interested in the matter, although he had had no contacts with this kind of material earlier, and the necessary skills were lacking. He acquired the respective measuring technique. As he had sufficient knowledge of craniology and osteology, the following work did not pose any difficulty. Thus, "conversations" with skeletons began. J. Aul usually worked in the evenings and often late into the night. He took repeated measurements trying to find the essential. In his thoughts, he questioned his "protégés" about their life, nutrition, clothing, their joys and worries. In addition, he consulted literature. The reports on

Sope and Ardu Neolithic people were published in 1935 [7]. Thus, J. Aul MSc had become one of first Estonian palaeoanthropologists.

In the same year, 1935, he was elected a member of the London-based International Committee for Standardization of the Technique of Physical Anthropology.

In 1936 J. Aul made a presentation at the Finno-Ugric people's 5th Cultural Congress in Tallinn *On anthropological research in Estonia,* which was published in German in the same year.

In August 1937 he participated in the 2nd World Congress of Anthropologists and Ethnographers in Copenhagen. He made a presentation in the section of standardization of anthropological technique, which had been ordered personally from him by the moderator of this section Dr. A. Tildesley, a member of the British Royal Society, who had visited Tartu earlier.

First public recognition for *mag. zool.* J. Aul's anthropological research was the prize from Kreenbalt Ltd, 500 kroons, which he received in 1937 [19].

As short-term statistical analysis of the material collected in the army during more than four years was impossible even technically, J. Aul separated from it the data of West Estonia (Saare, Lääne and Pärnu Counties). Based on the anthropological data of 3824 men of this region, he wrote the monograph *Some anthropological characteristics of Estonians of West Estonian counties and their racial features* (*Lääne-Eesti maakondade eestlaste antropoloogilisi tunnuseid ja tõuline kuuluvus*) [2, 7]. This was also his doctoral thesis, which he defended on 19 March 1938 [10]. The French summary of the thesis was published even earlier, at the end of 1937 [19].

For background and comparison, studying of ethnic minorities in Estonia and peoples of neighbouring peoples proved necessary. The first paper on this theme, on the anthropology of Estonian Swedes and on the anthropological influence of Swedes on Estonians was completed as a presentation in 1936. An article in German was published a few years later in the yearbook of the Learned Estonian Society [19].

To enable Doctor of Natural Sciences J. Aul to upgrade his anthropological knowledge, the administration of the University of Tartu awarded him a foreign scholarship for eight months, from 1 August 1938 to 1 April 1939, for travelling to three European countries:

Poland, Germany and Switzerland [14]. At the beginning of the last month of his stay abroad, J. Aul sent and application to Prof. G. Rägo, Dean of the Faculty of Mathematics and Natural Sciences for *venia legendi* in anthropology.

J. Aul delivered his habilitation lecture *On age-related changes in anthropological characteristics of adults and their significance* on 31 May 1939, and on 3 October he received the qualifications of Associate Professor [3, 12]. In the spring semester of 1940 he started lecturing on anthropology to students of zoology. Teaching of anthropology at the University of Tartu can be associated with J. Aul's name for more than four following decades, although there were shorter or longer pauses in lectures, but this did not happen on his own initiative [13].

As an active member of the Naturalists Society, J. Aul made a total of 17 presentations from 1926–1939 at the general meetings of the Society, in the zoology section and the Tallinn department of the Society. Fifteen of his presentations concerned anthropology [17, 11]. In 1929, together with seven other members of the Society, he initiated the idea of the days of Estonian naturalists, in order to encourage naturalists to joint undertakings. During the two first Estonian naturalists' days (1931 and 1934) he was a member of the organizing committee and at three of them (the third in 1937) he made presentations on anthropology. From 1933, J. Aul as a member of the Society counselled those who were interested in amphibians and reptiles. From 1933–1938 he also worked at the editorial office of the popular scientific journal *Eesti Loodus* (*Estonian Nature*) under three chief editors. In this journal he published his own articles and short news items on zoology as well as anthropology [11]. On 19 April 1939 *dr. phil. nat.* J. Aul convened seven members of the Naturalists Society (H. Habermann, R. Indreko, E. Kumari, K. Pärn, A. Tõnurist and V. Üprus) in order to found its anthropology section [5]. Its aim was to be promotion of anthropological research, capturing public interest in the subject and uniting people who worked in anthropology or its bordering areas. After a report by J. Aul, the meeting decided to lay the foundation to the anthropology section. An application for founding the section was presented to the board of the Society with signatures of all the participants in the meeting. After thirteen years of J. Aul's extremely active work in the area of anthropology, the

Naturalists' Society got its anthropology section [11]. J. Aul himself, however, can be considered the founder of Estonian anthropology. On 11 May 1939 he confirmed as chairman of the anthropology section of the Society. The further work in the section was meant to proceed in three directions: scientific reports (mainly on research results), expeditions to gather new material and publishing. Now it can be said that under J. Aul's chairmanship, the anthropology section worked successfully during the following half century [17, 11].

Thus, persistent and hard-working Juhan Aul had become an anthropologist – beside his everyday work as senior assistant at the Institute of Zoology of the University of Tartu. The anthropological data on Estonian men, women and school students collected by him by that time had made it possible to consider Estonia one of the countries most thoroughly measured anthropologically.

REFERENCES

1. Aul, J. (1930) Sõrulastest. Loodusevaatleja, 3, 81–86.
2. Aul, J. (1937) Lääne-Eesti maakondade eestlaste antropoloogilisi tunnuseid ja tõuline kuuluvus. Tartu Ülikooli matemaatika-loodusteaduskonnale *doctor philosophiae naturalis* astme omandamiseks esitatud väitekiri. Tartu.
3. Aul, J. (1939) Antropoloogiliste tunnuste vanuselistest muudatustest täiskasvanute juures ja nende arvestamisest. Tartu.
4. Aul, J. (1977) Eesti naiste antropoloogia. Tartu Riikliku Ülikooli Toimetised. Vihik 438. Antropoloogia-alaseid töid III. Kogumik on pühendatud prof. J. Auli 80 sünnipäevale. Tartu, 5–103.
5. Aul, J. (1978) Antropoloogiasektsioon. In: 125 aastat Eesti Looduseuurijate Seltsi. Tartu, 75.
6. Aul, J. (1982) Eesti kooliõpilaste antropoloogia. Tallinn, Valgus.
7. Aul, J. (1982) Kuidas minust sai antropoloog. Eesti Loodus, 12, 797–799.
8. Ауль Ю. (1964) Антропология эстонцев. (Anthropologia estonica). Ученые Записки Тартуского Государственного Университета. Выпуск 158. Тарту.
9. Bunak V. (1930) Klein J. Quelques donnees sur l`Anthropologie des Sõrviens. Tartu, 1929. Русский антропологический журнал. Москва-Ленинград, 1/2, 81.

10. Estonian History Archives (EHA). Stock 2100, Series 2, Item 47.
11. Kasmel, J. (1999) Loodusuurijate Seltsi antropoloogiasektsiooni asutamisest 1939. aastal. In: Eesti Antropomeetriaregistri aastaraamat. 1999. Tartu, 11–16.
12. Kasmel, J., Kasmel, T. (1998) *Dr. phil. nat.* Juhan Auli habiliteerumisest Tartu Ülikooli matemaatika-loodusteaduskonnas 1939. aastal. In: Eesti Looduseuurijate Seltsi aastaraamat. 78. köide. Tallinn, Teaduste Akadeemia Kirjastus, 229–245.
13. Kasmel, J., Kasmel, T. (2000) Prof. Juhan Auli esimesest antropoloogia loengukursusest 1940. aasta kevadsemestril. In: Eesti Antropomeetriaregistri aastaraamat. 2000. Tartu, 32–35.
14. Kasmel J., Kasmel, T. (1997) About Juhan Aul`s Research Trip in 1938–1939. In: Museum of Tartu University History. Annual 1996. Tartu, 86–89.
15. Kongo, L. (1978) Eesti Looduseuurijate Seltsi tegevus ja organisatsioon. In: 125 aastat Eesti Looduseuurijate Seltsi. Tartu, 7–46.
16. Loodusuurijate Seltsi 1926. aasta aruanne. (1927) In: Tartu Ülikooli juures oleva Loodusuurijate Seltsi aruanded. XXXIV. Tartu, 9–10.
17. Loodusuurijate Seltsi aruanded aastatel 1926–1939. (1927–1940) In: Tartu Ülikooli juures oleva Loodusuurijate Seltsi aruanded. XXXIV–XLVI. Tartu.
18. Piiper, J. (1929) Lühike ülevaade Tartu Ülikooli juures oleva Loodusuurijate Seltsi arenemisest 1853–1928. In: Tartu Ülikooli juures oleva Loodusuurijate Seltsi aruanded. XXXV. Tartu, 12–19.
19. Professor Juhan Aul. Kirjanduse nimestik 1919–1997. (1997) Koost S. Mikelsaar. Tartu.
20. Tartu Riikliku Ülikooli arstiteaduskond aastail 1802–1975. (1976) Koost V. Kalnin, E. Raudam. Tartu.

Address for correspondence:
Jaan Kasmel
Centre for Physical Anthropology
Lossi 38, 6ed Anatomicum, tartu 51003
E-mail: jaanjkasmel@hot.ee

Papers on Anthropology XVI, 2007, pp. 20–29

ON JUHAN AUL AND HIS STUDENTS IN ANTHROPOLOGY

Linda Kongo

Juhan Aul's hardworking life began in Sauga commune in Pärnu County in 1897. Having acquired the qualifications of the teacher of natural sciences and the Estonian language at Tallinn School of Teacher Education in 1921, he worked for some time as a teacher. Thereafter, in 1928, he graduated from the University of Tartu with the Master of Zoology degree and received the Doctor of Natural Sciences degree from the University of Tartu in 1938. He became interested in anthropology as early as in 1924 when he worked as a teacher in Tartu School of Teacher Education. He was inspired by the head of the school Juhan Tork (1889–1980) who told Aul about the Italian anthropologist Maria Montessori and her papers on changes in schoolchildren's physical and psychical development [21]. Thus, Juhan Aul began anthropological measurements of schoolchildren, being particularly interested in twins. He collected data on schoolchildren until 1940, when he began lecturing on anthropology at the University of Tartu [2].

Having acquainted himself with pertinent literature, he became fascinated by the Finnish anthropologist K. Hildén's study on the anthropology of Siberian peoples. Inspired by that, he first planned anthropological studies in a limited region. Being still a student, he began anthropological studies on Sõrve peninsula on the island of Saaremaa and published the paper "Anthropology of Sõrve". He broadened his area of research over the whole of Saaremaa and recruited other students to help him. At first, the precision of measurements was insufficient; therefore, those materials remained unpublished.

In 1933, J. Aul started anthropological measurements in the army all over Estonia. More than 15,000 persons were measured. Unfortunately, all these materials were destroyed in the war. A year later, Aul completed a paper on the anthropological influence of Estonian

Swedes on Estonians. His doctoral dissertation, however, was the monograph *Anthropological characteristics and racial features of Estonians in West Estonian counties*, which he defended it in 1938. From that time onwards, Aul occupied several posts at the University of Tartu and travelled in Poland, Germany, Switzerland and elsewhere.

In 1950, as demanded by the followers of the Stalinist biologist Lysenko, he was dismissed from the post of associate professor at the University of Tartu, being accused of promoting eugenics.

In 1957 the University of Tartu employed him again as associate professor at the Department of Zoology; he received the title of professor and became head of the department. From 1976–82, he was consultant professor and became professor emeritus in 1993.

On 27 April 1939, on J. Aul's initiative, the section of anthropology was founded at the Estonian Naturalists Society. Along with Juhan Aul, its founding members were entomologist Harald Haberman (1904–86), archaeologist Richard Indreko (1900–61), ornithologist Eerik Kumari (1912–84), geographer and geologist Karl Pärna (1904–66), student Erna Tõnurist (later Aina Aul, 1910–41) and neurologist Voldemar Üprus (1902–56). At the founding meeting of the section, J. Aul delivered a report where he drew attention to the need to continue ongoing anthropological research and to arise interest in this branch of science. It should be noted that, along with Juhan Aul, the other founding members of the section who continued to practise anthropology were Aina Aul and Richard Indreko, who was engaged in paleoanthropology.

Since the foundation of the anthropology section, Juhan Aul engaged students to take anthropological measurements, but not all of them continued independent work in anthropology.

After World War II, the activity of the anthropology section resumed in 1956. Within more than ten years, expeditions were made to schools of Estonia and abundant material was collected. Students took anthropometric measurements, made presentations at the meetings of the anthropology section and wrote graduation theses. Only a few of them continued to work in this area later [3].

The first student of Juhan Aul who chose anthropology as her speciality was **Karin Mark** (1922–99). She was primarily interested in paleoanthropology. She examined the ancient skeletons collected at archaeological excavations by the Institute of History at the Academy of Sciences. Using this material, she wrote her graduation thesis *Paleoanthropological data on the Later Iron Age in the Estonian SSR and its eastern border areas.* A continuation to this study was her candidate's dissertation *Paleoanthropology of the Estonian SSR* that she defended in Moscow in 1953. Having exhausted the existing paleoanthropological research material, K. Mark began to explore the ethnic history of the Estonians relying on materials collected by J. Aul and herself. She took expeditions outside the borders of Estonia, reaching as far as Western Siberia. As a result, she wrote several research papers and made presentations at international conferences. A detailed overview of her life and work has been written by Leiu Heapost [5].

A significant part of J. Aul's work consisted in anthropological investigation of school students. This trend has been continued by his students. History of anthropology was taken up by Ken Kalling and Jaan Kasmel. If Leiu Heapost, Galina Sarap, who had come from Leningrad, and Gudrun Veldre entirely devoted themselves to anthropological research, then most students supervised by J. Aul confined themselves to graduation theses.

Leiu Heapost (b. 1936) began anthropological research as a student and in 1963 defended her graduation thesis on physical development of schoolchildren in Rapla district [4]. The theme of her candidate's dissertation, defended in 1975, was physical development of Tallinn schoolchildren. In the foreword to Leiu Heapost's bibliography, Gudrun Veldre writes, "Her research papers reflect the body build peculiarities of Estonians at present as well as in ancient times but also the population-genetic features of present-day Estonians. With particular thoroughness, she has studied the spread of different blood groups…" [6]. She has presented her research results at many international conferences and published them in Finland, Sweden, Poland, Hungary, Germany and Belgium. Her numerous publications (104 items in her bibliography) analyse measurement results of people living in Estonia as well as in the neighbouring countries – Latvia and Russia. In 1966 she participated in an anthropological expedition to the Khanty-Mansi and Yamal-Nenets Autonomous Regions of Russia where she determined the blood groups of 300 Khants, Mansi and Komi. At a meeting of the anthropology section in 1976, she spoke about blood groups of Finno-Ugric peoples. From 1963–95, Leiu Heapost was the secretary of the anthropology section and from 1996–2004 its chair.

In an indirect way, **Galina Sarap** (1940–1993) can also be considered Juhan Aul's student, although she graduated from Leningrad University. Like Leiu Heapost, she later worked at the Institute of History of the Academy of Sciences. In 1973, she started collecting odontological material from schoolchildren of Rakvere, Paide and Jõgeva. She continued her work in Lääne and Pärnu Counties. Together with Leiu Heapost, she also worked in Põlva, Võru, Keila and Kehtna, studying the odontological and population genetic-features of schoolchildren living there. She did not confine herself to odontological research of Estonians but also took research trips to the Transcarpathian region where she studied Hungarians who are a kindred people of Estonians. The odontological materials collected by her in Estonian schools from 1973–81 are included in the book published in 1994 with K. Mark and L. Heapost as co-authors [13].

Another follower of J. Aul's teachings in anthropology is **Gudrun Veldre** (b. 1962). In 1985 she wrote her graduation thesis on physical development characteristics of 3–4-year-old children in Tartu. She began her career as a teacher in secondary schools of Tartu. Thereafter she worked at the Institute of Zoology and Hydrobiology and the Institute of Molecular and Cellular Biology, both affiliated to the University of Tartu. At present, she is a research fellow at the Department of Cardiology at the University of Tartu. Her first article, on measuring 9-year-old schoolchildren of Tartu, was published in 1992. From 1997–99 she continued measuring Tartu schoolchildren. She presented her results in cooperation with co-authors in anthropological collections and at international anthropological conferences, including in Williamsburg, USA, in 1993 where she presented the report *Recent Achievements in Anthropological Studies of Children and Youth in Estonia*. In 2003 she defended her doctoral thesis *Somatic status of 12–15-year-old Tartu schoolchildren*. The study records the anthropometric variables of children measured in 1997–99 that can be compared with recent data later. From 1996–2004 Gudrun Veldre was the secretary of the anthropology section, from 2004 its chair.

Adolf Horn (1919–73) represented a different trend in anthropological research – dermatoglyphics. When working as a schoolteacher in Tartu, he studied, together with his wife Leida Horn, finger patterns, mostly in school and university students aged 10–25 years. He collected copious and precise data on Estonians' dermatoglyphics and published his results in several articles [7, 8]. In 1970 he presented his research results on Estonians' finger and palmar patterns at a meeting of the anthropology section; in 1972 he made a presentation on the density of papillary ridges on Estonians' finger bulbs.

Next follows an overview of students who collected anthropological material under J. Aul's supervision and, on this basis, wrote their graduation theses or published some articles.

Evi Remm (b. 1930) participated in anthropological expeditions of the Department of Zoology of the University of Tartu to Võru County but has not published any articles on the theme. Later she worked in the field of entomology at the Institute of Zoology and Botany of the Academy of Sciences.

Viivi Schütz (from 1959 Timm, 1934–1997) travelled in her student years with Prof. J. Aul to children's camps and schools of Estonia and measured schoolchildren. In 1958 she wrote her graduation thesis on physical development of Tartu schoolchildren [16]. In the following year, together with Karin Mark, she visited the territory of the Mari people and collected anthropological material. As she could not find employment in anthropology, she became a teacher. Later she worked as an expert on freshwater molluscs at Võrtsjärv Limnological Station.

From 1959–76 studies of schoolchildren's physical development continued at different schools of Estonia and a number of graduation theses were written. After graduation, most of these students were employed as schoolteachers.

Evi-Mai Kirhäiding (Kruusmaa, b. 1935) was the first secretary of the anthropology section of the Estonian Naturalists Society in the post-war period. In 1958 she participated in an anthropological expedition to the Volga region in Russia and presented a report at a meeting of the anthropology section. Using her research results from the former Tartu and Elva districts, she wrote a graduation thesis on schoolchildren's physical development [11]. She began her professional career as a teacher, later worked as a chemist at several laboratories.

Vello Kadakas (b. 1937) made anthropological measurements on Mordvinians as a student and, based on these materials, wrote his graduation thesis [9]. Thereafter he worked as a schoolteacher for two years and later took up postgraduate studies. After defending a candidate's dissertation in histology and embryology, he worked at the Institute of Experimental and Clinical Medicine and finally at the Estonian Marine Institute on fish pathology.

Mall Võhandu (b. 1936) also wrote her graduation thesis in 1961 on the physical development of schoolchildren in what were then Põlva and Räpina districts. She works as a teacher of biology and chemistry at Kiltsi Basic School.

A year later **Heidi Kruuda** (now Lukk, b. 1938) wrote her graduation thesis [12] and was employed in Pärnu as a teacher of biology. In 1963 **Aino-Liis Tassa** (now Ertel, b. 1938) defended a graduation theses on the development of Estonian schoolchildren's legs [18], although at a meeting of the anthropology section in 1959 she had made a presentation on lungs capacity and chest circumference in athletes of the University of Tartu. From 1960–63 she was the secretary of the anthropology section. She worked as a teacher of chemistry in Pärnu, later as a chemist at Pärnu water company.

In 1963 **Aini Virma** (now Vaarmann, b. 1941) collected data on schoolchildren's physical development in Harju County. She made a presentation at a meeting of the anthropology section on the development of height and weight in schoolchildren of the former Keila district but did not finalize it as a graduation thesis. Later she worked as a chemist at Tallinn Pedagogical University.

The theme of the graduation theses of **Viiu Tõrv** (now Salo, b. 1941) [19] and **Liina Riismaa** (b. 1943) was physical development of schoolchildren in the town and district of Pärnu. Viiu Tõrv later worked as a geologist and geobotanist for the Geological Survey of Estonia, specializing in studying the peat resources of wetlands. Liina Riismaa worked for some time at what was then the Young Naturalists Station, and then worked as a teacher and trade union functionary in Rapla County. She published the results of her anthropological research under the name of Liina Roosmaa-Rosimannus ten years after graduation in the yearbook of the Estonian Naturalists Society [14].

In 1969 **Maie Kahu** (now Kangur, b. 1947) wrote her graduation thesis on the physical development of South-Estonian schoolgirls. Having worked for a short time at the Young Naturalists Station, she later joined the Institute of Experimental and Clinical Medicine at the Academy of Sciences (now the National Institute for Health Development). A year later **Aime Akkerta** (now Leht, b. 1944) defended her graduation thesis on the physical development of schoolgirls in Harju district [1]. She first worked as a teacher at Järve Secondary School; now she works at the Dental Polyclinic.

Two of J. Aul's students presented their graduation theses in 1970. One of them, **Evi Uus** (b. 1945), discussed the physical development of schoolboys of Harju district [20]. **Meeli Roosalu** (b. 1948) wrote her graduation thesis on physical and psychical similarities of twin schoolchildren in the town of Viljandi [15]. Evi Uus works as a teacher at Lähte secondary school. Meeli Roosalu worked after graduation as a teacher at Tallinn Vocational Secondary School No. 12, later as associate professor the Department of Sports Theory at the Faculty of Physical Education at Tallinn Pedagogical University. Her interest in anthropology continued later as well. For example, in 1994 she participated in a joint seminar of the Estonian Naturalists Society and the University of Tartu on anthropological research of the head and the skull.

The following graduation thesis was already based on medical research. It was defended in 1976 by **Sirje Sisask** (b. 1950) and dealt with the scope and types of memory in schoolchildren [17]. After graduation Sirje Sisask first worked as a teacher of chemistry and biology; later she worked at the Faculty of Education and at the History Museum of the University of Tartu.

The anthropology section, however, began to engage lecturers of physical culture and medicine in its work.

Even earlier, in 1975, Gennadi Jagomägi (b. 1931), lecturer at the Faculty of Exercise and Sports Sciences of the University of Tartu, had delivered a report at a meeting of the anthropology section on gender differences in lower extremities of athletes. In 1978 medical scientist Aavo Mikelsaar (b. 1941) made a presentation on dimorphism of chromosomes and in 1979 Helje Kaarma (b. 1933) on the system of mutual correlation between anthropological variables.

In 1980 the anthropology section, in cooperation with the Department of Gynecology of the University of Tartu, held a joint conference of anthropologists and physicians.

At a meeting of the anthropology section in 1981, Leiu Heapost made a joint presentation with physicians Helje Kaarma and Virve Kask (b. 1930) about impressions from the 2nd conference of Soviet anthropologists in Minsk. Cooperation developed with the anthropology section of the association of Estonian anatomists, histologists and embryologists. From that time onwards, anthropological research mostly took an orientation towards medicine and physical culture and became to be supervised by Helje Kaarma.

REFERENCES

1. Akkerta, A. 1970. Harju rajooni kooliõpilaste (tütarlaste) füüsilisest arengust [On physical development of schoolgirls of Harju district].125 pp., bibl. 36 items. Manuscript at the Department of Zoology and Hydrobiology, University of Tartu.
2. Aul, J. 1982, Kuidas minust sai antropoloog [How I became an anthropologist]. Eesti Loodus. 12, 797–99.
3. Aul, J. 1997. Professor Juhan Aul. Kirjanduse nimestik 1919–1997 [Bibliography 1919–1997]. Compiled by Sirje Mikelsaar. Tartu. 80 pp.
4. Heapost, L. 1963. Rapla rajooni kooliõpilaste füüsilisest arengust [On physical development of schoolchildren of Rapla district]. 141 pp., bibl. 35 items. Manuscript at the Department of Zoology and Hydrobiology, University of Tartu.
5. Heapost, L. 2000. Karin Mark. 24.III 1922–04.XII 1999. In memoriam. Eesti antropomeetriaregistri aastaraamat 2000 [Yearbook of the Estonian Anthropometric Register]. Pp.179–185.
6. Heapost, L. 2006. Bibliograafia 1972–2006. Ed. Gudrun Veldre. Tartu. 16 pp.
7. Horn, A. 1974a. Sõrmemustrite põhitüüpide esinemissagedusest eestlastel [On the frequency of main types of finger patterns in Estonians]. Antropoloogia-alaseid töid, II. Tartu Riikliku Ülikooli Toimetised, 330, 67–90.
8. Horn, A. 1974b. Finger ridge-count for Estonians. Anthropologischer Anzeiger, 4, 2, 112–123.

9. Kadakas, V. 1961. Idapoolsete mordvalaste antropoloogiast [On the anthropology of eastern Mordvinians]. 63 pp., bibl. 49 items. Manuscript at the Department of Zoology and Hydrobiology, University of Tartu.
10. Kahu, M. 1969. Lõuna-Eesti kooliõpilaste (tütarlaste) füüsilisest arengust [On physical development of South-Estonian schoolgirls]. 113 pp., bibl. 26 items. Manuscript at the Department of Zoology and Hydrobiology, University of Tartu.
11. Kirhäiding, E.-M. 1959. Tartu ja Elva rajooni üldhariduslike koolide õpilaste füüsilisest arengust. 116 pp. Manuscript at the Department of Zoology and Hydrobiology, University of Tartu.
12. Kruuda, H. 1962. Eesti tütarlaste arengust postmikrobaarsuse ajajärgul [On development of Estonian girls at the stage of microbarity]. 123 pp., bibl 22 items. Manuscript at the Department of Zoology and Hydrobiology, University of Tartu.
13. Mark, K, Heapost, L, Sarap, G. 1994. Eestlaste antropoloogia seoses etnogeneesi küsimustega [Anthropology of Estonians in relation to problems of ethnogenesis]. Tallinn. 297 pp.
14. Riismaa-Rosimannus, L. 1977. Pärnu rajooni kooliõpilaste füüsilisest arengust [On physical development of schoolchildren of Pärnu district]. Eesti Looduseuurijate Seltsi aastaraamat [Yearbook of the Estonian Naturalists Society], vol. 65, pp. 87–119.
15. Roosalu, M. 1972. Viljandi linna kooliõpilaste-kaksikute füüsilisest ja psüühilisest sarnasusest [On physical and psychical similarities between twin schoolchildren in the town of Viljandi]. 1972. 132 pp., bibl. 10 items.
16. Schütz, V. 1958. Tartu linna kooliõpilaste füüsilisest arengust [On physical development of schoolchildren in the town of Tartu]. 94 pp, bibl. 14 items. Manuscript at the Department of Zoology and Hydrobiology, University of Tartu.
17. Sisask, S. 1976. Mälu ulatusest ja tüüpidest kooliõpilastel [On scope and types of memory in schoolchildren]. 40 pp., bibl. 13 items. Manuscript at the Department of Zoology and Hydrobiology, University of Tartu.
18. Tassa, A.-L. 1963. Eesti kooliõpilaste jalgade arengust [On development of Estonian schoolchildren's legs]. 136 pp., bibl. 19
19. Tõrv, V. Pärnu linna kooliõpilaste füüsilisest arengust [On physical development of schoolchildren of the town of Pärnu]. 130 pp., bibl. 17 items. Manuscript at the Department of Zoology and Hydrobiology, University of Tartu.

20. Uus, E. 1970. Harju rajooni kooliõpilaste (poeglaste) füüsilisest arengust [On physical development of schoolboys of Harju district]. 143 pp., bibl.37 items. Manuscript at the Department of Zoology and Hydrobiology, University of Tartu.
21. Vals, H. 1982. Tagasi inimese juurde [Back to the human]. Edasi, 28, 4 February.
22. Võhandu, M. 1961. Põlva ja Räpina rajooni kooliõpilaste füüsilisest arengust [On physical development of schoolchildren of Põlva and Räpina districts]. 126 pp., bibl.20 nim. items. Manuscript at the Department of Zoology and Hydrobiology, University of Tartu.

Address for correspondence:
Linda Kongo PhD.
Estonian Naturalists' Society
Struve street 2, Tartu 51003, Estonia
E-mail: linda.kongo@mail.ee

Papers on Anthropology XVI, 2007, pp. 30–48

FOUNDERS OF THE SECTION OF ANTHROPOLOGY AT THE ESTONIAN NATURALISTS' SOCIETY AND THEIR BIOGRAPHIES AND SCIENTIFIC BIBLIOGRAPHIES

Mart Lintsi[1], Linda Kongo[3], Helje Kaarma[1], Marina Aunapuu[2], Andres Arend[2]

Centre for Physical Anthropology[1], Chair of Histology[2] at the Institute of Anatomy of the Faculty of Medicine, University of Tartu, Estonia, Estonian Naturalists' Society[3] at the Estonian Academy of Sciences

ABSTRACT

The present study deals with the founders of the section of anthropology at the Estonian Naturalists' Society (ENS) and their biographies and scientific bibliographies. Only the chairman of the section of anthropopology Juhan Aul had dr. phil. nat. scientific degree in the branch of anthropology. We may divide all other founders into four groups as follows: the first – the colleague from the Institute of Zoology at the University of Tartu – MSc. Harald Haberman, the second – two students of zoology (stud. rer. nat.) Eerik Kumari and Aina Erna Emmeline Tõnurist, the third – colleagues from the same building – the archeologist MSc. Richard Indreko and the student Karl Pärna and the fourth – Medical Doctor Voldemar Üprus. As our study shows no one of the other founders, only J. Aul, had been involved previously in the studies at field of physical anthropology and they all continued their scientific studies in the field of the main profession.

Key words: physical anthropology, history, scientific biography, bibliography

INTRODUCTION

The Estonian Naturalists' Society was founded already in 1853. But until 1939 the issue of the founding of the section of anthropology was not raised up. On March1938 the senior assistant of the Institute of Zoology at the University of Tartu Juhan Aul as dr. phil. nat. was habilitated with the dissertation "Anthropological signs and the breed group of Estonians from West-Estonian counties". From 1 August 1938 to 1 April 1939 J. Aul received scholarship for the postgraduate refreshing trip with the purpose of improving his knowledge in the anthropological science in Poland, Germany and Switzerland.

J. Aul [2], Kasmel [18] and Kongo [19, 20] have written about the anthropological section's founding as follows: a group of the members of the Estonian Naturalists' Society initiated the idea of the anthropological section and after that a letter to the Managing Committee of the Estonian Naturalist Society was written on 19 April 1939 with the proposal of founding the section of anthropology. These founders were: Juhan Aul (dr. phil. nat.), Eerik Kumari (stud. rer. nat.), Karl Pärna (stud. rer. nat., lately geographer), Harald Haberman (MSc. Aul's colleague from the Institute of Zoology at theUniversity of Tartu), Voldemar Üprus (Medical Doctor), Richard Indreko (MSc. archeologist) and Aina Tõnurist (stud. rer. nat.).

Addendum
Registered on 19 April 1939. No. 91.

To the Board of the Estonian Naturalists' Society.

Statement

We, the undersigned members of the Estonian Naturalists'Society, at our meeting on 19 April 1939, decided to found at the Naturalists' Society the section of anthropology according to the to the following order of business and we request the Board of the Society to present the founding of the above mentioned section for ratifying at the general assembly of the Naturalists' Society.

At the same time we present Chairman of the Section dr. phil. nat. Juhan Aul to the general assembly of the Naturalists' Society for *ratification. Elected to the board of the section were Dr. V. Üprus (Vice-Chairman) and the student A. Tõnurist as a secretary.*

We remain in hoping for the positive attention from the Board and from the Society's general assembly to support our initiative

The founding members of the section of anthropology:

Tartu, 19 April, 1939.

Juhan Aul
Eerik Kumari
K. Pärna
H Haberman
Voldemar Üprus
R. Indreko
A Tõnurist
To support 20 April 1939 Board
Founded on 27 April, 1939 Arnold Jüris

Meeting of the Estonian Naturalists' Society

From the protocol of the meeting No 776 of the ENS as of 27 April 1939 we received the information: There were together the chairman of the ENS professor dr. H. Kaho, the vice-chairman professor dr. A. Öpik, the secretary professor dr. Paris, the treasurer's assistant Neugard and vice-secretary A. Jüris – all 21 members and one guest.

In the official part under Point 3 it was written:

The section of the anthropology to be founded by the ENS on the initiative of dr. J. Aul and other members according to the following order of the business:

§ 1. The purpose of the section of the anthropology is to bring together the persons who are working in the field of anthropology or who are working in the border disciplines and simply persons interested in anthropology, to assist to spreading of the knowledge of the anthropological science and to deepening of the interest in anthropology and for the promotion of the anthropological investigation in Estonia.

§ 2. For the purposes to be achieved, mentioned in the previous paragraph, the section organizes meetings, congresses, scientific and popular scientific presentations, excursions, demonstrations, publishes printed materials, first and foremost the labor manuals for co-workers.

§ 3. The members of the section are the members of the ENS who want to cooperate with the section of anthropology.

§ 4. The section will be headed with the board consisting of the three members – the chairman, the vice-chairman and the secretary-treasurer.

§ 5. The section elects the board members, the candidate for the chairman is proposed to the general meeting for approval.

§ 6. The tenure of the board lasts for one year.

§ 7. The section provides financial support for covering and may nominate the members, the membership fees.

§ 8. The inventory and the library of the section are the property of the ENS and they are registered in the inventory book.

Thus with the decision of the board of the ENS the anthropological section was born on 27 April 1939.

In the literature concerning the history of anthropology in Estonia we did not find an article in which the biographies and scientific bibliographies of the founders of the anthropological section were analyzed.

Chapter I The first person – the first chairman of the section

Juhan Aul
(born on 15 October 1897 – died on 29 August 1994)

The short biography and the scientific bibliography (most important works).

For the celebration of the 100^{th} birthanniversary of J. Aul his personalia was published [25]. In this booklet there is also the biography of J. Aul composed by K. Põldvere (follower in his professorial post for teaching anatomy to the students of biology) [27]. Therefore we name only the most important facts of the life of J. Aul [3, 4, 6, 25, 27] in the present article.

He was born in the Pärnu County, in the parish of Aare at Arudel as the son of the cottager Mihkel Klein (1874–1945) and Juuli Steinberg (1878–1950). He studied in the primary school of Suigu 1906–1910, in the country elementary school of Taali in 1910–1912, in the municipal school of Pärnu in1913–1915, at the elite secondary school in Tallinn as a nonresident student allowed to take examinations without having attended lectures in 1921 regulary.

Aul studied zoology at the University of Tartu in 1921–1928 and graduated with the Master's degree in 1928. It is interesting to remark that his first prize competitive work from 1923 "The development of the baby frog in alcohol's environment: the experimental study" under the guidance of professor of physiology A. Lipschütz which was taken into consideration for the Master's degree.

Initially he worked at the Institute of Zoology as a deputy junior assistant and from 1 January 1929 as a senior assistant.

Up to 1931 his name was Johann Klein. In connection with the marriage to Marie Aul he changed his name to Juhan Aul. The name Aul had a zoological meaning of the "long tailed duck" in the Estonian language and it is sounds very well in Estonian.

On 31 May 1939 he had venia legendi for the docent's (associated professor) occupation and from 3 October 1939 he received the docent degree and license at the University of Tartu.

On 30 May 1941 he was confirmed as the deputy of the senior lecturer.

On 10 November 1944 he was confirmed as the senior lecturer and from 1 September 1946 as the deputy of docent.

From 7 February 1948 the Supreme Attestation Commission of the Soviet Union conferred the Doctoral degree in biology and the docent's profession to him.

In 1950 J. Aul was moved off from the staff of Tartu State University.

From September 1954 J. Aul newly received a post of the docent at the Department of Zoology.

On 9 January 1957 The Supreme Attestation Commission of the Soviet Union conferred the professor's post in zoology.

In 1958–1969 J. Aul was the Chairmen of the Department of Zoology and later on as professor of zoology.

In 1976–82 he was a consulting professor at the Department of Zoology.

The ENS elected J. Aul honorary member in 1967.

He had been the supervisor for one candidate dissertation (Leiu Heapost) and for 20 diploma theses.

In 1976 J. Aul was honored with K.E. v Baer remembrance medal for the anthropological investigation.

J.Aul died in August 29 1994 and is buried in the Raadi cemetery.

J. Aul's most important publications

Aul J. (1923) Development of baby frog in alcohol's environment: the experimental study. The first prize essay. Tartu, 39 p. Remark: in 1928 submitted as master work. (In Estonian)

Aul J. (1931) Motherland's quadrupeds :(amphibians, reptilians, mammalians): Systematic units and generic determinator and descriptor. Tartu, Nature, 176 pp. (In Estonian)

Aul J. (1938) The habilitation dissertation for academic degree dr. phil. nat. in University of Tartu in Faculty of Mathematics and Natural Sciences " Anthropological signs and breed groups of Estonians from West-Estonian counties". Tartu, 331 pp. (In Estonian)

Aul J., Ling H., Paaver K. (1957) Mammalians of Estonian S.S.R. Tallinn, Estonian State Press. 351 pp. (In Estonian)

Aul J. (1962) Human Anatomy: Textbook for biologists. Tallinn, Estonian State Press. 435 pp. (In Estonian)

Aul J. (1964) Anthropologia Estonica. Acta et Commentationes Universitatis Tartuensis. 387 pp. (In Russian)

Aul J., Ling H. (1969) Zoology of Vertebrata. Tallinn, Valgus Press, 584 pp. (In Estonian)

Aul J. (1976) Human Anatomy: Textbook for biologists. 2nd revised edition. Tallinn, Valgus Press. 359 pp. (In Estonian)

Aul J. (1977) Estonian women's anthropology. Acta et Commentationes Universitatis Tartuensis. 5–103 pp. (In Estonian)

Aul (1982) Estonian schoolchildren's anthropology. Tallinn, Valgus Press, 139 p. (In Estonian)

Chapter II The second person

Harald Haberman
(born on 19 December 1904 – died on 16 December 1986)

H. Haberman [10, 11, 16] was born in Tallinn as a son of the cabinetmaker Mart Haberman. He finished Tallinn polytechnical secondary school (later on the 2nd Tallinn secondary school for sciences) in 1924.

At the University of Tartu he studied zoology in 1924–1932.

On 15 December 1933 he habilitated with his Master's thesis "On the data of Lake Tamula and Lake Vagula littoral benthos in the summer of 1932".

In 1932–1939 he was the auxiliary of the conservator of the Museum of Zoology of the University of Tartu.

In 1939–1940 he was the senior assistant at the Institute of Zoology of the University of Tartu.

In 1944–1948 he was vice-rector of Tartu State University, the head of the Department of General Biology and Darwinism.

In December 1945 his Master's thesis was attested as the candidate thesis in biology. He also received the docent's post.

On 5 April 1946 the Council of Ministers of the Estonian S.S.R. confirmed the statutes of the newly founded Estonian Academy of Sciences and its membership. H. Haberman was confirmed as the Corresponding Member of the Estonian Academy of Sciences.

From 1 January 1947 up to 1977 he was the founder and the first director of the Institute of Biology (later the Institute of Zoology and Botany) at the Estonian Academy of Sciences.

In 1948–1950 he was a PhD student at the Institute of Zoology of the Academy of Sciences of the Soviet Union and in 1950 he habilitated his Doctoral thesis "Coleopteran of the coastal area of the Estonian S.S.R.". In 1951 his Doctoral thesis was attested in biology by the Supreme Attestation Commission of the Soviet Union.

On 30 June 1954 H. Haberman was elected a Member of the Academy of Sciences of the Estonian S.S.R. and in 1957–1964 he was Academic-Secretary of the Department of Biology at the Estonian Academy of Sciences.

In 1955 the Supreme Attestation Commission of the Soviet Union conferred him the professor's post in the field of entomology.

In 1927–1939 H. Haberman was the Chairman of the section of zoology at the ENS, in 1946–1952 the vice-chairman of the ENS and in 1952–1954 the Chairman of the ENS, from 1964 the honorary member of the ENS and from 1984 the Honorary President of the ENS.

In 1964 H.Haberman received the honorary title of the merited scientists of Estonian S.S.R.

In 1977 H. Hagerman retired from the director's post of the Institute of Zoology and Botany at the Academy of Sciences of the Estonian S.S.R and he was appointed to work as a consulting senior scientist.

Harald Haberman died on 16 December 1986 in Tartu.

H. Haberman's most important publications

Haberman H. (1952) The systematical nomenclature and date of the dissemination and sites of discovery of coleopterans of Estonian S.S.R. 1. Adephaga. Tartu, 61 pp.

Haberman H. (1962) Chrysomelidae, Halticinae of Estonia. Tartu, 220 pp.

Haberman H. (1968) Coleoptera, Carabidae of Estonia, Tallinn, Valgus Press, 598 pp.

Haberman H. (1968) Essence of life: data and thoughts. Tallinn, Valgus Press, 127 pp.

Chapter III The third person

Richard Indreko
February 25 1900 – March 10 1961

Richard Indreko [7,14,15,] was born on 25 February 1900 in the Järvamaa County in the Purdi parish as son of the handicraftsman Otto Indreko and Mari Hinnov. He studied at the primary school of Paide in 1908–1912, at the municipal school and the grammar school in 1912–16, and at the secondary school of Paide in 1918–1922.

He studied at the University of Tartu in 1922–27, at first at the Faculty of at Mathematics and Life Sciences and from 1923 at the Faculty of Philosophy, where his principal disciplines were archeology and ethnography.

He habilitated Master's degree in 1932, the theme of his thesis was "Some oldest findings of the Stone Age in Estonia" and Doctoral degree in 1941 "The Middle Stone Age in Estonia". The last one was published in the German language in Sweden 1948.

He was the auxiliary worker of the Institute of Archeology (cabinet of Archeology at the University of Tartu) in 1923–1933, in 1933–1937 the assistant of a lecturer, in 1938–1942 the performer of teaching tasks. In 1942 he was appointed to the post of Chairman of the Cabinet of Archeology and Museum of the University of Tartu. In 1942–1943 he was Assistant Professor of ancient sciences.

In 1943 he emigrated to Finland and in 1944 to Sweden.

In Sweden he worked at the State History Museum of Stockholm and in 1944–1947 he was the assistant of the archives, in 1947–1955 the grant-aided scholar and in 1955–1961 the antiquary.

From 1951 up to his death he was chairman of the Estonian Scientific Institute in Sweden.

He died on 10 March in 1961 in Sweden from the heart infarction.

R. Indreko's most important publications

Indreko R. (1937) Primeval times of Estonia. Tartu.

Indreko R. (1937) Earthen-stronghold of Asva. Tartu.

Indreko R. (1948) The middle Stone Age in Estonia. Stockholm. (In German)

Indreko R. (1962) The prehistoric age. Aspects of Estonian culture. London

Indreko R. (1964) The Cultures in East-Europe and West-Siberian of the Mesolithic age and the early Mesolithic age. Stockholm. (In German)

Chapter IV The fourth person.

Eerik Kumari
March 7 1912 – January 8 1984

Eerik Kumari [13,21,22,28] (up to 20 January 1938 Erik-Mathias Sits, Eerik-Madis Kumari – the name after the Kumari islet) was born in the Läänemaa County in the parishof Kirbla in the family of the peasant Voldemar Sits.

In 1922–1931 he studied in Tallinn at the private Gymnasium of H. Kubu with a curriculum of joint and practical lines, in 1931–1932 at the Military School and received the ensign rank (an Estonian reserve officer's lowest rank).

In 1932–1940 he studied at the University of Tartu at the Faculty of Mathematics and Life Sciences and graduated from the university in the field of zoology.

In 1941 was he in Tallinn the Deputy of the Director of the State Life Sciences Museum and in 1946 in the same museum's deputy chief curator.

In 1947 he moved to the Institute of Biology at the Academy of Sciences of the Estonian S.S.R. (from 1951 renamed to the Institute of Zoology and Botany) as Head of the department of Zoology and up to 1949 parallelly the Deputy Chief of the Museum of Zoology.

In 1949 he habilitated by the Scientific Council of the University of Tartu with the Candidate's degree in biology, the theme of his thesis was "The kingfisher Alcedo atthis ispida L. in the Estonian S.S.R.: the zoogeographical and ecological study".

In 1952 he habilitated the Doctoral thesis at the Institute of Biology of the Academy of Sciences of the Soviet Union in Leningrad "The Contemporary Symbiosis and the Genesis of the Avifauna of the Estonian S.S.R." (In Russian).

In 1952–1977 he was the Vice-Director in the scientific research of the Institute of Zoology and Botany at the Academy of Sciences of the Estonian S.S.R.

In 1954 the Supreme Attestation Commission of the Soviet Union attested him the Senior Scientist in the field of ornithology.

In 1955 the Supreme Attestation Commission of the Soviet Union attested him the professor's post degree in the field of ornithology.

In 1961 the Academy of the Sciences of the Estonian S.S.R. elected E. Kumari Corresponding Member of the Academy.

The member of the ENS from 1932, the secretary-treasurer of the ENS in 1946–1954, the Chairman of the ENS in 1954–1962, from 1972 the honorary member of the ENS and from 1982 the honorary president of the ENS.

In 1972 he was nominated the Merited Scientist of the Estonian S.S.R.

In 1955–1984 he was the Chairman of the Committee of the Protection of Natural Scenery of the Estonian S.S.R.

In 1976 he was honored with the memorial medal of K.E. v Baer.

In 1989 the Memorial Foundation of E. Kumari was founded with the purpose of awarding scientists working in the field of the protection of natural scenery.

After World War Two he was the leader of ornithological research in Estonia and in 1953 he was the founder of the ornithological research station in Puhtu.

In 1978 he retired from the Vice-Director's post and he continued to work as the consulting senior scientist.

E. Kumari was the supervisor of four candidate dissertations (R. Ling, S. Onno, A. Jõgi, O. Renno), he was acting as an opponent of five Doctoral theses and 24 candidate dissertations habilitations. He was the editor of nearly 50 books and collections.

Erik Kumari died on 8 January 1984 and was buried in the Raadi cemetery in Tartu.

Eerik Kumari's most important publications

Kumari E. (1953) Field guide for the identification of Estonian birds. Tallinn, Estonian State Press, 159 p.

Kumari E. (1954) Birds of Estonian S.S.R. Tallinn, Estonian State Press, 415 p.

Kumari E. (1959) Field guide for the identification of Estonian birds. 2nd revised edition. Tallinn, Estonian State Press, 199 p.

Kumari E. (1963) How to survey birds. Tallinn, Estonian State Press, 283 p.

Kumari E. (1966) Bay of birds. Tallinn, Valgus Press, 120 p.

Kumari E. (1968) Primeval valley of the river Ahja. Tallinn, Estonian Book Press, 88 p.

Kumari E. (1972) Primeval valley of the river Ahja. 2nd revised edition. Tallinn, Estonian Book Press, 95 p.

Kumari E. (1973) The protection of natural scenery. Editor. Tallinn, Valgus Press, 835 p.

Kumari E. (1974) Field guide for the identification of Estonian birds. 3rd revised edition. Tallinn, Valgus Press, 200 p.

Kumari E. (1975) The migration of birds. Tallinn, Valgus Press, 328 p.

Kumari E. (1982) The red book: prohibited plants and animals of Estonian S.S.R. (Editor). Tallinn, Valgus Press, 246 p.

Kumari E. (1984) Field guide for the identification of Estonian birds. 4th revised edition. Tallinn, Valgus Press, 224 p.

Chapter V The fifth person

Karl Pärna
February 27 1904 – July 1 1966

Karl Pärna[5,26,33] was born in the Tartumaa County, in the Vara parish, at the Ingli village. His father was the carpenter and his mother the farm laborer.

He was a talented person studying on his own. In 1927 he finished the grammar school as a nonresident student allowed to take examinations without having attended lectures regularly. In 1928 he settled in Tartu and worked as an apprentice of the master cabinetmaker and later on as a mechanic. In 1932 he finished the Evening Secondary School of Tartu also as a non-resident student allowed to take examinations without having attended classes regularly. Parallel to work, in 1939 he graduated from the University of Tartu, the Faculty of Mathematics and Life Sciences as a geologist-geographer with the level of cum laude. His Master's thesis was ready in 1940 and it was defended on 26 September 1947 as the Candidate of Geographic Sciences at the Learned Council of Tartu State University.

He was the lecturer of the Department of Geography. The well-known scientist academician A. Luha characterized him as follows: " K. Pärna is an exceptionally reserved man, even to the excessively developed degree."

In 1947–1951 he was the researcher at the Institute of Geology of the Academy of Sciences of the Estonian S.S.R.

In 1951–1964 he worked as an engineer of geology at the "Eesti project" (the designing establishment) and as the part-time lecturer of the University of Tartu.

He had received the scholarship for the home studies in 1935–1938 and worked in summer in North- and West-Estonia and presented the novel views for the landscape studies. As Quaternary geologist he studied the distribution of the ice-artificial lakes and the formation of the coastal area post ice (glacial) age. His studies embraced the areas between the Võsu and the Navesti rivers, the areas around Elva, Tartu and Kilingi-Nõmme and other districts.

On 28 September 1962 he defended the thesis "Geology of the big ice-lakes on the territory of Estonia" at the Council of Physics-Mathematics and Technical Sciences of the Academy of Sciences of the Estonian S.S.R.

To the practician and non-staff lecturer was omitted the scientific degree of the Candidate of Sciences of the geology and mineralogy was not conferred.

Exactly after his 60th birthday he retired.

It is said "after a long-dated grave sickness" he died on 1 July 1966 and was buried in the Jõgeva County, in the cemetery of Järve (today Maarja-Magdaleena) next to his parents.

Karl Pärna's most important publications

Pärna K. (1940) Network of settlements of North-Harju County. I part. Tartu, 166 p.

Pärna K. (1940) Network of settlements of North-Harju County. II part. Development of Tallinn County networks of settlements and the relationships with the other landscape components. Tartu, Master thesis.

Pärna K. (1958) The sandy region of Elva, his developmental hydro-geography. Estonian Nature,

Pärna K. (1960) Geology of Baltic and local big ice-lakes in the territory of Estonian S.S.R. Collection of the scientific studies of the Institute of Geology of Academy of Sciences of Estonian S.S.R. Nr. 5.

Chapter VI The sixth person

Aina Erna Emmeline Tõnurist (later Aina Aul) (born on 22 April 1910 – died in July 1941)

Aina Erna Emmeline Tõnurist [8,31] was born in the parish of Mäetaguse on 22 April 1910. She was stud. rer. nat. at the University of Tartu.

She entered the membership of the ENS on 8 October 1936 and she was recommended by the members Mrs. Magda Kobin and Mr. Neeme-Õnneleid Mikelsaar.

In 1940 she married Juhan Aul and took the name Aina Aul. She died in July 1941.

Chapter VII The seventh person

Voldemar Üprus (born on 5 March 1902 – died on 5 November 1956)

Voldemar Üprus [32] was born on 5 March 1902 in the manor of Vooru in the parish of Vana-Suislepa.

He graduated from the University of Tartu in 1933 as a medical doctor.

In 1933–34 he had a scholarship of the Rockefeller foundation and studied in London.

From 1940 he worked at the Department of Neurology of the University of Tartu and from the beginning of 1943 as the Head of the Department of Neurology.

In 1944–1948 he was the head of the Department of Neurology at the State University of Tartu.

From 1949–1956 he worked in the Hospital of Kohtla-Järve and studied the diseases of the peripheral nervous system and their prophylactics caring the miners of oil shale.

Voldemar Üprus's most important publications

Üprus V. (1927) The experimental study of heart remedies to the heart glycogen. 73 p. First award study.

Üprus V. (1928) In vivo introduced alchohol's braking up in experiments and in cadaver materials. 61 p. First award study.

Üprus V. (1930) The parent's alcoholism and the children's epilepsy (clinical and experimental study). Tartu, 130 p, First award study.

Üprus V. (1931) The myoclonic reaction in the offspring's in the second and of the third generation of the alcoholic parents. Tartu, 142 p, The second award study.

Üprus V. (1947) The epidemiological analysis of the prevalence of poliomyelitis in East-South part of Estonian S.S.R in 1945 and 1946. Manuscript. Habilitated in June 30 1947 for getting the academic degree of the candidate of medicine.

CONCLUSION

The anthropological section of the ENS was born thanks to the initiative of dr. rer. nat. Juhan Aul, thanks to the support of his colleagues and his students. The biographies and scientific bibliographies of all the founding members to second our primary hypothesis that only J. Aul was the researcher in the field of anthropology and all other founders supported his proposal. H.Haberman was his colleague from the Institute of Zoology, E. Kumari and E. Tõnurist his students, R. Indreko was a colleague from same building (Aia Street 46) and K. Pärna a student, Dr. V. Üprus had investigated the same scientific theme as young Aul – the influence of the alcochol in the experimental research. We may hypothesize that all the founding members had positive relationships with J.Aul. All other founders on the basis of the analysis of their career and the scientific bibliographies had not made research in the field of anthropology.

As Põldvere declared [27], he had seen the magnificent project planned by Aul and it sounded well: "The Anthropological Institute at the Estonian Academy of Sciences".

After comparing the magnificent project and the goals of the Institute and the results of Aul's work extending over a lifetime (three monographs – on 15,000 servicemen, over 1,000 young females and over 30,000 schoolchildren) Põldvere had had an opinion that Aul himself with his long-lasting scientific activity had fulfilled nearly all the planned studies for the whole institute.

There is a simple explanation which studies were performed. Aul had said about the situation: "... in the era of the technical progress anthropology has not had an important place among other sciences. "[1]

However, in Tallinn there was the Institute of History at the Academy of the Estonian S.S.R (today bearing the name the Institute of History at the University of Tallinn) were a scientific research group under the guidance of Aul's former students Karin Mark, PhD [23,24] and Leiu Heapost, PhD [12] was formed. In the others institutes of Tallinn professor Dr. med. Raiot Silla and Dr. med. Maimu Teoste, PhD [29] also worked at the problems of Estonian schoolchildren's anthropology in connection with the health problems.

At the University of Tartu medical doctor Heino Tiik, PhD [30] habilitated in the field of the anthropology (J. Aul was the scientific opponent to him and at the same time a consultant), medical doctor from the Women's Clinic Helje Kaarma [17] habilitated in Minsk with the Doctor of Science degree. She also worked at the problems of anthropology. There were associated professor Heli Grünberg, PhD, Bela Adojaan, PhD, and Maie Thetloff , MSc, [9] and Gudrun Veldre, PhD [34].

At the Faculty of the Exercise and Sport Sciences there were and also today there are researchers in the branch of sport anthropology professor emeritus Atko Viru, professor Toivo Jürimäe and professor Jaak Jürimäe, professor Lennart Raudsepp, Leila Oja, PhD, Aire Leppik, PhD, Terje Sööt, MSc, docent emeritus Jaan Loko, PhD, Milvi Visnapuu, MSc, Triin Pomerants, MSc and many others.

At the Faculty of Medicine in the Clinic of Rehabilitation and Sports Medicine professor Jaak Maaroos, associated professor Anatoli Landõr, dr. Maie Ojamaa, dr. Nadežda Ignatjeva and others studied sport anthropology.

The section of the Anthropology at the ENS is still alive today (the leader of the section is Gudrun Veldre, PhD).

Aul's studies had not lost their importance also by today, they remain the basis for comparing the contemporary results of the anthropometric studies with the historical ones.

REFERENCES

1. Aul J. (1977) Anthropology of Estonian women's. Acta et commentationes Tartuensis, 438, 6–7.
2. Aul J. (1978) The section of the Anthropology. In book: 125 years of the Estonian Naturalists' Society. Tartu, p. 75. (In Estonian)
3. Aul, J. (2000) Encyclopaedia Estonica. Estonian biographies. Estonian Encyclopaedic Press. Tallinn, 14, 28–29. (In Estonian)
4. Aul, J. (2000) Estonian Science Biographic Lexicon. Estonian Encyclopaedic Press. Tallinn, I, 109. (In Estonian)
5. Eilart J. (1966) In memoriam Karl Pärna. Estonian Nature, 5:314–315. (In Estonian)
6. Estonian Biographic Database ISIK. http://www2.kirmus.ee/ biblioserver/isik/ Aul, Juhan (In Estonian)
7. Estonian Biographic Database ISIK. http://www2.kirmus.ee/ biblioserver/isik/ Indreko, Richard (In Estonian)
8. Estonian Biographic Database ISIK. http://www2.kirmus.ee/ biblioserver/isik/ Tõnurist, Aina (In Estonian)
9. Grünberg H., Adojaan B., Thetloff M. (1998) Growth and growth disorders: methodical guidelines for assessment of children's physical development. Tartu, 31 p. (In Estonian)
10. Haberman H. (2000) Encyclopaedia Estonica. Estonian biographies. Estonian Encyclopaedic Press. Tallinn, 14, 76–77. (In Estonian)
11. Haberman H. (2000) Estonian Science Biographic Lexicon. Estonian Encyclopaedic Press. Tallinn, I, 327–328. (In Estonian)
12. Heapost L. (1984) Developmental anthropology of Tallinn's schoolchildrens (1966–1969). Tallinn. Valgus Press, 281 p. (In Estonian)
13. http://www.tartu.ee/index.php?page_id1443_id Erik Kumari

14. Indreko R. (2000) Encyclopaedia Estonica. Estonian biographies. Estonian Encyclopaedic Press. Tallinn, 14, 101. (In Estonian)
15. Indreko R. (2000) Estonian Science Biographic Lexicon. Estonian Encyclopaedic Press. Tallinn, I, 423–424. (In Estonian)
16. Jagomägi I., Karro E. (1981) Harald Haberman's bibliographic list. 119p. (In Estonian)
17. Kaarma H. (1981) Multivariate statistical analysis of the women's anthropometric characteristics' system. Tallinn, Valgus Press, 168 p.
18. Kasmel J. (1999) From the founding of the section of Anthropology by Estonian Naturalists' Society. Yearbook of the Estonian Registry of Anthropology, 1999, 11–16. (In Estonian)
19. Kongo L. (1999) The role of the Estonian Naturalists' Society in the anthropological research. Yearbook of the Estonian Registry of Anthropology, 1999, 17–24. (In Estonian)
20. Kongo L. (2003) 1853–2003= 150 active years of the Estonian Naturalists' Society. Tallinn, Press of the Estonian Academy of Sciences. 471 pp. (In Estonian)
21. Kumari E. (2000) Encyclopaedia Estonica. Estonian biographies. Estonian Encyclopaedic Press. Tallinn, 14, 195. (In Estonian)
22. Kumari E. (2000) Estonian Science Biographic Lexicon. Estonian Encyclopaedic Press. Tallinn, I, 162–163. (In Estonian)
23. Mark K. (1970) Zur Herkunft der finnisch-ugrischen Völker vom Standpunkt der Anthropologie: [Übersetzung aus dem Estnischen] / Akademie der Wissenschaften der ES.S.R, Institut für Geschichtsforschung. Tallinn. Estonian Book. 131 pp.
24. Mark K., Heapost L., Sarap G. (1994) Anthropology of Estonians in connection with the question of the etnogenesis. Tallinn. Press of Estonian Academy of Sciences. 331 p.
25. Mikelsaar S. /editor) (1997) Professor Juhan Aul's bibliographic list. 1919–1997. The Library of the University of Tartu. Tartu University Press. 80 pp. (In Estonian)
26. Pärna K. (2000) Encyclopaedia Estonica. Estonian biographies. Estonian Encyclopaedic Press. Tallinn, 14, 392. (In Estonian)
27. Põldvere K. (1997) On Juhan Aul's life and activities. In: Mikelsaar S. Professor Juhan Aul's bibliographic list. 1919–1997. The Library of the University of Tartu. Tartu University Press. 7–14. (In Estonian)
28. Reinsalu K. (1985) Erik Kumari's bibliographic list. Tallinn. 203p. (In Estonian)

29. Silla R., Teoste M. (1989) The health of Estonian Youth. Tallinn. Valgus Press, 285 p. (In Estonian)
30. Tiik H. (1964) Physical development and health status of the students of Estonian S.S.R. Thesis of the candidate of medical sciences. 239 p. Tartu. Manuscript. (In Estonian)
31. Tõnurist, A. Membership card of the ENS from October 08 1936.
32. Üprus V. (2000) Encyclopaedia Estonica. Estonian biographies. Estonian Encyclopaedic Press. Tallinn, 14, 630. (In Estonian)
33. Varep E. (1968) Karl Pärna. Yearbook of the Estonian Geographic Society 1966. Tallinn, Valgus Press, 262–263. (In Estonian)
34. Veldre G. (2003) Somatic status of 12–15-year-old Tartu schoolchildren. Tartu, Doctoral dissertation. 198 pp.

Adrdress for correspondence:
Mart Lintsi
Centre for Physical Anthropology
Lossi 38, EE-51003, Tartu, Estonia
E-mail: antrop@ut.ee

Papers on Anthropology XVI, 2007, pp. 49–55

ULTRASTRUCTURAL ANALYSIS OF THE HUMAN KIDNEY BIOPSIES

Marina Aunapuu, Mara Pilmane[1], Mai Ots[2], Andres Arend

Department of Anatomy, University of Tartu, Ravila 19, 50411 Tartu,
[1] Institute of Anatomy and Anthropology, Stradins University, Kronvalda 9, 1010 Riga, Latvia
[2] Department of Internal Medicine, University of Tartu L. Puusepa 6 50411, Tartu, Estonia

ABSTRACT

Background. Ultrastructural investigation of renal biopsy is often necessary to confirm or specify the diagnosis. The aim of this study was to characterize ultrastructural changes in the human kidney biopsy.
Methods. 23 renal biopsies were collected between February 1993 and October 1994 in the Department of Internal Medicine, of the Maarjamõisa Hospital. Ultrathin sections were prepared from renal biopsies and were examined with the electron microscope Jeol 300 and Philips 400.
Results. Ultrastructural changes in the renal corpuscles and in the glomerular basement membrane (GBM) were studied and in 13 cases (56.5%) homogeneous and normal GBM in the glomeruli was found. In 10 cases altered structures were seen and the renal biopsies based on the pathological changes were divided as follows: IgA nephropathy in 6, chronic glomerulonephritis in 3 ja acute glomerulonephritis in 1 biopsies.
***Conclusion*s**. Electron microscopic investigation reveals ultrastructural changes in the renal biopsies which in many cases can clarify the diagnosis.

Key words: kidney biopsies, ultrastructure, IgA, podocytes, glomerular basement membrane

INTRODUCTION

Electron microscopy has a fundamental role in the evaluation of renal diseases.[1] Chronic renal insufficiency is caused as a result of decreased glomerular filtration and it progresses to the final stage of renal failure in years or dozens of years.[2] One of the causes of chronic renal insufficiency can be hypertension as a result of which different segments of the nephron are damaged.[2] In the case of chronic renal insufficiency, the renal tissue and tubules are destroyed and, as a result, the speed of glomerular filtration decreases. The glomerular basement membrane (GBM) plays a key role in the renal function and many kidney diseases cause ultrastructural changes in the GBM.[3,4] The function of the GBM is to prevent the passage of proteins with a large molecular mass and diameter. Therefore only the proteins with a small molecular mass can pass the basement membrane of clinically healthy patients, while the basement membrane plays the role of a molecular screen.[4] In electron microscopy, the GBM is an amorphous structure, which consists of three layers. *Lamina densa* is the electron dense layer, *lamina rara interna* and *lamina rara externa* are the electron lucent layers.

Podocytes play an important role in the maintenance of the renal glomerular function.[5] The location and cellular organization of podocytes is unique.[6] Podocytes are mostly branched, irregular, highly differentiated and specialized cells, which attach to the glomerular basement membrane. Podocytes` cell body is large and bulges into the urinary space. Podocytes have long primary cytoplasmic foot processes, which form secondary foot processes. The short processes, which intertwine with each other, usually derive from one or several main processes of a podocyte.[7] Every podocyte with its processes surrounds one glomerular capillary. Foot processes are parallel with the capillary and are separated from them with spaces. In a GBM between the feet of podocytes elongated filtration pores covered with a unique elongated diaphragm are formed.[8] The filtration slits diaphragm, restricts the passage of any large molecule but its main role is in controlling water flow.

In this study the ultrastructural examination of the renal biopsy specimen enabled to improve the diagnosis.

SUBJECTS AND METHODS

The study is based on kidney biopsies obtained from 23 adult patients. The renal biopsies were collected between February 1993 and October 1994 in the Department of Internal Medicine, of the Maarjamõisa Hospital in Tartu. This was the first ultrastructural investigation of kidney biopsies in Tartu. Renal biopsies were obtained by using a standard percutaneous method with local anaesthesia.

ELECTRON MICROSCOPY

For electron microscopic examination, biopsies were fixed in 2.5% glutaraldehyde solution buffered with the sodium cacodylate buffer at pH=7.4 for two hours, postfixed for 1 hour in 1% osmium tetroxide solution at the same temperature and pH, dehydrated in a series of graded ethanols and embedded in Epon-812 (Fluka, Germany). The biopsies were sectioned under a light microscope to select the tissues containing glomeruli for electron microscopy. Semithin and ultrathin sections were cut on a Reichert Om U3 ultramicrotome with a diamond knife Diatome (Switzerland). Semithin sections stained with methylene blue – azur II were examined using an Olympus BX-50 microscope. Ultrathin (70 nm) sections from the selected blocks were mounted on copper grids, mesh size 200. Sections were stained with uranyl acetate and lead citrate and examined under a TEM Jeol-200 and Philips 400. Glomeruli were evaluated for ultrastructural features including electron-dense deposits, podocyte and GBM changes.

RESULTS AND DISCUSSION

Ultrastructural changes in the renal corpuscles and in the GBM in renal biopsy specimens from patients with renal diseases in the 23 kidney biopsies were studied and of these, 13 cases (56.5%) showed normal ultrastructure and homogeneous GBM in the glomeruli. The pathological diagnosis was made in 10 cases and the study demonstrates that the ultrastructural changes in kidney biopsy can be variable.

Based on electron microscopic studies, the 10 biopsies with pathological changes were divided as follows:

IgA nephropathy – 6 biopsies. The electron microscopic study showed changes in the ultrastructures demonstrating an irregularly thickened and wrinkled GBM (Figure. 1, A, D). The GBM thickness was greater than for the normal GBM and the thickest was *lamina densa*. Granular electron-dense deposits were present in all the biopsies in the mesangial region and in the Bowman space (Figure. 1, B, C). The deposits varied in size and were occasionally large. In the mesangium, there was the proliferation of mesangial cells and the extensive enlargement of the mesangial matrix. The structural changes of podocytes are expressed by the increased body of the cell, which is irregular and includes a small number of electron-dense granules in cytoplasm. Podocyte processes are partly long, elongated, but at the same time there are also fused processes. Due to the interdigitated flat foot processes the filtration slits had closed or narrowed (Figure. 1, C).

Chronic glomerulonephritis – 3 biopsies. Based on the light microscopic study, we observed that glomeruli had increased in most of the renal corpuscles as a result of the proliferation of mesangial cells (Figure. 1, E). The studies of the ultrastructure demonstrated that the GBM was irregularly thickened, partly folded in wavy sections, and in such areas its layers were not distinguishable from each other and there were no filtration slits. Foot processes attached to the GBM were long and contained vacuoles in the apical part. Podocytes were conventionally branched and the bodies of the cells contained enlarged mitochondria with broken cristae.

Acute glomerulonephritis – 1 biopsy. The capillary loops of renal corpuscles were filled with erytrocytes. The modest proliferation of mesangial cells could be observed in the mesangium of glomeruli, and in the GBM there were unevenly thickened segments where its layers were not clearly distinguishable (Figure. 1, F). The foot processes of podocytes were irregular and large GBM segments lacked filtration slits due to interdigitated foot processes.

In 13 biopsies no changes in the ultrastructure of the renal corpuscles in the GBM, podocytes or mesangium were found as a result of electron microscopic studies.

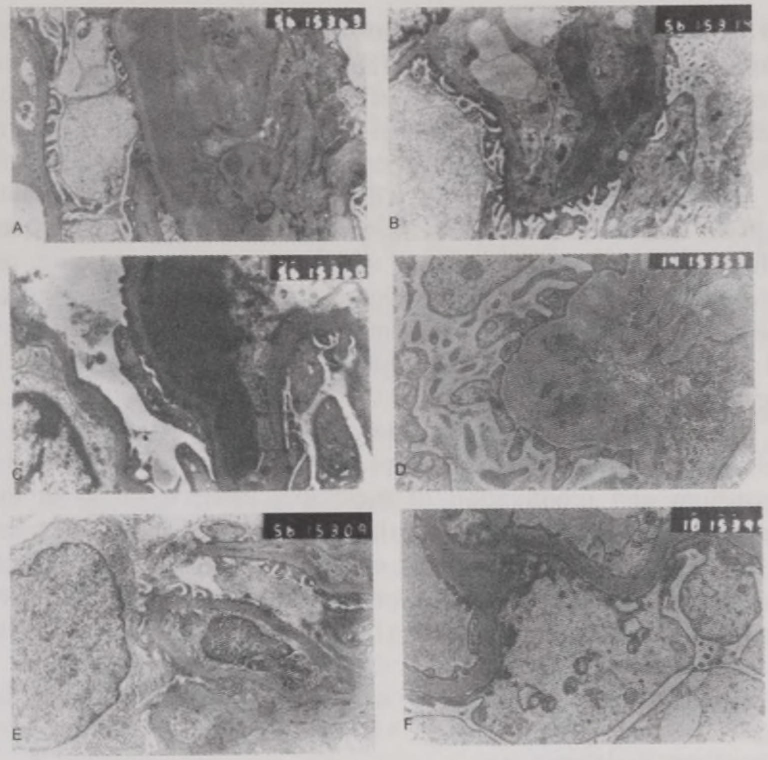


Figure 1. A. EM study demonstrated an irregularly thickened GBM and electron dense deposits (original magnification 5600x). B. Electron dense deposits and increased mesangial matrix in IgA nephropathy (original magnification 5600x). C. Electron dense deposits in the Bowman's capsule. Interdigitated flat foot processes the filtration slits had closed or narrowed (original magnification 5600x) D. EM study demonstrated an irregularly thickened and wrinkled GBM (original magnification 14000x). E. Glomerulonephritis chronica, proliferation of mesangial cells (original magnification 5600x). F. Glomerulonephritis acuta, thickened sections where its layers were not clearly distinguishable (original magnification 5600x).

Primary IgA nephropathy is a form of glomerulonephritis characterized by prominent mesangial IgA deposits without clinical signs of systemic disease[9] and therefore the ultrastructural investigation of the kidney biopsy is often necessary to establish the clinical diagnosis.

The distribution, size, extent, and composition of the deposits are also central elements of IgA diagnosis. The strong granular electron-dense deposit[11,13] was characteristic of all IgA nephropathies. In the studied biopsies the area of electron-dense deposit was the Bowman capsule, less frequently the deposit could be observed in the GBM. In the studied kidney biopsies the GBM was of extremely variable thickness and in some areas its layers were undistinguishable from each other. These results coincide with those obtained by other researchers.[10,12] The secondary foot processes of podocytes, attaching to the GBM[14], were sometimes interdigitated with each other and therefore the number of filtration slits had decreased. Such changes cause serious problems in the filtration process and damage the kidney. According to the literature[12] adults often have IgA nephropathy with mesangial electron dense deposits in the area of the mesangium and proliferation of mesangial cells, resulting in the enlargement of the mesangial matrix. In the studied kidney biopsies such enlargement of the mesangial matrix was observed in two cases. The podocytes cell body and foot processes are functionally different segments and the chronic podocyte injury may lead to podocyte detachment from the GBM.[6]

In summary, the present biopsy investigation demonstrates that the electron microscopic study of the kidney ultrastructures can in many cases clarify the diagnosis.

ACKNOWLEDGEMENT

This study was supported by targeted financing under the project No. 0182688s05 from the Ministry of Education and Research of Estonia. The authors thank Ass. Prof. Dr. Heikki Helin for assistance in carrying out electron microscopic studies.

REFERENCES

1. Gu X., Herrera G.A. (2002) The value of electron microscopy in the diagnosis of IgA nephropathy. MetaPress, 26, 203–10.
2. Ots M., Pechter Ü., Tamm A. (2000) Characteristics of progressive renal disease. Clin Chim Acta, 297, 29–41.

3. Biondo B., Grosso E., Fogato E., Giordano F., Matturri L. (1995) Glomerular morphometry of twenty-three biopsied patients with IgA nephropathy. Am J Nephrol, 15, 99–104.
4. Sinniah R., Khan T.N. (1999) Renal tubular basement membrane changes in tubulointerstitial damage in patients with glomerular diseases. Ultrastruct Pathol, 23, 359–68.
5. Oh J., Reiser J., Mundel P. (2004) Dynamic (re)organization of the podocyte actin cytoskeletron in the nephrotic syndrome. Pediatr Nephrol, 19, 2, 130–7.
6. Asanuma .K, Mundel P. (2003) The role of podocyte in glomerular pathobiology. Clin Exp Nephrol, 7, 4, 255–9.
7. Mundel P., Kriz W. (1995) Structure and function of podocytes: An update. Anat Embryol, 192, 385–97.
8. Pavenstadt H. (2000) Roles of the podocyte in glomerular function. AJP-Renal Physiology, 278, F173–79.
9. Alexopoulos E., Seron D., Hartley R.B., Nolasco F., Cameron J.S. (1989) The role of interstitial infiltrates in IgA nephropathy: a study with monoclonal antibodies. Nephrol Dial Transplant, 4, 187–95.
10. Vogler C., Eliason S.C., Wood E.G. (1999) Glomerular membranopathy in children with IgA nephropathy and Henoch Schönlein Purpura. Pediatric and Developmental Pathology, 2, 227–235.
11. Markowitz G.S., Kambham N., Maruyama S., Appel G.B., Cohen D.J., Kim R.C., Andres G.A., D`Agati V.D. (2000) Membranous glomerulopathy with Bowman`s capsular and tubular basement membrane deposits. Clin Nephrol, 54, 478–86.
12. Osawa G., Kimmelstiel P., Seiling V. (1966) Thickness of glomerular basement membranes. Am J Clin Pathol, 45, 7–20.
13. Katz A., Chan P. (1998) IgA glomerulonephritis with irregular intramembranous dense deposits. Nephron, 80, 340–343.
14. Linossier M.T., Palle S., Berthoux F. (2003) Different glycosylation profile of serum IgA in IgA nephropathy according to the glomerular basement membrane thickness: normal versus thin. Am J Kidney Dis, 41, 558–64.

Address for correspondence:
Dr Marina Aunapuu
Department of Anatomy, University of Tartu
Ravila 19, Biomedicum, 50411 Tartu, Estonia
E-mail: mariaun@ut.ee

Papers on Anthropology XVI, 2007, pp. 56–69

DAILY PHYSICAL ACTIVITY OF POLISH YOUTH

Michal Bronikowski[1], *Renata Śleboda*[1], *Ewa Szczepanowska*[2], *Adam Kantanista*[1], *Małgorzata Bronikowska*[1].

[1] University School of Physical Education, Poznań, Poland
[2] University of Szczecin, Institute of Physical Culture, Szczecin, Poland

ABSTRACT

The aim of this study is to make an attempt to determine an extension of exercise intensity and energy expenditure during the whole day of physical activity of youths from gymnasium, coming into the period of pubertal maturation. Differences between the extension of exercise loads, undertaken during the fall-winter and spring-summer periods, are also determined.

Studies were carried out in 10 boys and 10 girls by the registration of their physical activity twice during 24 h – in the fall-winter and the spring-summer periods, in common days of the week. The registration of exercise loads was realized by the Sport-Testers of Polar Company, model S 610i.

Comparing the level of physical activity in the fall-winter and spring-summer periods in the 13-year-old girls, it was observed that there was an increase of the time of the duration of exercises undertaken above 140 bpm (50% of HRR).

During 24 hours only 6–7% of time (about 90 minutes) for boys, and even less – only 4–6% (about 60–90 minutes) for girls was set off for exercises of load stimulating functions of oxygen supply, that is at the level above 140 bpm (above 50% of HRR).

A characteristic phenomenon was an observed relation between energy expenditure at the level above 3000 kcal in winter and summer, while on average it was amounted to a half less during 24 hours. Hence, comparing intensity load scopes in these two examined periods a decreased level of physical activity in the fall-winter period was observed among both the examined girls and boys.

Key words: physical activity of youths energy experditure, pubertal maturation

INTRODUCTION

The human healthful condition is described generally by genetic determinants with a slight influence on them by us, and our lifestyle as the main determinant of human psychophysical healthfulness. Physical exercise undertaken regularly influences advantageously an organism in many scopes: it reduces the threat connected with the so-called civilised diseases syndrome (particularly of circulating system), it favorably changes a relation between the fat mass and the muscle mass, and improves the secretion of hormones responsible for metabolic processes.

An especially significant period in human life is a stage of obligatory school education, when the phenotype is shaped, and also some habits can appear (of the healthful or not healthful lifestyle). Consciousness, increasing with age creates excellent educationally-didactic possibilities in this field. Hence, since several years one can observe a tendency to retract “developmental clippers” (Osiński 1988, Przewęda, Dobosz 2003, Bronikowski 2003) [13,15,2] between the secular trends and the decreasing level of physical efficiency. The increasing phenomenon of the body excessive fat deposition, particularly in young persons, causes reasonable anxiety. It is partly the effect of the lack of balance between the energy absorbed by the organism through meals and its lower expenditure during the whole day. According to the norms proposed by Ziemlański (1998) [22] youths realizing a moderate level of physical activity should take on average 2200–2700 kcal (8–10 MJ) per day. Ekelund et al. (1999) [7] in their studies described the energetic expenditure of a 15-year-old youth as about 10.9 MJ (about 2,900 kcal) per day.

In this work the attempt to determine an extension of exercise intensity and energy expenditure during the whole day of the physical activity of the youths from gymnasium, coming into the period of pubertal maturation, is presented. Differences between the extension of exercise loads, undertaken during the fall-winter and spring-summer periods, are also determined.

MATERIAL AND METHODS

Studies were carried out in the groups of randomly selected 13-year-old girls and boys. Only these pupils were taken under consideration who were in the limits of one standard deviation from the mean value for a given age category – in relation to body height and body mass. Coherently, studies were carried out in 10 boys (an average body mass – 48.9 kg, the body height – 161.9 cm) and 10 girls (an average body mass – 46.9 kg, the body height – 156.9 cm) by the registration of their physical activity twice during 24 h – in the fall-winter and the spring-summer periods, on common days of the week. The registration of exercise loads was realized by the Sport-Testers of the Polar Company, model S 610i, and then data were analyzed statistically.

The work loads were classified into 4 intensity zones expressed as percentages of the heart rate reserve (HRR), i.e. the difference between maximal and resting heart rates. Maximal heart rates (HRmax) for this age category were computed by the Ball State University formula (cf. [28]): HRmax=214–0.8×age (about 201 bpm <beats per minute> for boys) or HRmax=209–0.7×age (about 197 bpm for girls). The following criteria for setting the intensity zones were adopted: zone 1 – up to 50% of HRR (140 bpm), zone 2 – between 51–65% of HRR (141–160 bpm), zone 3 – between 66–85% of HRR (161–180 bpm), and zone 4 – above 85% of HRR (above 180 bpm). From each physical education (PE) lesson four children were randomly selected and equipped with the Polar Sport-Testers S 610i. Heart rates were recorded every 15 s.

RESULTS

Figure 1a. Graphs introducing a curve of intensity of the whole day's physical activity in 13-year-old boys during the fall-winter period

Figure 1b. Percentage and time breakdown of exercise loads in 13-year-old boys during a common week day in the fall-winter period

During the fall-winter period among the examined 13-year-old boys the greatest activity during a day was observed between 9 and 13 a.m. It was connected with the participation in obligatory exercises of PE at school. An increased activity was registered also between 7 and

9 p.m. but it was due to the loads at the level of 120–130 bpm – 40% of HRR (Figure 1a). The examined boys performed on average only 95 minutes (from 24 hours) undertaking exercise with the accelerating heart rate to the level of 140 bpm (50% of HRR), and more; it was in the whole 6.6% of a total day time (Figure 1b). The whole day's physical activity caused energy expenditures at the level of 3,100 kcal.

Figure 2a. Graphs introducing a curve of intensity of the whole day physical activity in 13-year-old boys during the spring-summer period

Figure 2b. Percentage and time breakdown of exercise loads in 13-year-old boys during a common week day in the spring-summer period

In the spring-summer period a distinct change in the level of intensity and time duration of exercise loads performed by 13-year-old boys followed. Besides a marked increase of the intensity curve during the stay at school, between 11 a.m. and 2 p.m., an increased activity was registered in the evening, between 6–8 p.m. There was a load of higher intensity as compared to the fall-winter period, at the limit of 60–70% of HRR (Figure 2a). However, it did not cause the cumulative time of exercises above 140 bpm (above 50% of HRR) – on average 93 minutes, and it was 6.3% of the total day time. The average energy expenditure was about 1,473 kcal, it meant almost a half less than in the winter period.

Figure 3a. Graphs introducing a curve of intensity of the whole day physical activity in 13-year-old girls during the fall-winter period

Figure 3b. Percentage and time breakdown of exercise loads in 13-year-old girls during a common week day in the fall-winter period

In a case of 13-year-old girls in the fall-winter period, during 24 hours, not a very large percentage of exercises of submaximal and maximal intensity was registered. An increased activity was registered between 2 and 6 p.m. The examined girls spent on average 66 minutes performing exercises of the intensity above 140 bpm (50% of HRR), and it was 4.6% of a total day-time (Figure 3b). The average energy expenditures were registered at the level of 3,180 kcal.

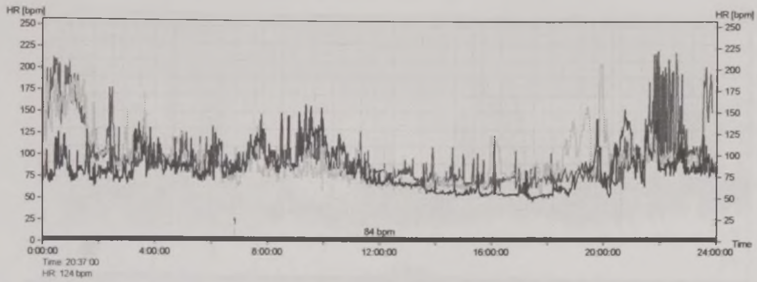
Figure 4a. Graphs introducing a curve of intensity of the whole day physical activity in 13-year-old girls during the sprig-summer period

Figure 4b. Percentage and time breakdown of exercise loads in 13-year-old girls during a common week day in the spring-summer period

Comparing the level of physical activity in the fall-winter and spring-summer periods in 13-year-old girls, an increase of time duration of exercises undertaken above 140 bpm (50% of HRR) was observed. In the spring-summer period, during 24 hours, the examined 13-year-old girls exercised with this intensity over 30 minutes longer than in the fall-winter period, totally about 90 minutes, and it was 6.3% of the total day-time. Similarly to boys, also among girls, the average energy expenditure was a half less – 1,499 kcal in this period.

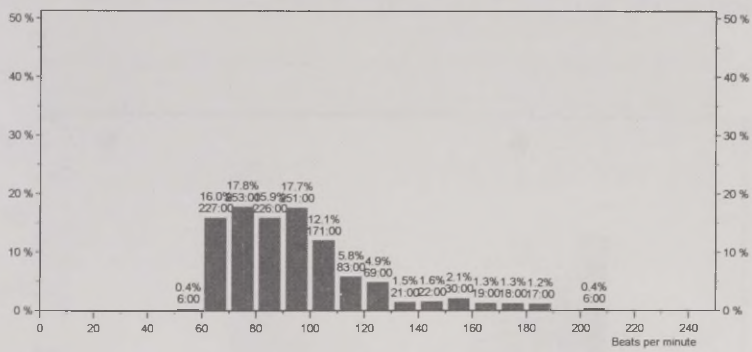
The examined youths spent most of the time during day and night with the intensity between 60–80 bpm: boys – 35% of the day-time, and girls – almost 40%, and it was 8.0 and 9.2 hours, respectively, and in a great part a period set off for sleep and rest was included. During 24 hours only 6–7% of time (about 90 minutes) for boys, and even less – only 4–6% (about 60–90 minutes) for girls was set off for exercises of the load stimulating functions of oxygen supply, that is at the level above 140 bpm (above 50% of HRR).

A characteristic phenomenon was an observed relation between energy expenditure at the level above 3000 kcal in winter and summer, while on average it was amounted to a half less during 24 hours. Hence, comparing the intensity load scopes in these two examined periods, a decreased level of physical activity in the fall-winter period was observed among both the examined girls and boys.



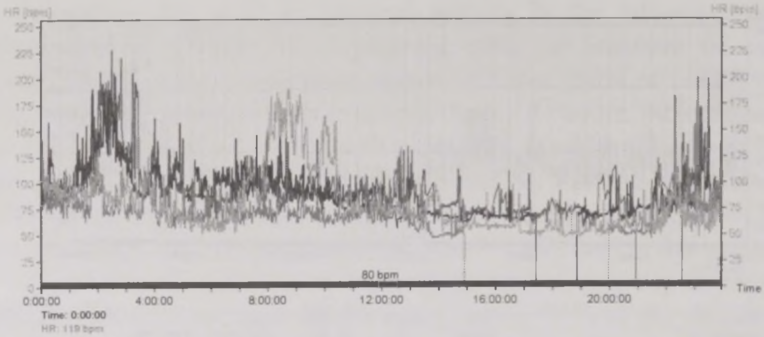
No	Exercise	Date	Cursor HR	Heart rate	Duration	Note
1.	2004-03-09 11:22	2004-03-09	70	97 / 222	23:53:57.6	24 h - ch³opiec 13lat
2.	2004-03-15 11:20	2004-03-15	[illegible]	94 / 207	23:38:21.3	24 h - ch³opiec 13lat
3.	2004-02-04 10:25	2004-02-04	124	84 / 159	24:01:14.3	24 h - ch³opiec 13 lat - jesien/zima
4.						
5.						

Figure 1a. Graphs introducing a curve of intensity of the whole day physical activity in 13 y.o. boys during the fall-winter period



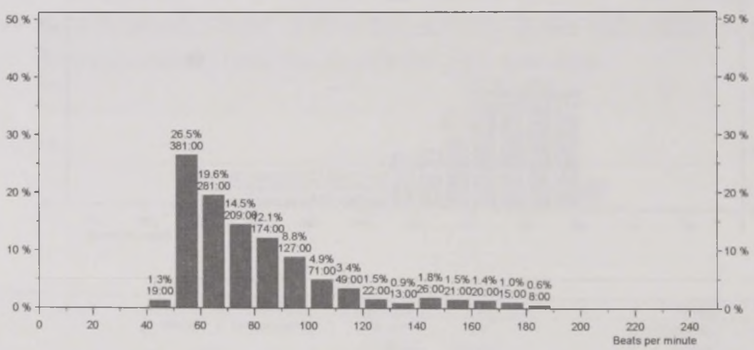
Person	michal	Date	2004-03-15	Heart rate averag	94 bpm		
Exercise	2004-03-15 11:20	Time	11:20:43	Heart rate max	207 bpm		
Sport	Running	Duration	23:38:21.3				
Note	24 h - ch³opiec 13lat			Selection	0:00:00 - 23:38:00 (23:38:00.0)		

Figure 1b. Percent and time breakdown of exercise loads in 13 y.o. boys during a common week day in the fall-winter period



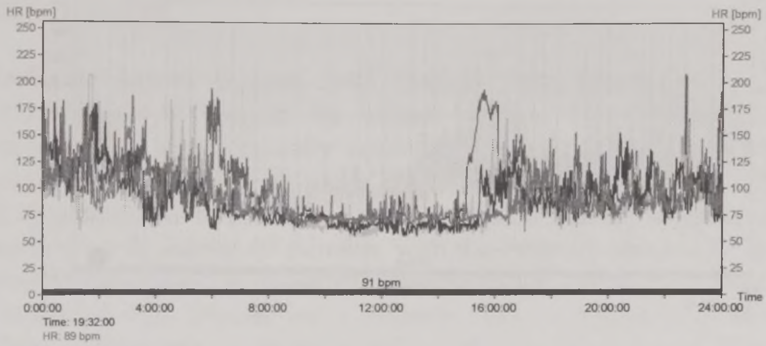
No	Exercise	Date	Cursor HR	Heart rate	Duration	Note
1. —	2004-05-11 09:46	2004-05-11	90	94 / 228	24:09:29.9	24 h - ch³opiec 13lat - okres wiosna/lato - ca³k
2.	2004-05-11 09:42	2004-05-11	[illegible]	89 / 190	24:09:23.2	24h - ch³opiec 13 lat okres - wiosna/lato. ACT
3. —	2004-05-11 09:42	2004-05-11	97	89 / 190	24:09:23.2	24h - ch³opiec 13 lat okres - wiosna/lato. ACT
4. —	2004-05-25 09:10	2004-05-25	93	75 / 200	23:56:23.5	24h - ch³opiec 13lat - Polar 1413 - Caltrac 213
5.	2004-05-25 09:10	2004-05-25	119	80 / 190	23:56:13.5	24h - ch³opiec 13lat - Polar 1222 kcal, Caltrac

Figure 2a. Graphs introducing a curve of intensity of the whole day physical activity in 13 y.o. boys during the spring-summer period



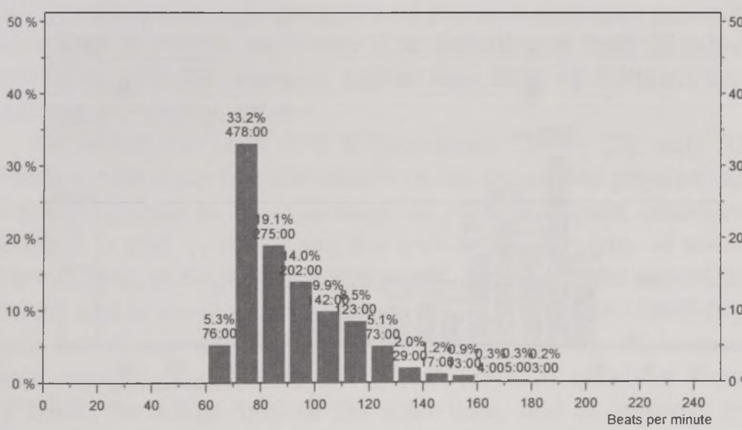
Person	michal	Date	2004-05-25	Heart rate average	80 bpm
Exercise	2004-05-25 09:10	Time	09:10:29	Heart rate max	190 bpm
Sport	Running	Duration	23:56:13.5		
Note	24h - ch³opiec 13lat - Polar 1222 kcal, Caltrac - 2617, ACTM - 878,			Selection	0:00:00 - 23:56:00 (23:56:00.0)

Figure 2b. Percent and time breakdown of exercise loads in 13 y.o. boys during a common week day in the spring-summer period



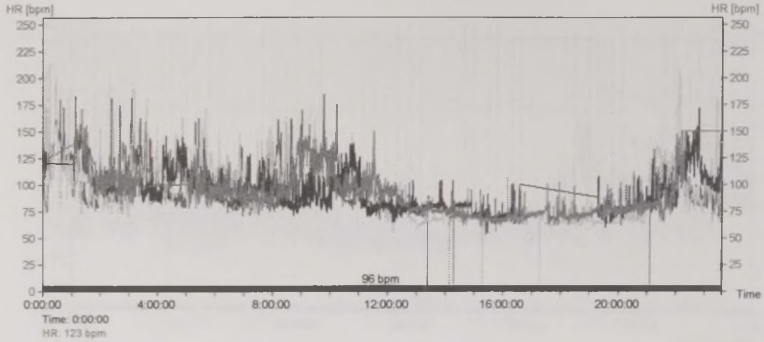
No	Exercise	Date	Cursor HR	Heart rate	Duration	Note
1. —	2004-03-02 14:17	2004-03-02	98	103 / 208	24:00:18.6	24h - dziewczyka 13lat
2. —	2004-03-02 14:16	2004-03-02	87	89 / 207	24:02:10.6	24h - dziewczynka - 13lat
3. —	2004-02-24 14:36	2004-02-24	103	90 / 182	24:00:45.2	24h - dziewczynka 13 lat
4.	2004-02-24 13:18	2004-02-24	89	91 / 187	24:00:01.3	24h - dziewczynka 13lat - jesień/zima
5.						

Figure 3a. Graphs introducing a curve of intensity of the whole day physical activity in 13 y.o. girls during the fall-winter period



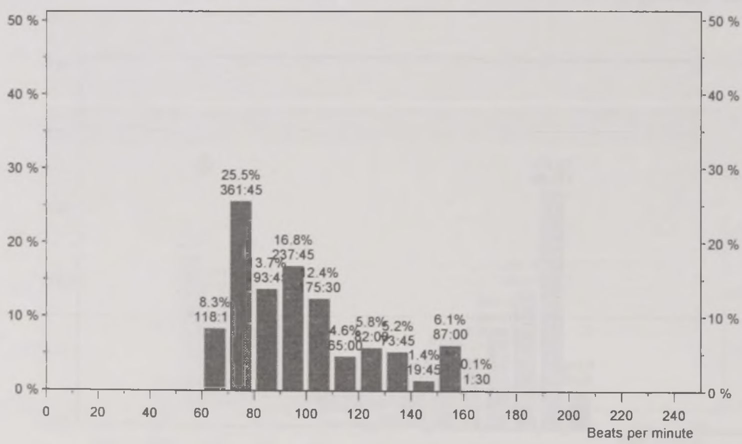
Person	michal	Date	2004-02-24	Heart rate ave	91 bpm		
Exercise	2004-02-24 13:18	Time	13:18:54	Heart rate ma	187 bpm		
Sport	Running	Duration	24:00:01.3				
Note	24h - dziewczynka 13lat - jesień/zima			Selection	0:00:00 - 24:00:00 (24:00:00.0)		

Figure 3b. Percent and time breakdown of exercise loads in 13 y.o. girls during a common week day in the fall-winter period



No	Exercise	Date	Cursor HR	Heart rate	Duration	Note
1. —	2004-05-12 10:02	2004-05-12	114	100 / 185	24:00:07.8	24h - dziewczynka 13lat - okres wiosna/lato -
2	2004-05-12 09:59	2004-05-12	1C7	94 / 213	24:00:16.8	24h - dziewczynka 13lat - okres wiosna/lato -
3 —	2004-05-19 09:31	2004-05-19	117	94 / 183	23:40:14.9	24h - dziewczynka 13lat - Polar 1503 kcal, Ca
4	2004-05-19 09:30	2004-05-19	123	96 / 179	23:36:58.4	24h - dziewczynka13lat - Polar 1504 kcal, Cal
5						

Figure 4a. Graphs introducing a curve of intensity of the whole day physical activity in 13 y.o. girls during the sprig-summer period



Person	michal	Date	2004-05-19	Heart rate ave	96 bpm	
Exercise	2004-05-19 09:30	Time	09:30:53	Heart rate ma	179 bpm	
Sport	Running	Duration	23:36:58.4			
Note	24h - dziewczynka13lat - Polar 1504 kcal, Caltrac - 1808 i ACT	Selection		0:00:00 - 23:36:45 (23:36:45.0)		

Figure 4b. Percent and time breakdown of exercise loads in 13 y.o. girls during a common week day in the spring-summer period

DISCUSSION

Different authors (Raczek 1986, Osiński 2001, Fairclough, Stratton 2005) [16,14,8] suggest the values between 140–150 bpm as a minimum of physiologically optimal exercise loads. Determining a recommended "movement dose" for children, Woynarowska (1997) [21] proposes a formula: 4x40x140 (physical activity undertaken 4 times a week, during 40 minutes, with the intensity above 140 bpm). Recommendations of American researchers (Corbin 1996) [6] are connected with introducing a formula "FIT" (frequency, intensity, time) – frequency 3 times a week with the intensity 60–90% of HRmax or 40–50% of VO_2max through at least 20–60 minutes. Hence, one can also suggest a possibility to analyze a caloric combustion value during meals. Caloric approach to the analysis of the effectiveness of physical exercises assumes an undertaking of exercises at the level of 300 kcal above a level of metabolic basal rate three times a week or – 200 kcal – four times a week (even adding up a few shorter exercises during a day). Mandigout et al. (2002) [11] have revealed that only programs of physical exercises performing at least 3 times a week and every time including at least 25 minutes of exercises, with the intensity higher than 80% of HRmax, cause an increase of VO_2max value.

According to Cabak and Woynarowska (2004) [5], only 35% of Polish youths have met the criteria of recommended physical activity. It places Poland in the mid-range of other European countries. The problem is also in decreasing the quality and intensity of school PE. For example, in England pupils aged 11–16 years have two PE lessons a week and in the research of Fairclough and Stratton (2005) [9] it has been found that the English schoolchildren during PE lessons have been engaged in moderate-to-vigorous physical activities (over 50% of HRR) for about 35% of the total time, and in vigorous activity (over 75% of HRR) for 8% of the total time. These activities were mainly team games. The 50% of HRR is a healthful threshold and represents the minimum intensity required to enhance the health-related fitness. In French children Baquet et al. (2002) [1]have reported that traditional PE classes have not elicited sufficient HRR by 50–60% of the scheduled time and only specially intensified PE lessons could contribute to an improvement of aerobic fitness in the case of three lessons a week. In Poland 4 times of 45 minutes per week seem to be also insufficient in promoting the cardio-respiratory fitness of schoolchildren (Bronikowski 2005) [3].

At the same time it seems that all day energy expenditure is too low in relation to a proposed caloric day dose for a youth in the pubertal period (Ziemlański 1998) [22]; therefore, an increasing phenomenon of overweight and obesity among children and youth is appearing. It is not advisable to diminish the caloric value of consuming meals, especially associated with a high daily demand. In this period it could lead to developmental disorders (the lack of the so-called "timber" for muscles and bones). Conclusions of other researchers (and also of our own), connected with the observation of an increasing secular trend and simultaneously a decreasing level of physical efficiency, and an increasing threat of overweight and obesity among children and youth, suggest rather the seeking of possibility not in the change of nutritional habits (or at least not only in diet) but in the change of lifestyle and the level of total activity (Vouri 2004, Woynarowska 2000) [18,21].

Numerous researchers have proved the reliability of evaluation of energy expenditure by a measurement of heart rate (Hiilioskorpi et al., 2003, Skinner et al. 2003, Falgairette et al. 1996, Van Den Berg-Emons et al. 1996, Ekelund et al. 1999) [10,19,8,17,7]. However, the interpretation of exercise load intensities through hart rate is a complex process, requiring an allowance of information about a kind of undertaken physical activity, and also physiological determinants as the basal metabolic rate or psychic as, for example, a degree of emotional engagement. It is due to taking account of a kind of exercise, secured for pupils by school, too (quality, form, type of lesson). The research carried out by us (Bronikowski 2005, 2006, Cabak, Woynarowska 2004) [3,4,5] and others (Fairclough, Stratton 2005) [9] suggests great differences in the level of exercise intensity of different kinds of physical activity (in it also different profiles of the intensity of PE lesson). It seems that the problem is also a change of an exercise profile (to a more sedentary) undertaken by youths in their leisure time. It should be a signal for the specialists of programming of physical activity and pro-healthful behaviors to undertake educational activities to change this disadvantageous and dredging phenomenon, the more so, because Marshall and Hardman (2000) inform us about the crisis of the PE status on the basis of international studies (in 126 countries all over the world) and they write that in Europe there are visible gaps between theory and practice. PE is still perceived like a subject of a lower category. In 61% of countries PE lessons are cancelled for a favor of other subjects. A greater pressure is put on the intellectual development. The number of PE lessons in many countries is not adequate to meet the needs of the present-day reality. Theoretically PE has a comparable status with other subjects but practice gives a different view. The problem is also a lack of policy in the quality study of PE. In France (according to Bonhomme 1993) in over 72% of preliminary schools pupils have 2 hours of PE lessons per week that is less than a school program requires. In England and Wales (according to Speednet 1999) many teachers do not want to teach PE. They prefer to carry out other "higher" lessons. In Poland low social consciousness about it is common; the goals and tasks of PE at schools are badly understood by national and domestic governments. From the studies of Marshall and Hardman (2000) [12] it follows that also from 126 countries all over the world, with the research carried out, in 37% of them PE is considered not an essential part of the teaching program.

PE could influence, in an essential way, undertaking physical activity by youths. However, its quality and also the place in the educational hierarchy should be changed.

The research carried out now is only the first step in the attempt to look for the possibilities of the formation of pro-healthful changes in the consciousness of children and youths.

REFERENCES

1. Baquet G., Berthoin S., Van Praagh E. (2002) Are intensified physical education sessions able to elicit heart rate at a sufficient level to promote aerobic fitness in adolescents? Res Q Exerc Spor, 73, 282–288.
2. Bronikowski M. (2003) Zmiany sprawności fizycznej u 13 letnich chłopców i dziewcząt z Poznania na przestrzeni lat 1979–1999. Człowiek i Ruch. Human Movement, AWF Wrocław, 1(7), 33–38.
3. Bronikowski M. (2005) How much physical activity a week to improve the health-related fitness of Polish schoolchildren? Phys Edu Sport www.pheds.com., 49(3), 219–223.

4. Bronikowski M. (2006) Profiles of intensity loads in physical education classes in Poland. Gymnica – Acta Univ Palacki Olomuc, 36(1), 47–59.
5. Cabak A., Woynarowska B. (2004) Aktywność fizyczna młodzieży w wieku 11–15 lat w Polsce i w innych krajach w 2002 roku. Wychowanie Fizyczne i Sport, 4, 355–360.
6. Corbin Ch. (1996) How much physical activity is enough? JOPERD, 67(4), 33–37.
7. Ekelund U., Yngve A., Sjostrom M. (1999) Total daily energy expenditure and patterns of physical activity in adolescents assessed by two different methods. Scandinavian Journal of Medicine and Science in Sports, 9, 257–264.
8. Falgeirette G., Gavarry O., Bernard T., Hebbelinck M. (1996) Evaluation of habitual physical activity from a week's heart rate monitoring in French school children. European journal of applied physiology and occupational physiology, 74(1/2), 153–161.
9. Fairclough S., Stratton G. (2005) Physical education makes you fit and healthy. Physical education's contribution to young people's physical activity levels. Health Educ Res, 20, 14–23.
10. Hiiloskorpi H. K., Pasanen M. E., Fogelholm M. G., Laukkanen R. M., Manttari A. T. (2003) Use of heart rate to predict energy expenditure from low to high activity levels. International Journal of Sports Medicine, 24(5), 323–336.
11. Mandigout S., Melin A., Lecoq A. M., Courteix D., Obert P. (2002) Effect of two aerobic training regimens on the cardiorespiratory response of prepubetal boys and girls. Acta Pediatr, 91, 403–408.
12. Marshall J., Hardman K. (2000) The State and Status of Physical Education in Schools in International Context. European Physical Education Review, 6(3), 203–229.
13. Osiński W. (1998) Zależności między zdolnościami motorycznymi a cechami, wskaźnikami i komponentami ciała dzieci i młodzieży z populacji wielkomiejskich. Wychowanie Fizyczne i Sport, 4, 11–29.
14. Osiński W. (2001) Aktywność fizyczna, sprawność i zdrowie – szczególne zadania wychowania fizycznego. Seria Monografie no 333. AWF Poznań, 5–21.
15. Przewęda R., Dobosz J. (2003) Kondycja fizyczna polskiej młodzieży. Studia i monografie, AWF, Warszawa.
16. Raczek J. (1986) Problem skuteczności obciążeń na lekcji wychowania fizycznego. In: Lekcja wychowania fizycznego. WSP Kielce, 151–161.

17. Van Den Berg-Emons R. J., Saris W. H., Westerterp K. P., Van Baak M. A. (1996) Heart rate monitoring to assess energy expenditure in children with reduced physical activity. Medicine and science in sports and exercise. Baltimore, 28(4), 496–501.
18. Vouri I. (2004) Physical inactivity is a cause and physical activity is a remedy for major public health problems. Kinesiology, 36(2), 123–153.
19. Skinner J. S., Gaskill S. E., Rankinen T., Leon A. S., Roa D. C., Wilmore J. H, Bouchard C. (2003) Heart rate versus % VO_2max: age, race, initial fitness and training response – Heritage, Medicine and science in sports and exercise, 35(11), 1908–1913.
20. Woynarowska B. (1997) Aktywność ruchowa w profilaktyce zaburzeń rozwoju i zdrowia u dzieci i młodzieży. Medicina Sportiva, 1, 75–81.
21. Woynarowska B., Mazur J. (2000) Zachowania zdrowotne i zdrowie młodzieży szkolnej w Polsce i innych krajach. Tendencje zmian w latach 1990–1998. Uniwersytet Warszawski, Warszawa.
22. Ziemlański Ś. (1998) Podstawy prawidłowego żywienia człowieka. Zalecenia żywieniowe dla ludności w Polsce. Instytut Żywności i Żywienia, Warszawa.

Address for correspondence:
Michał Bronikowski
Akademia Wychowania Fizycznego im. Eugeniusza Piaseckiego w Poznaniu
Zaclad Metodyki Wychowania Fizycznego
61–871 Poznań, ul. Królowej Jadwigi 27/38
E-mail: bronikowski.michal@wp.pl

Papers on Anthropology XVI, 2007, pp. 70–79

THE ABSOLUTE AND RELATIVE GROWTH RATE OF THE LONGITUDINAL MEASUREMENTS IN RIGA SCHOOL-AGE BOYS

Zeltīte Cēderštrēma, Jānis Vētra, Ilva Duļevska

Riga Stradins University, Institute of Anatomy and Anthropology

ABSTRACT

Changes in social and economic factors call for the necessity to follow up the changes of the human body forms and functions, as well as to test whether the boys in the city of Riga are seen to have changes in the physical development in this century, since in the last ten years the physical and puberty parameters of boys in Latvia have not been defined. Therefore, in 2005 the Institute of Anatomy and Anthropology started a study on “Evaluation of Riga school-age boys physical development in the turn of the century”. Anthropometrical measurements were carried out in Riga schools of 550 boys at the age from 7 to 18 years.

The aim – to study the absolute and relative growth rate of the body longitudinal parameters in boys: the body height, the trunk length, the upper extremity length and the lower extremity length.

Analyzing the acquired data on the parameters of 7–18 year-old boys, we can conclude that: the increase of the body height, the trunk length, the upper extremity length and the lower extremity length dynamics are positive in all the age groups, but an accelerated growth is seen at the age from 7 to 8 years, and from 13 to 14 years.

INTRODUCTION

The topicality of this problem is determined by negative tendencies in children's health indices of several post-socialist countries, the increase of the incidence of various diseases, which call for the necessity to work out certain criteria for children and adolescents' physical development.

THE AIM

To study the absolute and relative growth rate of the body longitudinal paramenters in boys.

MATERIAL AND METHODS

For the basis of the study we used the anthropometrical measurements used in 2005 and 2006 for investigating the boys of 7 Riga school and 5 pre-school institutions. The boys included in the study were divided into 12 groups. The anthropometrical indices analysed – the body height, the trunk length, the upper extremity length and the lower extremity length.

RESULTS

During the study we analysed the body height, the trunk length, the upper extremity and the lower extremity indices in boys at the age from 7 to 18 years (table 1.):

1) body height – in 7-year-old boys the medium body height value is 124.4 cm. At the age of 8 years the medium body height is 131.4 cm which increased by 7.0 cm within the year. At the age of 9 years the medium value is 136.62 cm, the yearly increase is 5.22 cm; at the age of 10 years the medium value is 140.47 cm, which increased within the year by 4.0 cm; at the age of 11 years the range of body height is from 133.8 cm to 165.7 cm, the medium value is 146.65 cm, which increased within the

year by 6.0 cm; at the age of 12 years, the medium value of boys is 152.46 and the yearly increase – 5.81 cm; at the age of 13 years the medium value is 158.02 cm, which increased by 5.56 cm; 14-year-old boys have grown by 9.05 cm; at the age of 15 years the medium body mass on average is 174.01 cm, which has increased by 6.94 cm; at the age of 16 years the body height varies from 158.4 – 189.4 cm, but the medium yearly increase is by 3.54 cm; at the age of 17 years the variations of height in boys is from 150.0 to 192.0 cm, the medium value is 177.97 cm which has increased within the year by 0.42 cm; at the age of 18 years, the medium body height is 181.05 cm, which has increased within the year by 3.08 cm.

2) body mass – in 7-year-old boys the body mass on average is 24.42 kg; at the age of 8 years – 28.64 kg, which has increased within the year by 4.22 kg. At the age of 9 years – 32.0 kg, which has increased within the year by 3.36 kg; at the age of 10 years – 33.21 kg, the yearly increase by 1.21 kg. At the age of 11 years the body mass is 22.5 – 70.0 kg, the medium value – 39.52 kg, the yearly increase – 6.31 kg. At the age of 12 years the medium body mass value is 44.15 kg, which has increased within the year by 4.63 kg; at the age of 13 years the medium value is 47.03 kg, which has increased within the year by 2.88 kg; at the age of 14 years the boys have put on weight by 6.81 kg; at the age of 15 years the medium value is 60.55 kg, which has increased within the year by 6.71 kg; at the age of 16 years it varies from 35.5 till 95.0 kg, the medium value is 64.77 kg, which has increased within the year by 4.22 kg; at the age of 17 years the medium value is 66.73 kg, which has increased within the year by 1.96 kg; at the age of 18 years the medium value is 72.06 kg, which has increased within the year by 5.33 kg,

3) trunk length – in 7-year-old boys the medium trunk length value is 36.88 cm. At the age of 8 years the medium trunk length is 38.90 cm which increased by 2.02 cm within the year. At the age of 9 years the medium value is 39.88 cm, the yearly increase is 0.98 cm; at the age of 10 years the medium value is 41.10 cm, which increased within the year by 1.22 cm; at the age of 11 years the range of body height is from 36.5 cm to 50.30 cm, the medium value is 42.81 cm, which increased within the year by 1.71 cm; at the age of 12 years, the medium

value of boys is 44.31 cm and the yearly increase – 1.5 cm; at the age of 13 years the medium value is 45.90 cm, which increased by 1.59 cm; at the age of 14 years, the medium trunk length is 48.24 cm, which has increased within the year by 2.34 cm; at the age of 15 years the medium trunk length on average is 51.13 cm, which has increased by 2.89 cm ; at the age of 16 years the trunk length varies from 43.30 – 58.40 cm, but the medium yearly increase is by 1.18 cm; at the age of 17 years the variations of height in boys is from 44.20 to 61.40 cm, the medium value is 53.40 cm which has increased within the year by 1.09 cm; at the age of 18 years, the medium trunk length is 53.99 cm, which has increased within the year by 0.59 cm,

4) upper extremity length – in 7-year-old boys the medium upper extremity value is 53.90 cm. At the age of 8 years the medium upper extremity is 57.05 cm, which increased by 3.15 cm within the year. At the age of 9 years the medium value is 59.81 cm, the yearly increase is 2.76 cm; at the age of 10 years the medium value is 62.17 cm, which increased within the year by 2.26 cm; at the age of 11 years the medium value is 65.37 cm, which increased within the year by 3.2 cm; at the age of 12 years, the medium value of boys is 68.31 cm and the yearly increase – 2.94 cm; at the age of 13 years the medium value is 70.51 cm, which increased by 2.20 cm; 14-year-old boys have 75.07 cm; at the age of 15 years the medium upper extremity length on average is 78.30 cm, which has increased by 3.23 cm ; at the age of 16 years the body height varies from 158.4 – 189.4 cm, but the medium yearly increase is by 1.16 cm; at the age of 17 years the variations of height in boys is from 150.0 to 192.0 cm, the medium value is 177.97 cm which has increased within the year by 0.07 cm; at the age of 18 years, the medium body height is 80.90 cm, which has increased within the year by 1.37 cm,

5) lower extremity length – in 7-year-old boys the lower extremity length on average is 63.15 cm; at the age of 8 years – 66.10, which has increased within the year by 2.95 cm. At the age of 9 years – 67.88 cm, which has increased within the year by 1.78 cm; at the age of 10 years – 69.21 cm, the yearly increase by 1.33 cm. At the age of 11 years the medium value of the lower

extremity length is 71.13 cm , yearly increase – 1.92 cm. At the age of 12 years the medium value of the lower extremity length is 73.36 cm, which has increased within the year by 2.23 cm; at the age of 13 years the medium value is 75.77 cm, which has increased within the year by 2.41 cm; at the age of 14 years the boys have 79.37 cm; at the age of 15 years the medium value is 83.23 cm, which has increased within the year by 3.86 cm; at the age of 16 years the medium value is 85.05 cm, which has increased within the year by 1.82 cm; at the age of 17 years the medium value is 86.19 cm, which has increased within the year by 1.14 cm; at the age of 18 years the medium value is 87.59 cm, which has increased within the year by 1.4 cm.

DISCUSSION

The results of 2005/2006 study, comparing to the 1996/1997 study data in 7–18 year-old girls show that the growth rate of longitudinal parameters is similar. For instance, both in boys and girls the gradual growth of the body longitudinal parameters in all age groups is seen (table 4). Puberty accelerated the growth period (PAP) in girls is seen at the age from 11 to 12 years, when the mean value of the body height increase reaches 7.82 cm per year. In boys the accelerated growth is seen at the age from 7 to 8 years, when the mean value of the body height reaches 7.0 cm per year and from 13 to 14 years, when the mean value increased by 9.05 cm per year (Table 3).

In girls the absolute trunk growth rate is seen from 11 to 12 years, i.e., 2.26 cm, which coincides with the mean groth rate of the body height. In boys the absolute trunk growth rate is seen from 13 to 15 years, where its growth per year is 2.34 cm and 2.89 cm, which also coincided with the mean groth rate of the body height.

For girls the maximal upper extremity growth increase is at the age from 11 to 13 years, and its mean value is 6.39 cm. For boys the maximal mean upper extremity growth is from 13 to 14 years and its mean value is 4.56 cm.

The greatest relative and absolute lower extremity growth rate in girls is seen from 8 to 14 years. The lower extremity length reaches maximum growth till midpuberty. The lower extremity accelerated growth in boys was seen from 13 to 15 years, where the mean growth per year is 3.6 cm and 3.86.

The relative anthropomentric parameters of boys are dynamically different (Table 2). Upper extremity growth in relation to the height practically does not change. A similar phenomenon is seen for the trunk length in relation to the height. Analyzing the lower extremity length in relation to the height of the body, one can see that these parameters are variable in relation to the age changes – one can observe the positive dynamics of these parameters, which reach their maximum from 13 to 14 years. Similar results are acquired, analyzing the lower extremity length in relation to the body height in girls, where the girls' body height accelerated growth is seen at the expense of the lower extremity growth (Table 5).

Table 1. Mean anthropometric parameters in boys at the age of 7 to 18 years

	Age of the boys (years)	N	Mean anthropometric parameters, cm			
			Body height	Trunk length	Upper extremity length	Lower extremity length
1.	7	37	124.40	36.88	53.90	63.15
2.	8	90	131.40	38.90	57.05	66.10
3.	9	89	136.62	39.88	59.81	67.88
4.	10	77	140.47	41.10	62.17	69.21
5.	11	89	146.65	42.81	65.37	71.13
6.	12	91	152.46	44.31	68.31	73.36
7.	13	88	158.02	45.90	70.51	75.77
8.	14	117	167.07	48.24	75.07	79.37
9.	15	116	174.01	51.13	78.30	83.23
10.	16	111	177.55	52.31	79.46	85.05
11.	17	100	177.97	53.40	79.53	86.19
12.	18	61	181.05	53.99	80.90	87.59

Table 2. Relative anthropometric parameters in boys at the age of 7 to 18 years

	Age of the boys (years)	N	Relative anthropometric parameters		
			Trunk length	Upper extremity length	Lower extremity length
1.	7	37	29.65	43.32	52.03
2.	8	90	29.60	43.41	52.35
3.	9	89	29.19	43.76	52.88
4.	10	77	29.25	44.26	53.21
5.	11	89	29.18	44.57	53.87
6.	12	91	29.06	44.79	54.17
7.	13	88	29.04	44.61	54.26
8.	14	117	28.87	44.92	54.58
9.	15	116	29.38	44.98	54.18
10.	16	111	29.46	44.75	54.06
11.	17	100	30.00	44.69	53.53
12.	18	61	29.82	44.69	53.54

Table 3. Absolute growth rate in boys at the age of 7 to 18 years

	Age of the boys (years)	N	Anthropometrical parameters	
			Body height, cm	Body mass, kg
1.	8	90	**7.00**	**4.22**
2.	9	89	5.22	3.36
3.	10	77	4.00	1.21
4.	11	89	6.00	**6.31**
5.	12	91	5.81	4.63
6.	13	88	5.56	2.88
7.	14	117	**9.05**	**6.81**
8.	15	116	6.94	**6.71**
9.	16	111	3.54	4.22
10.	17	100	0.42	1.96
11.	18	61	3.08	5.33

Table 4. Mean anthropometric parameters in girls at the age of 7 to 18 years in 1996/1997 study (I. Duļevska, 2002)

	Age of the girls (years)	N	Mean anthropometric parameters, cm			
			Body height	Trunk length	Upper extremity length	Lower extremity length
1.	7	46	126,45	36.58	54.62	63.20
2.	8	105	130,34	37.38	56.03	65.84
3.	9	116	136,01	38.97	59.11	69.52
4.	10	148	141,98	40.66	61.66	72.95
5.	11	175	146,44	42.29	63.57	75.99
6.	12	147	154,26	44.55	66.99	79.63
7.	13	116	158,61	45.52	69.66	82.84
8.	14	143	163,40	46.99	71.82	85.24
9.	15	113	165,98	48.38	72.27	86.00
10.	16	91	166,56	48.39	72.70	86.64
11.	17	66	168,51	49.02	73.40	87.94
12.	18	48	167,54	50.56	72.38	86.18

Table 5. Relative anthropometric parameters in girls at the age of 7 to 18 years

	Age of the girls (years)	N	Relative anthropometric parameters		
			Trunk length	Upper extremity length	Lower extremity length
1.	7	46	28.91	43.18	52.98
2.	8	105	28.69	42.99	53.40
3.	9	116	28.66	43.46	53.89
4.	10	148	28.64	43.44	53.84
5.	11	175	28.93	43.58	54.35
6.	12	147	28.91	43.41	54.15
7.	13	116	28.69	43.92	54.38
8.	14	143	28,75	43.95	54.41
9.	15	113	29.16	43.57	54.07
10.	16	91	29.06	43.64	54.01
11.	17	66	29.09	43.55	54.26
12.	18	48	30.14	43.20	53.56

CONCLUSIONS

Analyzing the acquired data on the parameters of 7–18-year-old boys, we can conclude that:

1) the increase of the trunk length is seen to be even in all age groups, but an accelerated growth is seen at the age from 7 to 8 years, and from 13 to 14 years,
2) the increase of the upper extremity length dynamics is positive in all age groups,
3) the increase of the lower extremity length dynamics is positive in all age groups,
4) accelerated body growth at the age of 13 and 14 year-olds is seen at the expense of the increase of the lower extremity length growth.

REFERENCES

1. Millere R., Segleniece K. (1977) Bērna augšana un attīstība. Rīga. Zvaigzne. 1977.
2. Segleniece K. (1977) Bērnu fiziskā attīstība. Rīga. Zvaigzne. 1977. 79. lpp.
3. Āboltiņa M, Brēmanis E. (1995) Pamatskolas bērnu morfofizioloģiskās īpatnības. Rīga. 1995.
4. Āboltiņa M. Kā aug mūsu bērns. Pamatskolas vecums – II daļa. Rīga. 1998, 106–129.
5. Krūmiņa Dž., Kokare I. Latvijas bērnu fiziskās attīstības normatīvi. Nacionālais Apgāds, 2005.
6. Duļevska I. (2002) Rīgas skolas vecuma latviešu meiteņu fiziskās attīstības izvērtējums gadsimtu pārmaiņu procesos. Disertācija. 2002.
7. Duļevska I. (2003) 7–18 gadus vecu meiteņu fiziskā attīstība un sekundārās dzimumpazīmes. Rekomendācijas Rīgas pilsētas skolām. Rīga. 2003.
8. Umbraško S. (2005) Skolēnu stājas un pēdas parametru vērtējums kā fiziskās attīstības rādītājs gadsimtu mijā. Disertācija. 2005.
9. Sitarama Raju P., Prasad K. V. V., Venkata Ramana Y., Syed Kabir Ahmed, Murthy K. J. R. (2003) Study on Lung Function Tests and Prediction Equations in Indian Male Children. Indian Pediatrics, 40, 705–711.

10. Pavel Blaha, Jana Vignerova. Longterm Observations of Body Parameters of Czech Children and Aolescents. Biennial Books of EAA, 3, 157–172.

Address for correspondence:
Zeltīte Cēderštrēma PhD
Riga Stradiņš University, Institute of Anatomy and Anthropology
Kronvalda blv. 9, Riga, LV-1010, Latvia
E-mail: aai_anat@inbox.lv, mailto:aai_anat@inbox.lv

Papers on Anthropology XVI, 2007, pp. 80–91

CHANGES IN BODY PROPORTIONS DURING GROWTH OF LATVIAN GIRLS IN RIGA

Ilva Duļevska, Silvija Umbraško, Zeltite Cēderštrēma, Janis Vētra, Uldis Teibe

Institute of Anatomy and Anthropology, Riga Stradins University,

ABSTRACT

The measurements of girls in Riga in 1996797 constitutes the basis of the research. In total 1.335 girls in the age of 7–18 years were measured. Body height and other lenght measurements and their relations to body height were researched. The following changes were detected:

a) at the age of 11 to 12 years the highest increase is seen in body height and the sizes of other body parts and extremities,
b) at the age of 12 to 14 years one can see the most intensive increase in body mass.
c) at the age of 17–18 years the constitutional type of Latvian girls corresponds to the dolichomorphous type, except for the length of armes, which are shorter and are more typical for mesomorphous type.

Key words: Body proportions, girls anthropometry, puberty

INTRODUCTION

One of the basic tendencies of a modern human biology study deals with the change process (puberty) of adolescents' physical development, which presents a lot of different hypothesies. With the advent of adolescence, a new stage of body growth is setting in, which is determined by the interrelation of sex glands and suprarenal hormones with growth hormones (somatotrophic), which causes (or is the basis) the intensive growth connected with puberty. This is the period when androgenous hormones become active and there is a theory that they, together with the growth hormone, are regulating the growth intensity during the whole puberty period. However, up to now no theory has been worked out to determine the sequence of endocrine processes.

The growth of separate body parts is not proceeeding equally in various developmental stages. Isodynamics, as well as hetero-dynamics, are of importance. An individual's anatomical, physiological, age and sex specificities are the phenotype-characterizing values, which describe the genotype's dynamic influence, as well as that of endogenous and exogenous factors. The influence of the genetic component on the morphologic status was found to be different in different developmental stages.

Each morphological sign is the dynamics of genetical and environmental interaction. Some authors state that the environmental factors prevail in the intrauterine developmental period. B. Nikitjuk is saying that foetus is very sensitive to the irritation of environmental factors. Up to 15 years the genotypic features increase, from the age of 16 to 18 years one can observe the decisive prevalence of external environmental factors.

K. Doroznova, on the contrary, points to the effect of external factors in the physical development at an early age, and is of the mind, that in a later period, the hereditary factors become more decisive.

A great number of scientists state that genetical factors affect the development of longitudinal dimensions, while the body mass is subjected to the effect of environmental factors.

Puberty is lasting for several years and is ranging due to the individual body features. It starts at the age of 10–12 years and ends at 14–16 years. In this developmental stage there are great changes seen in the body mass increase, changes in the size of leg length, and in girls – changes in pelvic size. Quite commonly body disproportions are observed as well. Changes in the voice are seen in both genders. In girls there are seen radical changes in the pelvic size, the breasts start developing, pubic and axillary hair develop, too. Menarche almost always starts after the body has reached its maximum growth rate [9]. Internal sex organs develop alongside with all these indices.

MATERIAL AND METHODS

The measurements of girls done at Riga schools in 1996/97 make the basis of the research.

Measurements were acquired at the following Riga city schools: Riga secondary school Nr. 49, Valdis Zalitis primary school, Riga Centre Humanitarian gymnasium, Riga secondary school Nr.3 and Riga secondary school Nr.99.

In total 1,335 girls, 7–18 years of age, were screened.

All the anthropological measurements were carried out, using methodical indications of R.Martin, K.Saller, and J.Primanis.

The age groups were screened considering the following principle: for instance, if the girl's calendar age was within 11 yrs.6 months to 12 yrs.5 months and 29 days, then the girl was considered to be 12 years old.

Measurements were done by the Swiss company Silber-Hagner& Co instruments.

Doing the analysis of anthropometric signs, we calculated their chief descriptive statistical parameters, and used the correlation and regression analysis method. Mathematical-statistical data processing was done by means of the statistical analysis of MS Excel, SPSS and STATISTICA.

RESULTS

One of the parameters of a growing human proportions is the ratio of the circumference of the head to the body height. Latvian girls of Riga at the age of 7 years have the head circumference of 94% of a 17-year-old gir's l size, but the ratio to the body height at the age of 7 years is 41%, showing that at this age the girls are characterized by body proportions typical for children. Alongside with body growth, the girls' head circumference gradually decreases till the age of 14 years, comparing to the body (from 44,1 to33,3%), and at the age of 14, it gets stabilized, admitting the average ratio of the head circumference to the body height being 33%.

Great dispersion of the majority of anthropometrical data, especially in separate age groups, as well as various indices of the growth acceleration of minimal and maximal dispersion indices, show more than clearly that the group of 1996/1997 Riga girls, as to their body consitution, is not uniform.

Changes of separate body parts may be considered as an indirect factor, depicting the changes of a growing individual's body proportions. It is expressed in percentage of their definitive value. Analyzing these indices at any age, one can define, which of the body measures in the further growth process will increase at a greater or lesser rate (Table 1). Latvian girls of the city of Riga, judging from the signs of relative sizes in the growth period, after reaching 7 years, have the highest growth rate for the width of the head (by 20.3%), until 10 years the highest growth rate is for the leg length, the feet size increases too, arm and shoulder increase is slight, it is less for the waistline. At the age of 12 years the extremities still continue to grow, the hip diameter reaches its maximum growth rate, the waistline growth increases, too. As a result, one can see the growth of body height at the age of 14 years, when the fastest growth is that for the hips (by 18.3%), but at the age of 16 years the closest to the definitive value are the head size, width of arms and hips and the arm length.

Analyzing the changes of separate body part proportions to the body height at each age group, we can specify the before-mentioned factors. Waistline reaches its maximum size at the age of 15 years (29.16% to the body height) and it is the closest to dolichomorphic type indices. Leg length reaches its peak size at the age of 14 years, when it reaches the target value between mesomorphous and dolichomorphous structure type representatives. Arm length reaches its highest value also at the age of 14 years, when it can be included into the mesomorphous type variant. Shoulder width reaches its maximum at the age of 15 years and it is more typical for brachimorphous type representatives.

Table 1. Changes of body proportions depending on the age group (% of body height)

Age	N	Head circumference	Waistline	Leg length	Arm length	Shoulder width	Pelvic width
7	26	41.1	28.91	52.98	43.18	22.63	15.93
8	70	40.0	28.69	53.40	42.99	23.15	15.63
9	82	38.6	28.66	53.89	43.46	23.20	15.58
10	93	37.3	28.64	53.84	43.44	23.38	15.64
11	110	36.4	28.93	54.35	43.58	23.54	15.73
12	99	35.0	28.91	54.15	43.41	23.57	15.72
13	75	34.1	28.69	54.38	43.92	23.69	15.88
14	93	33.3	28.75	54.41	43.95	23.82	16.26
15	81	33.1	29.16	54.07	43.57	24.18	16.57
16	67	32.9	29.06	54.01	43.64	23.98	16.79
17	44	32.8	29.09	54.26	43.55	23.87	16.70
18	32	33.0	30.14	53.56	43.20	24.23	16.97

Mutual dynamics of body height and other longitudinal dimensions

The first longitudinal body dimension changes in Latvian girls of the city of Riga are seen at the age of 9–10 years, when the body height increase is respectively 5.67 cm and 5.97 cm. At this age there is the greatest increase of leg length per year – 3.68 cm and 3.43 cm. In the further years these indices are growing equally until 17 years. After this age one may not observe the increase of body height and leg length, and it can be considered a definitive value for this sign. The study shows that other longitudinal dimensions are increasing as well at the age of 9 years, when the arm increase per year is seen to be 3.08 cm. Waistline increase is observed at the age of 9–10 years, when it increases by 1.59 and 1.69 cm respectively. At the age of 11–12 years, we observed maximum increase of arm length, when it reaches 3.42 cm per year, and the greatest increase in waistline, and it is 2.26 cm. 17-year-old girls are seen to present the definitive value of these signs. The relative dimensions of the waistline increase at the age of 14–15 years as well. Relative indices of shoulder width also increase in 15-year-old girls.

At the beginning of puberty, i.e. at the age of 9 years, one can see even an increase of longitudinal body dimensions. In the middle stage of puberty (from 11–12 years) and until its end (16–17 years) these indices are growing faster. At the age of 17–18 years, the relative waistline dimension to the relative body height is 29.9% (Fig. 1 and 2).

The mean relative leg length reaches its maximum in 11–14 years, i.e. the middle stage of puberty, then the growth period until the end-stage of puberty is gradually decreasing. At the age of 17–18 years the relative mean leg length is 51.5% of the relative mean body height.

The relative mean arm length increases evenly until 14 years, then its growth rate decreases and at the age of 18 years the growth process stops. From 10 to 11 years the increase of mean values of all the body longitudinal dimensions decreases.

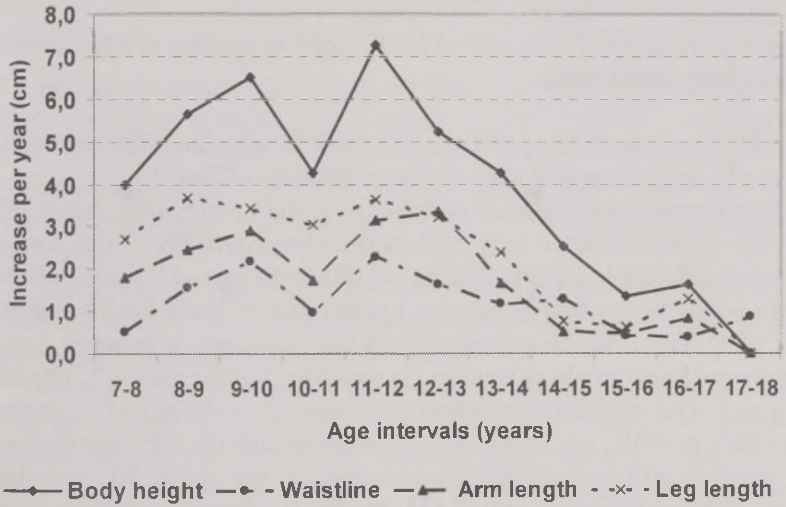


Figure 1. Absolute growth rate of body height in relation to other longitudinal body dimensions.

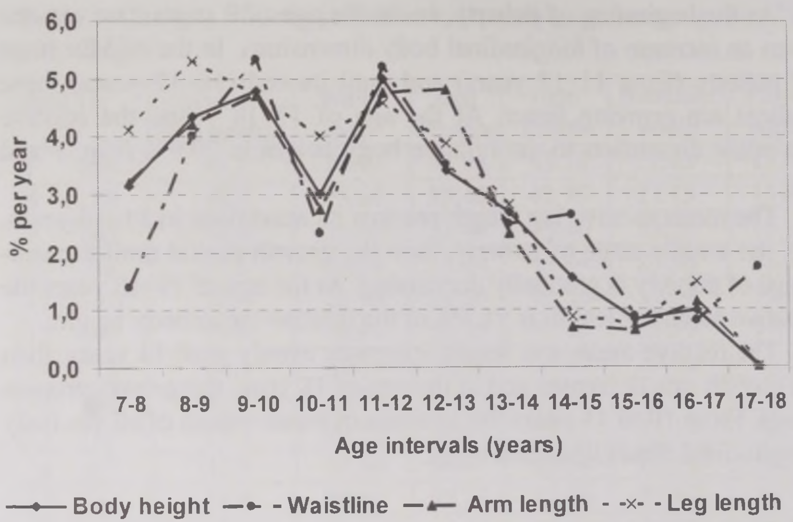


Figure 2. Relative growth rate of body height in relation to other longitudinal body dimensions.

Interrelation between body height and other longitudinal dimensions is shown by regression and correlation coefficients (Table 2.)

Leg length has the closest correlation to the body height, and at all the age groups it has a very high correlation coefficient. The correlation coefficient is slightly lower ($r<0,69$) at the age of 9 years, which corresponds to the first maximum growth rate of body height and to that of 15 years, which corresponds to the end-stage of puberty. Arm length and body height correlation is the closest at the age of 7, 10 and 18 years. The smallest correlation coefficient is at the age of 13 years ($r=0.555$, $p=0.01$), i.e. in the middle stage of puberty. The correlation of waistline and body height are less close, at the age of 10 years the correlation coefficient is only 0.411, but the maximum correlation is at 14 years ($r=0.758$, $p=0.01$).

Waistline dimensions affect the body height from 13 to 14 years. At the age of 17–18 years the variety of body height is determined by leg length. Considering the results of measurements and analyzing the acquired data, we can come to the conclusion that the decisive factor for body height variation is leg length.

Table 2. Correlation of body height and longitudinal body dimensions depending on age group (Pearson's correlation coefficients, p<0.01)

Age group (yrs.)	N	Waistline	Arm length	Leg length
7	46	0.680	0.868	0.954
8	105	0.652	0.723	0.980
9	115	0.490	0.767	0.899
10	147	0.411	0.858	0.989
11	174	0.566	0.751	0.963
12	147	0.466	0.681	0.955
13	117	0.555	0.555	0.957
14	143	0.758	0.711	0.979
15	113	0.556	0.639	0.891
16	90	0.655	0.741	0.981
17	65	0.601	0.806	0.989
18	47	0.448	0.846	0.989

Leg length and waistline dimension affect the body height differently. Body height in separate age groups increases relatively, more at the expense of leg length and not for the waistline dimensions. The difference of the absolute value of leg length to maximum body height variants (*max-min*) in older girls increases 2–3 times in comparison with waistline.

Analyzing the acquired study data on the dynamics of longitudinal body growth, we can conclude that the growth process of Latvian girls proceeds in harmony and proportionally.

In order to determine the constitutional type body changes in Latvian girls in Riga, we used the Pignet-Vervaek's index, which takes into account three basic indices: body mass and chest circumference to body height. Up to 15 years, the time when one can in reality assess the constitutional body type, using the values of this index, body proportions can be compared only by comparing body mass and growth tendencies of chest circumference and their mutual dynamics in relation to the body height.

The study material shows that Latvian girls, at the age of 7–8 years, have a gradual body mass increase, and its more radical increase is observed at the age of 9 years (the difference between 8 and 9 years is 3.41 kg), however, the maximum value is reached at 13 years, when body mass, comparing to 12 years increases by 5.43 kg. From 13 to 15 years the body mass increases by 4.0 kg per year, but at 15–16 years it stabilizes. At this age the majority of body width dimensions are stabilizing. The tendency in the increase of chest is more pronounced from 10 years (by 3.2 cm), the greatest increase is seen at 13 years (3.75 cm) and 14 years (4.0 cm). Until 15 years Latvian girls in the city of Riga are characterized by the wide body constitution, which is due to the faster increase of body mass and chest cinrcumference to body height. After 16 years the body mass in girls is continuing to grow, but the body mass and width dimensions have become stabilized. At the age of 17–18 years the constitutional type of Latvian girls corresponds to dolichomorphous type, except for arm length which is more typical of mesomorphous type.

DISCUSSION

Characterizing the body proportions, several methods were used in the study of 1996–1997. The ratio of head circumference to body height was stated, which shows that children at 7–14 years have characteristic proportions with relatively big head circumference to the body height. At the age of 14 years the ratio of head circumference and body height presents a grown-up individual's status (about 30%). Like an indicator of body proportions for girls the ratio of separate body parts to their definitive value was used. It shows the different growth rates of these body parts. Extra to this method, we used separate body part proportions to body height. Here are the references to I.Kokare, J.Vetra and Dz.Krumina's study made on the parameters of the proportions of body parts in Latvian soldiers during historical time changes (1939–1996), where the authors have mentioned the changes in the scheme of body proportions. The study points out that the increase of body height by 86.3% in Latvian soldiers has occurred at the expense of the increase of the lower body segment. The relative shoulder width had increased too, at the same time decreasing the relative hip width, besides the body mass was significantly decreased. The authors consider that a male figure has become more „masculine" in 1996. The study of Riga girls shows that a similar tendency is being observed, by the increase of shoulder width, but the decrease of the relative hip width. In such a case, these are not the signs which would be related to a definite gender, but despite it, it points to the century changes.

CONCLUSIONS

1. It has been made clear that Latvian girls of the city of Riga, being of different ages, are characterized by the changes of body anthropological signs:
   a) at the age of 11 to 12 years the highest increase is seen in body height and the sizes of other body parts and extremities;
   b) at the age of 12 to 14 years one can see the most intensive increase in body mass.
2. At the age of 17–18 years, the constitutional type of Latvian girls corresponds the to dolichomorphous type, except for the length of arms, which are shorter and are more typical for the mesomorphous type.

REFERENCES

1. Krūmiņa Dž., Kokare I., Duļevska I., Vētra J., Teibe U. Dažādu ģimenes faktoru ietekme uz jaundzimušo galvenajiem antropometriskajiem parametriem. The International Scientific Conference: The Child in the World, the World in the Child. Liepāja, 1997, 157.
2. Kokare I., Krūmiņa Dž., Duļevska I., Vētra J., Teibe U. Some Parameters of Riga Nevvborns Growth Processes During the First Three Months of Life. The 8thTartu International Anthropological Conference. Tartu, 1997, 31.
3. Krūmiņa Dž., Kokare I., Duļevska I., Vētra J.. Infant growth compensates newborn status. The 14th International Congress of Antropological and Ethnological Sciences. – Wiliamsburg, ASV, 1998.
4. Kokare I., Krūmiņa Dž., Duļevska I., Vētra J., Teibe U.. Par auguma garuma atkarību no ģimenes un vecāku pazīmēm. The International Scientific Conference: The Child in the World, the World in the Chield. Liepāja, 1997, 157.
5. Duļevska I., Vētra J. Par zemlāpstiņas tauku krokas biezumu Rīgas pilsētas meitenēm. 3. Pasaules ārstu kongress. Rīga, 1997.

6. Duļevska I., Kokare I., Krūmiņa Dž., Vētra J., Teibe U.. Secular trend in weight, length and menarche age in 12-years-old Latvian girls. The *8th* Tartu International Antropological Conference. Tartu, 1997, 31.
7. Duļevska I., Vētra J., Kokare I., Krūmiņa Dž., Umbraško S.. Correlation between body height, weight and onset of menarche in Latvian girls. 5th WACHE/ASHB Conference. Adelaide, 1997.
8. Lindberga R., Raubiško B., Duļevska I.. Studies of archaeological material: skull structural peculiarities and paleopathologicai changes in lettish from XIIIth to XVIIIth century. The 12th Congress of Italian Antropological Association. Palermo, 1997.
9. Duļevska I., Vētra J., Kokare I., Krūmiņa Dž., Umbraško S., Teibe U. Menarcheal age in two generations of Latvia. The 14th International Congress of Antropological and Ethnological Sciences-Wiliamsburg, ASV, July 26–8 August, 1998.
10. Duļevska I., Vētra J., Teibe U., Umbraško S. Antropometric measurements of Latvian girls from Riga and their dependence on menarcheal age. The 11th Congress of the European Anthropological Association. Jena, 1998.
11. Дулевска И. Характеристика подкожножировых складок у девочек, обследованных в 1996/97 годах. Гигиена детей и подростков на пороге третьего тысячелетия. Основные направления развития. Москва: НИИ гигены и охраны здоровья детей и подростков. 1999, С. 45–46.
12. Duļevska I. Anthropological review through the centuries on the Latvian women. Acta Medico-Historica Rigensia: Vol. V (XXIV). Riga, 1999. 127–132.
13. Duļevska I. Sekundāro dzimumpazīmju un menarhes interkorelācija latviešu meitenēm. Medicīnas nozares zinātniskā konference. Rīga: RSU, 2000. 95.
14. Duļevska I. The definition of the body content for school-aged Latvian girls in Riga in the research of 1996–1997. LZAV, 2002. In Press.
15. Duļevska I. Rīgā dzīvojošo latviešu meiteņu morfoloģiskā statusa izmaiņas 20.gadsimtā. Acta Medico-Historica Rigensia. Vol. VI (XXV). Riga, 2002. in Press.
16. Duļevska I. Physical development and social circumstances of school-aged girls in Riga. International conference – Ecological aspects of animals and human health: Zdrovvotne uwarunkowania produkcji zvvierzecej. Lomža, 2002. 13–19.

17. Duļevska I. Rīgas pilsētas latviešu meiteņu ķermeņa proporciju izmaiņas augšanas procesā. Pieņemts publicēšanā RSU ZR krājumā 2002.
18. Duļevska I. Latviešu sieviete un bērni antropoloģiskajos pētījumos Latvijā. Pieņemts publicēšanā RSU ZR krājumā 2002.

Address for correspondence:
Ilva Duļevska PhD
Riga Stradiņš University, Institute of Anatomy and Anthropology
Kronvalda blv. 9, Riga, LV-1010, Latvia
E-mail:ilva.dulevska@mvm.lv

Papers on Anthropology XVI, 2007, pp. 92–99

RECOVERY AFTER REPEATED SPRINTS ASSOCIATED WITH AEROBIC CAPACITY IN BASKETBALL PLAYERS (RECOVERY AFTER SPRINTS IN BASKETBALL PLAYERS)

A. Gocentas[1], A. Landõr[2], A. Juozulynas[3]

[1] Department of Rehabilitation, Institute of Experimental and Clinical Medicine, Vilnius University, Zygimantu 9, Vilnius, LT 01513, Lithuania
[2] Department of Sports Medicine and Rehabilitation, University of Tartu, Puusepa 1a, 50406, Estonia
[3] Institute of Experimental and Clinical Medicine, Vilnius University, Zygimantu 9, Vilnius, LT 01513, Lithuania

ABSTRACT

Basketball is a high-intensity intermittent activity during which players perform efforts of sprinting and jumping that place considerable demands on the system of oxygen delivery. We found significant correlations between basketball-specific activity and oxygen uptake in our previous research. Data about relationships between laboratory testing and field performance are highly complicated and controversial. The aim of this study was to test whether recovery between intermittent sprint efforts is related to aerobic capacity in competitive basketball players.

Seven competitive male basketball players (VO_{2max} = 47.97±10.25 ml · min^{-1} · kg^{-1}) took part in the study after being informed in detail of the nature of the experiment. The subjects had the following characteristics (mean ± SD and range [minimum-maximum]): age, 25±4.39 [21–31] years, height, 201.7±5.88 [193–209] cm, body mass, 98.86±10.56 [85–112] kg. Cardiopulmonary exercise tests (CPET) were conducted using an electrically braked cycle ergometer Ergoline 800 (Ergoline, Bitz, Germany). We selected series of ten consecutive sprints for analysis. The distance of one sprint was 75 meters. Relative rest between sprints lasted 120 s. During periods of relative rest players were standing, walking and stretching. Exercise intensity distributions during analysed field activity were determined using monitoring of heart rate (Polar Team System, Polar Electro Oy, Kempele, Finland). We found strong significant inverse correlation between VO_{2AT} and decrease in recovery ($r = -0.893$). Also we found correlation between oxyP and the median/maximum recovery ratio ($r = 0.857$).

We conclude that the quality of recovery after repeated consecutive sprints is associated with aerobic capacity. Aerobically better prepared athletes show less decrease in recovery of heart rate between sprints. Further research is necessary to specify repeated sprint ability testing in basketball.

Key words: basketball, recovery, physiological indices, oxygen uptake, heart rate

INTRODUCTION

Basketball is a high-intensity intermittent activity during which players perform efforts of sprinting and jumping that place considerable demand on the system of oxygen delivery [5, 10]. Basketball as a kind of intermittent activity cannot be appropriately simulated in laboratory [10]. Therefore, it is necessary to assess the physiological profiles and energy patterns of this invasion game because the knowledge of cardiovascular, metabolic, and respiratory requirements in sport provides the basis for an adequate design of training regimens [1, 2, 6, 8, 10]. Data about relationships between laboratory testing and field performance are highly complicated and controversial. We found significant correlations between basketball-specific activity and aerobic capacity in our previous research [5, 6]. The aim of this study was to test whether recovery between intermittent sprint efforts is related to aerobic capacity in competitive basketball players.

MATERIAL AND METHODS

Seven competitive male basketball players (VO_{2max} = 47.97±10.25 ml/kg/min) took part in the study after being informed in detail about the nature of the experiment. Laboratory exercise tests were performed in the morning in all cases. All subjects were given the opportunity to become familiar with the cycle ergometer. Cardiopulmonary exercise tests (CPET) were conducted using the electrically braked cycle ergometer Ergoline 800 (Ergoline, Bitz, Germany). Power output was increased by 30 W every minute and pedalling cadence was kept constant at 60–70 rpm. All tests were carried out under laboratory conditions complying with the ATS regulations [2, 8]. 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 [2, 14]. Anaerobic threshold was determined using the V-slope method [14]. Time based (every 20 sec) mean values of oxygen uptake and oxygen pulse were obtained using the VMAX229 (Sensormedics Corps. Yorba Linda, CA, USA) gas analyser. CPET was part of health assessment of the athletes before the season.

After two weeks, during real pre-season practices, the athletes performed a series of interval runs. They completed the interval running sessions after a 15 min warm-up consisting of low-intensity running and self-administered stretching performed as practice and specific additional warm-up. We selected series of ten consecutive sprints for analysis. The distance of one sprint was 75 m. Relative rest between sprints lasted 120 s. During the periods of relative rest the players were standing, walking and stretching. Exercise intensity distributions during analysed field activity were determined using monitoring of heart rate (Polar Team System, Polar Electro Oy, Kempele, Finland). For analysis, we used derivative values of exercise intensity expressed in beats per minute (bpm). Decreasing of recovery (dec_rec) was calculated as the difference between recovery after the first and the last sprint divided by the value of recovery after the first sprint. Also we used median of decreasing of recovery (med_dec_rec), median of recovery (med_rec), median of peaks (med_peak), and the ratio of the median of recovery to the largest recovery (med/max).

All statistical analysis was performed using the computer software SPSS 11.0 (Statistical Package for Social Sciences, SPSS Inc., Chicago, IL, USA). The level of significance was set at 0.05. Spearman's nonparametric rank test was used to evaluate relationships between the parameters of field exercise intensity and aerobic capacity.

RESULTS

All seven players completed the study. The subjects had the following characteristics (mean ± SD and range [min-max]): age, 25±4.39 [21–31] years, height, 201.7±5.88 [193–209] cm, body mass, 98.86±10.56 [85–112] kg.

The selected values of aerobic capacity measured during laboratory cardiopulmonary testing are presented in Table 1. The values of aerobic capacity of the studied athletes are not extremely high but are comparable to the upper limit of normative values for healthy adults. The results are consistent with other findings of aerobic fitness in basketball players.

Table 1. Parameters of aerobic capacity in the studied subjects established during cardiopulmonary exercise tests

Parameters	Mean	Median	Standard deviation
VO_{2max_R} (ml/kg/min)	47.9714	48.7000	10.25146
VO_{2max_A} (ml/kg/min)	4.70800	4.97000	0.905503
oxyP (ml/bpm)	27.7714	28.4000	4.50026
VO_{2AT} (ml/kg/min)	2.5587	2.5020	0.75208

Table 2 demonstrates correlation matrix between aerobic capacity and quality of recovery during real field exercise. We found strong significant inverse correlation between VO_{2AT} and decrease in recovery ($r = -0.893$). Also we found correlation between oxyP and the median/maximum recovery ratio ($r = 0.857$). We suggest that the established correlation depends on the duration and number of interval runs and pauses between the runs.

Table 2. Correlations between variables of aerobic capacity and the variables of recovery during field exercise in basketball players

Parameters		VO_{2max}	oxyP	VO_{2AT}
dec_rec	r	–.750	–.607	–.893(*)
	p	.052	.148	.007
med_dec_rec	r	.464	.250	.429
	p	.294	.589	.337
med_rec	r	–.072	–.342	–.288
	p	.878	.452	.531
med_peak	r	.072	–.414	–.054
	p	.878	.355	.908
med/max	r	.500	.857(*)	.607
	p	.253	.014	.148

* Correlation is significant at the 0.05 level (2-tailed).

Figure 1 presents correlations between the peaks and recovery for each athlete during the performance of the series of interval runs. This graph enables to compare the data of individual players in the team. The dynamics of the recovery between the sprints is individual for each player enabling to follow the changes in progress during the training programme.

DISCUSSION

Our results indicate that decrease of recovery during a field test of repeated sprints is associated with laboratory-established aerobic capacity. Aerobically better prepared subjects are able to recuperate better between interval runs.

In an attempt to examine relationships between repeated sprint ability and aerobic capacity we investigated the association between performance (power and time) and maximal oxygen uptake [9, 12, 13]. Our aim was to analyse changes in quality of recovery. Monitoring of heart rate was considered a useful tool to express intensity of exercises [1]. A decrease in recovery between the runs was noticed in all study subjects. The logarithmic graphs presented in Figure 1 provide empirical support to individual trends of heart rate recovery, which is associated with vagal tonus and receptors of acetylcholine [3, 7].

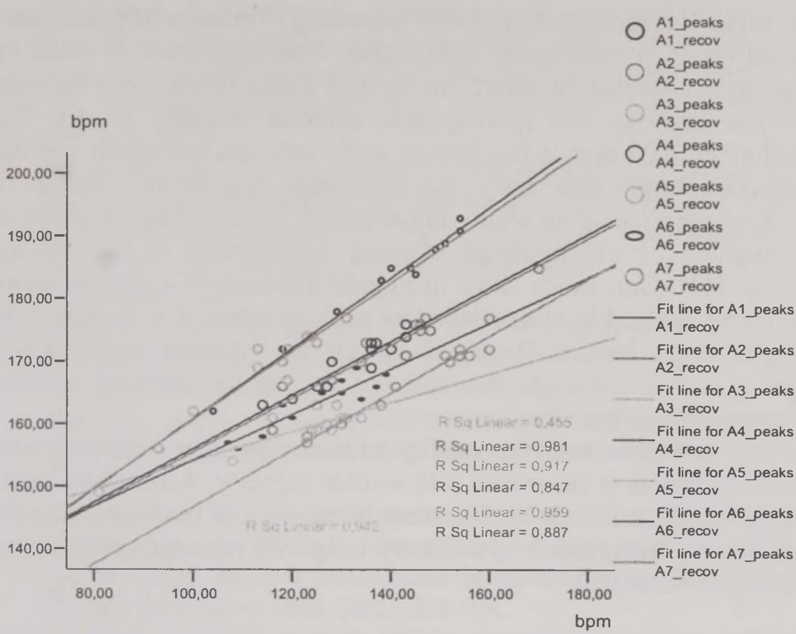


Figure 1. Individual correlations between peaks and recovery during series of sprints in basketball players.

Found correlation between oxyP and median maximum recovery ratio supports the importance of good aerobic capacity in the athletes of team sports. Higher oxyP is associated with lower decrease of recovery. This means that quality of recovery between interval runs is higher in players with higher oxyP.

A statistically significant inverse correlation was established between the decrease in recovery and VO_{2AT} but not VO_{2max}. We can suggest that this correlation depends on the design of run-rest intervals. Comparison of studies of repeated sprint ability is complicated because of different sprint distances, number of repetitions and durations as well as because of different modes and periods of recovery [4, 13].

The association between decrease in recovery and VO_{2max} in our study is described by high correlation coefficient ($r = -0.75$). Lack of significance ($p=0.052$) in correlation between VO_{2max} and decrease in recovery can be associated with the small number of investigated athletes. We can only suggest that increasing of number of participants could result in satisfactory significance. This suggestion is based on our previous research where we showed stable relationship between aerobic capacity and sport-specific exercise intensity [5, 6]. The performed field runs in our present study were not basketball-specific exercise. Despite this fact, to our knowledge, it is the first attempt to analyse repeated sprint ability in basketball. Repeated sprint ability is a measure of match-related physical performance in professional soccer [11]. Our results allow to suggest that tests of a similar nature could be applicable in basketball as well. In future it is necessary to elucidate the basketball-specific design for repeated sprint ability testing and to introduce this tool for altering the overload training stimulus during practices.

We conclude that the quality of recovery after repeated consecutive sprints is associated with aerobic capacity. Aerobically better prepared athletes show less decrease in recovery of heart rate between sprints. Further research is necessary to specify repeated sprint ability testing in basketball.

REFERENCES

1. Achten J., Jeukendrup A. E. (2003). Heart rate monitoring: applications and limitations. Sports Med, 33 (7), 517–38.
2. American Thoracic Society & American College of Chest Physicians (ATS/ACCP). (2003). Statement on cardiopulmonary exercise testing. Am J Respir Crit Care Med, 167 (2), 211–277.
3. Billman GE. (2002). Aerobic exercise conditioning: a nonpharmacological antiarrhythmic intervention. J Appl Physiol, 92, 446–454.
4. Bishop D., Spencer M. (2004). Determinants of repeated-sprint ability in well-trained team-sport athletes and endurance-trained athletes. J Sports Med Phys Fitness, 44(1), 1–7.
5. Gocentas A., Landõr A., Andziulis A. (2004). Dependence of intensity of specific basketball exercise from aerobic capacity. Papers on Anthropology, 13, 9–17.
6. Gocentas A., Landõr A. (2006). Dynamic sport-specific testing and aerobic capacity in top-level basketball players. Papers on Anthropology. 15, 55–63.

7. Hautala, A. J., Rankinen T., Kiviniemi A. M., Mäkikallio T.H., Huikuri H. V., Bouchard C., and Tulppo M.P. (2006). Heart rate recovery after maximal exercise is associated with acetylcholine receptor M2 (*CHRM2*) gene polymorphism. Am J Physiol Heart Circ Physiol, 291, 459–466.
8. Lauer M, Froelicher ES, Williams M, Kligfield P. (2005). Exercise testing in asymptomatic adults: a statement for professionals from the American Heart Association Council on Clinical Cardiology, Subcommittee on Exercise, Cardiac Rehabilitation, and Prevention. Circulation, 12(5), 771–6.
9. Midgley A.W., McNaughton L.R., Wilkinson M. (2006). Is there an Optimal Training Intensity for Enhancing the Maximal Oxygen Uptake of Distance Runners? Sports Med, 36, (2), 117–132.
10. Pipe AL. (2003). Preparticipation screening and the basketball player. In: McKeag G, editor. Basketball. Malden: Blackwell Science; 2003, 66–75.
11. Rampinini E, Bishop D, Marcora SM, Ferrari Bravo D, Sassi R, Impellizzeri FM. (2007). Validity of simple field tests as indicators of match-related physical performance in top-level professional soccer players. Int J Sports Med, 28(3), 228–35.
12. Seiler K.S., Kjerland G.Ø. (2006). Quantifying training intensity distribution in elite endurance athletes: is there evidence for an "optimal" distribution? Scand J Med Sci Sports, 16, 49–56.
13. Spencer M., Bishop D., Dawson B., Goodman C. (2005). Physiological and Metabolic Responses of Repeated-Sprint Activities: Specific to Field-Based Team Sports. Sports Med, 35(12), 1025–1044.
14. Wasserman K., Hansen J. E., Sue D. Y., Casaburi R., Whipp B. J. (1999). Principles of exercise testing and interpretation. 3rd edition. Philadelphia, Lippincott, Williams & Wilkins.

Address for correspondence:
Anatoli Landõr
Department of Sports Medicine and Rehabilitation University of Tartu
Puusepa 1a, Tartu, 50406, Estonia
E-mail: anatoli.landor@kliinikum.ee

Papers on Anthropology XVI, 2007, pp. 100–121

ABKHAZIA REVISITED: SECULAR CHANGES IN THE TWO GENERATIONS OF RURAL CHILDREN

E. Godina[1], *V. Batsevich*[1], *O. Yasina*[1], *A. Prudnikova*[2]

[1] Institute and Museum of Anthropology,
Moscow State University, Moscow, Russia
[2] Department of Anthropology, Biological Faculty,
Moscow State University, Moscow, Russia

ABSTRACT

388 children in the age from 6 to 17 years (183 boys and 205 girls), living in two rural districts of Abkhazia, were investigated cross-sectionally in 2004. The program included about 30 anthropometric measurements, the evaluation of the developmental stages of secondary sexual characteristics, information on the menarcheal age by status quo and retrospective methods. Information on the child's and the parents' birth place, parental occupation and education, as well as the number of children per family was collected by the questionnaire. The results were compared with the data obtained by N. Miklashevskaya and colleagues in 1979–1981 as a part of the "Abkhazian longevity" project (Miklashevskaya et al., 1982). In both generations children and adolescents from the same villages were measured: the Chlou village of the Ochamchirsky district (rayon) and the Duripsh village of the Gudautsky district (rayon). The two investigations were separated by a very dramatic set of political and socio-economic changes, which took place in the Republic of Abkhazia, including the end of the Soviet era and the 1992–1993 war between Abkhazia and Georgia. The analysis reveals that the stature, weight and the BMI of prepubertal children (8 to 11 in girls and 8 to 12 in boys) does not demonstrate any significant changes, while the modern generation of teenagers shows an increase in the above mentioned characteristics. The differences are statistically significant. This

trend is typical both for the children from different villages and for the combined sample. For body diameters (shoulder and pelvic width) there are no significant changes in the whole age range. Skinfold thickness and body fat content (kg and %) also increased in the modern generation of pubertal children. Possible explanations of the results are discussed.

Key words: auxology, human ecology, somatic development, secular changes, Abkhazian children

INTRODUCTION

The studies of secular changes, in spite of the huge body of works already published, still remain of considerable interest both in Russia and abroad. This is understandable because the results of interpopulation comparisons in time for different countries give different results depending on local environmental conditions.

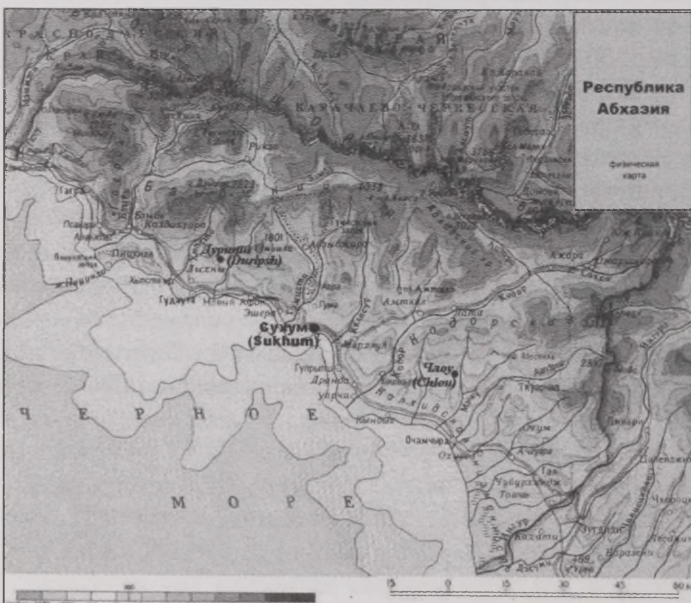
Thus, in many European countries and in the USA there is a strong tendency towards increasing weight and obesity in recent years (Johnston, 2002; Padez et al., 2004) [6,12]. At the same time in the USA the decrease of stature was stated, quite contrary to what is observed for most countries of Europe (Komlos, Baur, 2004) [7]. In Russia most recent secular changes for some populations show the tendency towards linearity, the stabilization of growth in length, and later ages of sexual maturation (Godina, Yampolskaya, 2004) [2].

Though there are many theories and hypothesis explaining secular changes, the most proved one connects them with socioeconomic changes in the society. In this case it is interesting to follow the changes in growth patterns in some areas of the former Soviet Union which are going on parallel to socioeconomic and political changes.

MATERIALS AND METHODS

The data for the present study were collected in the Caucasian Republic of Abkhazia. Abkhazia is a rebellious part of Georgia. There was, and still is a lot of animosity and political disagreement between these two countries, which in 1992–1993 expressed itself in a severe armed conflict known as the Georgian-Abkhazian War. The results of this war are still quite visible across Abkhazia.

Altogether 388 children in the age from 6 to 17 years old were examined cross-sectionally in 2004. 183 boys and 205 girls were observed in two rural areas of Abkhazia – the village of Chlou, the Ochamchirsky district (rayon) and the village of Duripsh, the Gudautsky district (rayon) (Picture 1). These villages have been chosen mainly because 25 years ago their population was investigated by N. Miklashevskaya and colleagues as a part of the "Abkhazian longevity" project (Miklashevskaya et al., 1982; Miklashevskaya, 1987) [10,9]. Thus, we may say that two generations of Abkhazian children and adolescents have been examined.



Picture 1. Map of the Republic of Abkhazia

In each village practically all the children were measured. It is reported that compared to the 1980's the number of children decreased due to the decreasing birth rate (Shamba, 2004) [13].

Table 1 presents the data on the number of the children investigated in two rural districts of Abkhazia.

Table 1. Investigated children by age, sex and geographical area

Age, years	Number of children			
	Ochamchirsky district (Chlou)		Gudautsky district (Duripsh)	
	Boys	Girls	Boys	Girls
6	2	5	0	0
7	10	9	2	4
8	10	10	9	10
9	13	17	6	7
10	11	13	10	9
11	9	7	6	7
12	13	5	6	10
13	15	11	8	12
14	7	13	7	9
15	16	13	8	10
16	5	12	4	6
17	3	4	3	2
Total	114	119	69	86

The children were measured during or immediately after school-hours; the age group consisted of the children whose age falls within the interval ± 6 months of the whole year (e.g., 7-year-olds: from 6.5 to 7.49, etc.).

A number of anthropometric measurements were taken according to standard techniques (Bunak, 1941; Weiner and Lourie, 1981) [1,15]. Subjects were measured bare-feet, wearing only underwear. Weight was taken using a battery-operated digital weighing scale (precision 100g).

Height and leg length (sum of the heights of iliospinale and symphysion points divided by two) were measured using an anthropometer (1mm precision). Body diameters (biiliac, bicristal, chest width and chest depth) were measured using a spreading caliper (1 mm precision). Chest, waist, arm, thigh and calf circumferences were measured using a plastic measuring tape (5 mm precision). Chest circumference was measured at the union of the 3^{rd} and 4^{th} sternebrae. Subcutaneous skinfolds (subscapular, biceps, triceps, abdomen, thigh and calf) were measured using a skinfold caliper, "Best modification" (1 mm precision). The body mass index (BMI) of the studied subjects was calculated as weight (kg) divided by height $(m)^2$. Chest index was calculated as chest depth divided by chest width, %. Body proportions were calculated as corpus length divided by leg length, %.

Beside anthropometric measurements, the stages of secondary sexual characteristics were assessed, the age at menarche was assessed by the status quo method.

Statistical analysis was performed with Statistica 6.0 software. The significance of differences was assessed by the Student's t-test and one-way ANOVA (the Sheffe test).

RESULTS

Patterns of growth in the observed group of rural Abkhazian schoolchildren

As general characteristics of this group, it may be said that Abkhazian schoolchildren compared to Moscow ones are much shorter and lighter (Godina et al., 2003). [3]

Growth curves for stature and weight of Abkhazian rural children are given in Figures 1 and 2.

Thus, for 7-year-old Abkhazian boys the average stature is 115.93 cm, for 17-year-olds – 169.22 cm. For Moscow boys the corresponding values are 124.06 and 174.87 cm. For girls the corresponding values are as follows: Abkhazian girls 116.98 and 158.64 cm; Moscow girls 124.33 and 164.43 cm. The difference between boys' and girls' height (sexual dimorphism) is approximately the same.

For the body weight Moscow children have also much higher values. 7-year-old Abkhazian boys have the average weight of 21.47 kg, while 17-year-olds have 60.72 kilos. Moscow boys for comparison have 24.91 and 65.96 kilos. For girls the corresponding figures are: 20.30 and 51.0 kg in Abkhazia; 24.80 and 56.33 kg in Moscow.

The comparison between Moscow and Abkhazian children can give some idea about the source of ethnic and socio-economic variations in growth patterns.

Comparison of growth parameters in the children of the Gudautsky and the Ochamchirsky region.

To compare the growth patterns in children and adolescents of two rural areas is of interest, first of all because the differences between these two groups have been found by Miklashevskaya et al. already in the 1980's. It was shown that the schoolchildren of Ochamchirsky district were more retarded than their counterparts in the Gudautsky district (Miklashevskaya et al., 1982; Miklashevskaya, 1987) [10,9]. The authors revealed the retardation of growth in many parameters among the former, that is the children of Chlou and other villages, and explained it by the fact that the Gudautsky group (Duripsh and other villages) were more urbanized and the longevity index was lower there than among the Ochamchirsky population. The Gudautsky region was more developed economically and the Duripsh village was one of the most prosperous in the former Abkhazia (Miklashevskaya et al., 1982; Miklashevskaya, 1987) [10,9].

The quarter of a century that passed since this historical investigation brought a lot of changes into the area. In the early 1990's the state of the Soviet Union collapsed, together with the centralized power, and the Republic of Abkhazia declared its independence from Georgia. What has followed is well known. In 1992 the war between Georgia and Abkhazia broke out bringing tragic and devastating results to both sides, particularly to Abkhazians. Abkhazia – the former jewel of the Soviet Union, the place of tourism and resort of millions of people from all over of the Soviet Union, became desolated and destroyed. Many breathtaking places –villas, resort houses, hotels, and tourist objects, still lie in ruins. All the communications, means of transportation (railroads, etc) are completely destroyed (see Picture 2 and 3).

Picture 2. Former Intourist Hotel "Abkhazia" in the downtown Sukhum – capital of Abkhazia. *Source*: courtesy of. Dr. Irena Khomyakova.

Picture 3. Railroad to nowhere (former main coastal railroad) – no trains, only goats. *Source*: courtesy of Dr. Irena Khomyakova.

The population of Gudautsky region during the war remained in more favorable conditions than compared to the other area. This can be seen in the growth curves of bodily parameters, so that the previously stated tendencies have been intensified reflecting ("mirroring") the processes that were taking place in the society.

Though there are no differences between the two groups in body height but in body weight and the subcutaneous fat layer the Duripsh children, girls in particular, are ahead of their coevals from Chlou. It should be mentioned, however, that none of these differences were significant. (Figures 3–6)

Secular changes in growth parameters and sexual maturation indices.

The focal point of this study is the analysis of secular changes between the two generations of rural Abkhazian children. (Figures 7 and 8)

As it was already said, in 2004, 388 children from 6 to 17 were investigated in the villages of Chlou, the Ochamchirsky district, and Duripsh, the Gudautsky district. In 1979 the number of children examined in the Ochamchirsky district totaled to 645 individuals,, and those of the Gudautsky region examined in 1981 equaled to 662 (Miklashevskaya et al., 1982; Miklashevskaya, 1987) [10,9].

The Gudautsky district was more prosperous and economically developed under the Soviet regime, but after the 1992–1993 war the differences became even more evident. The consequences of the war were more devastating for the population of the Ochamchirsky district (the Chlou village). This district was located in the area of direct military operations, while the Gudautsky district was not in the field of actions. Also, the Ochamchirsky district is more remote geographically and located in the mountain area (see Picture 1). With all kinds of roads, including the motorways, now being in a very bad condition, the economic rebuilding of this region goes much slower than in the coastal areas (the Gudautsky district).

To compare the 2004 data with the ones in literature, the averages for different villages investigated in 1979–1981 under N. Miklashevskaya's guidance (Miklashevskaya et al., 1982) [10] were combined with a simple procedure of weighted statistics:

$$\bar{\bar{X}} = \frac{N_1\bar{X}_1 + N_2\bar{X}_2}{N_1 + N_2},$$

where $\bar{\bar{X}}$ – the value of weighted average, N_1 – the number of children investigated in Chlou in 1979 г.; N_2 – the number of children investigated in Duripsh in 1981; $\bar{X}_1$- average value for a parameter in Chlou children in 1979 г.; $\bar{X}_2$- average value for a parameter in Duripsh children in 1981.

The analysis of data for height, weight and the BMI shows that the average values for these traits increase in modern pubertal Abkhazian children, while in prepubertal children they remain practically the same as in the previous generation (Figures 9–12).

Thus, modern boys of 8 and 12 years have almost the same values of stature as their counterparts in the 1980's: 121.76 и 121.56 cm correspondingly for 8-year-olds; 141.79 and 140.83 cm for 12-year-olds. During puberty, between 13 and 15 years, the differences became more pronounced and statistically significant. The average stature of adolescent boys investigated in 2004 as compared to their coevals from the previous generation equals 148.61 v 145.22 cm for 13-year-olds, and 161.39 v 157.15 см for 15-year-olds.

The same is true for other body dimensions. (Figures 13–18). Significance of differences (the results of t-test) is shown in Table 2.

Thus, it can be seen that with some exceptions, which may be explained by a small sample size, there is almost an absence of differences in the prepubertal children of two generations and the appearance of such differences with the beginning of puberty, starting from 12 years in girls and 13 years in boys. The same trend is observed if the data for separate villages are compared, particularly for the Duripsh village.

Table 2. Significance of differences (t-test) in the growth parameters of Abkhazian children examined in 1980's and 2004.

<table>
<tr><th>Age, years</th><th>Stature</th><th>Body weight</th></tr>
<tr><td colspan="3">Boys</td></tr>
<tr><td>8</td><td>ns</td><td rowspan="5">ns</td></tr>
<tr><td>9</td><td>0.0189</td></tr>
<tr><td>10</td><td rowspan="3">ns</td></tr>
<tr><td>11</td></tr>
<tr><td>12</td></tr>
<tr><td>13</td><td>0.0036</td><td>0.0000</td></tr>
<tr><td>14</td><td>0.0086</td><td>0.0016</td></tr>
<tr><td>15</td><td>0.0161</td><td>ns</td></tr>
<tr><td colspan="3">Girls</td></tr>
<tr><td>8</td><td>0.0204</td><td>0.0040</td></tr>
<tr><td>9</td><td>0.0031</td><td rowspan="3">ns</td></tr>
<tr><td>10</td><td rowspan="2">ns</td></tr>
<tr><td>11</td></tr>
<tr><td>12</td><td>0.0484</td><td>0.0047</td></tr>
<tr><td>13</td><td>0.0003</td><td>0.0002</td></tr>
<tr><td>14</td><td>0.0095</td><td>0.0069</td></tr>
<tr><td>15</td><td>ns</td><td>0.0162</td></tr>
<tr><td>16</td><td>0.0225</td><td>0.0415</td></tr>
</table>

Sexual maturation

The mean age of development of secondary sexual characteristics for the Abkhazian girls of the modern generation equals 10 years 3 month for breast development, 11 years 10 month for pubic hair, 11 years 0 month for axillary hair and 13 years 4 months for the age of menarche, the girls of Duripsh being earlier than the girls of Chlou by 3 months.

These figures are lower than the corresponding values for the girls of the previous generation. The mean age of breast development in the 1980's was 10 years 5 month, pubic hair 11 years 6 month, axillary hair 11 years 9 month, and age of menarche 14 years 4 month for Chlou and 14 year 0 month for Duripsh.

Thus, it may be said that the process of sexual maturation is more advanced in the girls of the present generation.

DISCUSSION

The study shows that in the modern Abkhazian population there are some changes in the somatic development of the young generation, which are expressed differently for different ontogenetic stages. While in the prepubertal stage of development there are no differences between the growth parameters of the children investigated in the 1980's and 2005, in the stage of puberty such differences do appear. At the same time the process of sexual maturation is also more accelerated in the present-day Abkhazian teenagers.

Two possible explanations of the obtained results might be given. There are some studies showing that in the stressful situations the processes of growth and development do accelerate both at the individual (Hulanicka, 1999; Hulanicka, Gronkiewics, Koniarek, 2001) [4,5], and the population level (Nikityuk, 1989) [11]. Because puberty is known as one of the ecosensitive periods, it may be suggested that the stressful influences of political and economic changes became more expressed at this particular period of ontogenesis.

There might be yet another interpretation of these results. The 12–17-year-olds investigated in 2004 were born in 1987–1992, that is before the war. Their early childhood, the most important period of human ontogenesis, occurred in a relatively safe and peaceful period, when Abkhazia continued to be a rich and prosperous area, following traditional values. The researchers who worked there at that time noted balanced diet, moderate daily activity, respectful attitudes towards the elderly and the care for children. All these traits contributed to the phenomenon of "Abkhazian longevity" (Kozlov, 1987) [8]. It is possible that growth parameters of children born in those years continued to increase and the terms of puberty became still lower than in the previous generation.

As for the 6–11-year-olds observed in 2004, they were born in 1993–1999, that is during and after the war. Their infancy and early childhood occurred in the hardships of military actions, fear, migrations, economic devastation, food shortages and even hunger, which reflected in the stunting of growth. This viewpoint is supported by the fact that among the two rural areas investigated in 2004 the children of Chlou, that were in the zone of direct military actions, are more retarded and smaller in the growth characteristics, compared to the other group.

We understand that the data on the modern generation of Abkhazian children are limited in number and further investigations are needed to prove the revealed tendencies.

ACKNOWLEDGEMENTS

The authors express their deep gratitude to Dr. Vassily Sh. Avidzba, Director of the Abkhazian Institute of Humanities Research, and to Dr. Petr K. Kvitsiniya, Senior researcher of the same Institute, for their help in organization of this study; to the school principals and teachers of the villages of Chlou and Duripsh, and last but not least – to all the Abkhazian children who participated in this study.

The research was supported by RGNF (grants ## 05-01-01-069-a and № 04-06-00260-a) and RFBR (grants # # № 05-06-80390-a, 05-06-80907-ЯФ_a, 07-06-00410-a).

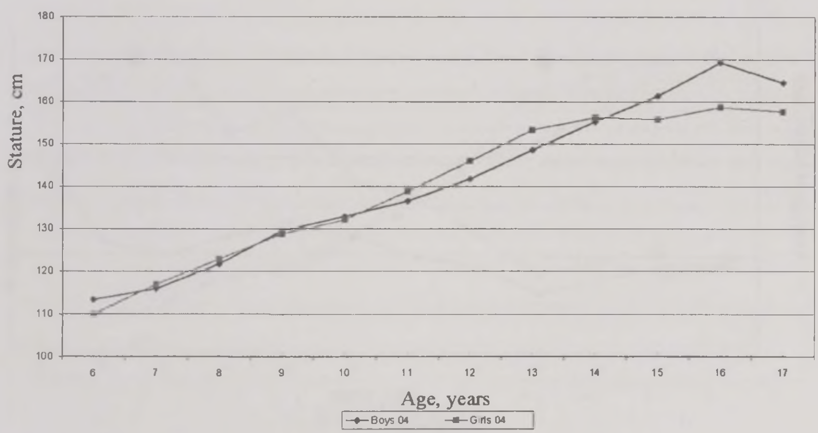


Figure 1. Growth curves of stature in Abkhazian boys and girls (combined data, 2004)

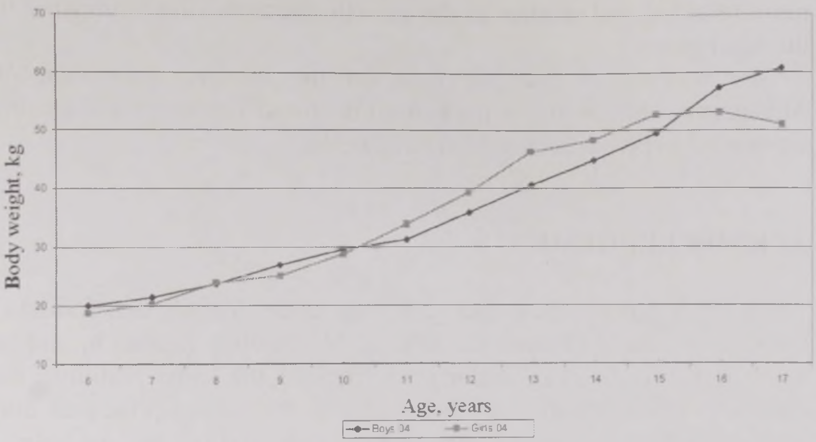


Figure 2. Growth curves of body weight in Abkhazian boys and girls (combined data, 2004)

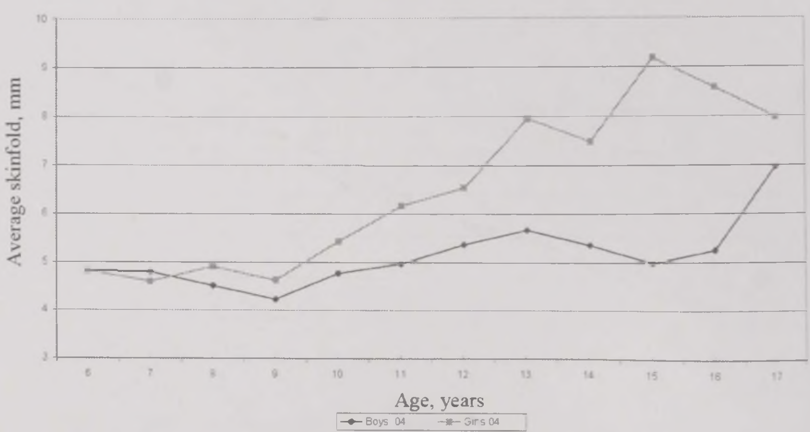


Figure 3. Growth curves of an average skinfold in Abkhazian boys and girls (combined data, 2004)

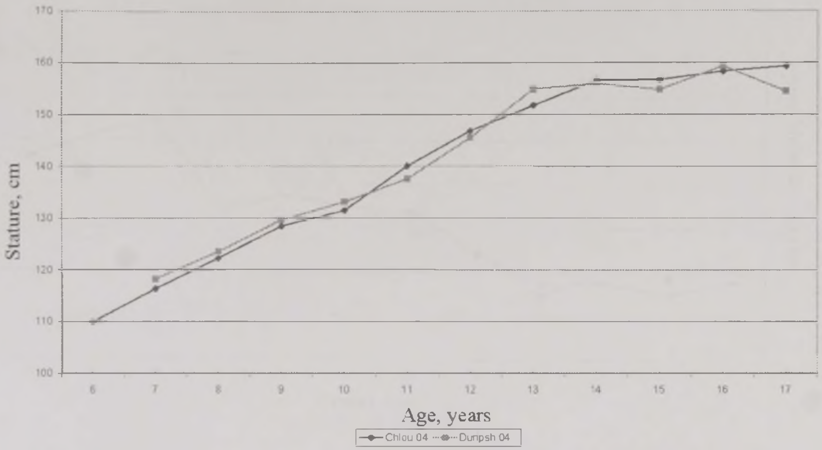


Figure 4. Growth curves of stature in Abkhazian girls of Chlou and Duripsh villages (2004)

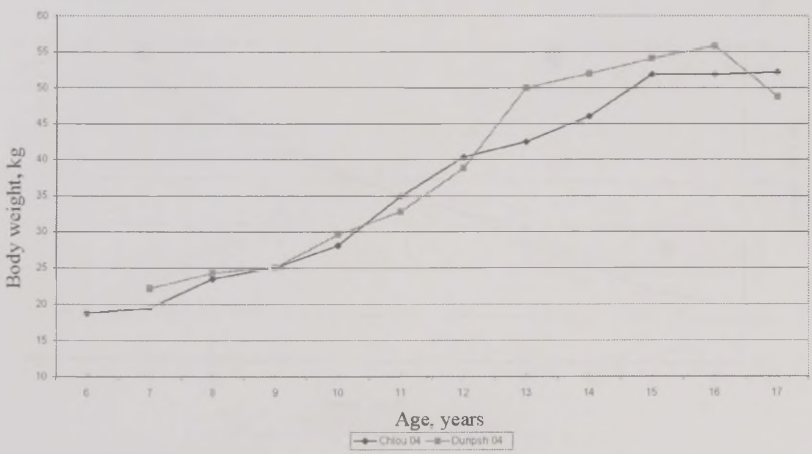


Figure 5. Growth curves of body weight in Abkhazian girls of Chlou and Duripsh villages (2004)

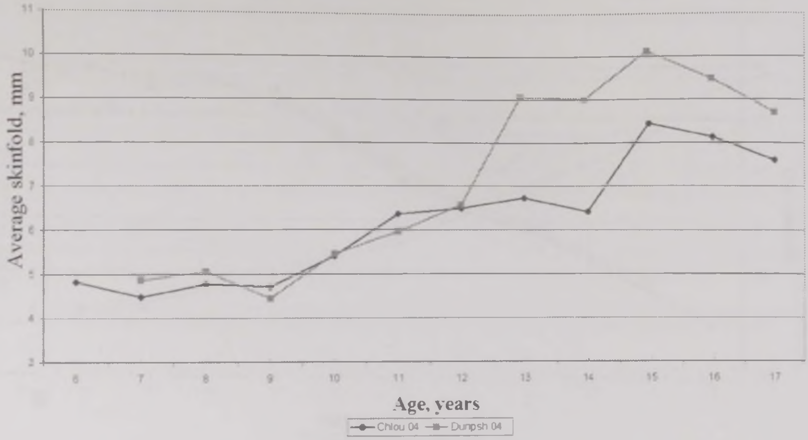


Figure 6. Growth curves of an average skinfolds in Abkhazian girls of Chlou and Duripsh villages (2004)

Figure 7. Growth curves of stature in Abkhazian boys of two generations

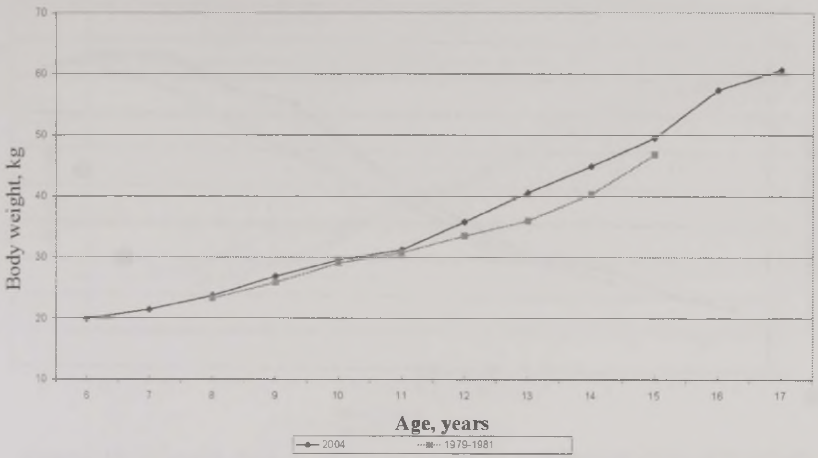


Figure 8. Growth curves of body weight in Abkhazian boys of two generations

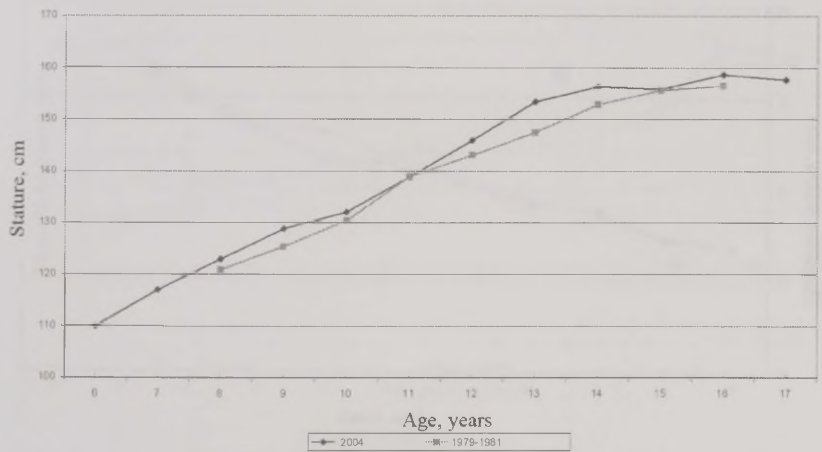


Figure 9. Growth curves of stature in Abkhazian girls of two generations

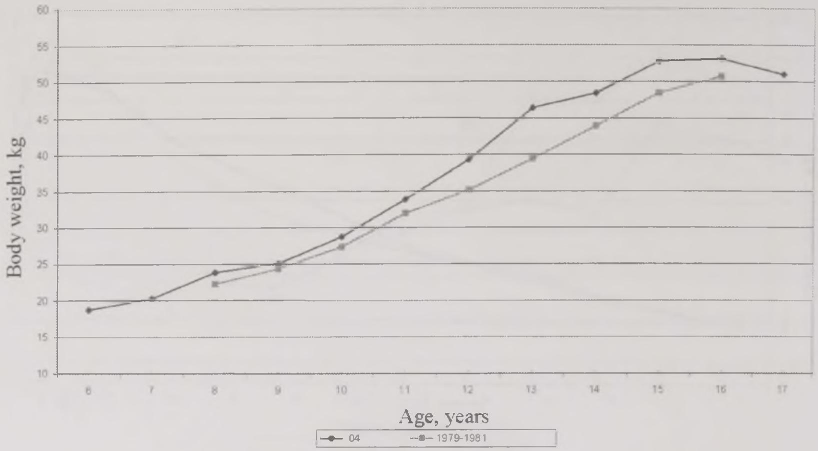


Figure 10. Growth curves of body weight in Abkhazian girls of two generations

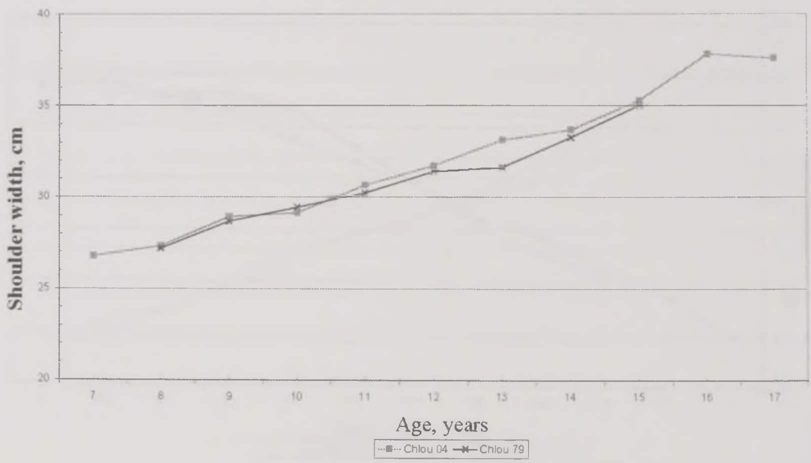


Figure 11. Growth curves of shoulder width in Abkhazian boys of Chlou village in two generations

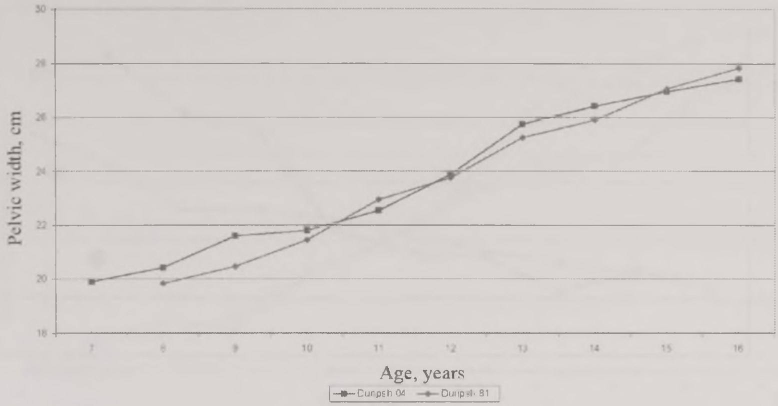


Figure 12. Growth curves of pelvic width in Abkhazian girls of Duripsh village in two generations

Figure 13. Growth curves of subscapular skinfold in Abkhazian girls of Chlou village in two generations

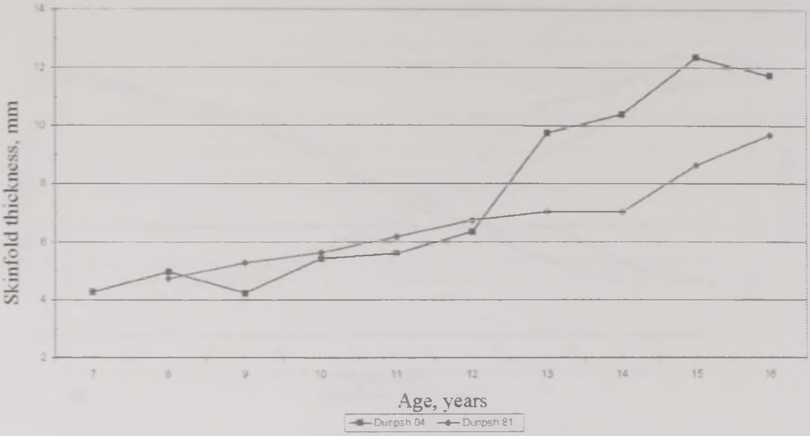


Figure 14. Growth curves of subscapular skinfold in Abkhazian girls of Duripsh village in two generations

Figure 15. Growth curves of arm circumference in Abkhazian girls of Chlou village in two generations

Figure 16. Growth curves of arm circumference in Abkhazian girls of Duripsh village in two generations

Figure 16. Growth curves of arm circumference in Abkhazian girls of Duripsh village in two generations

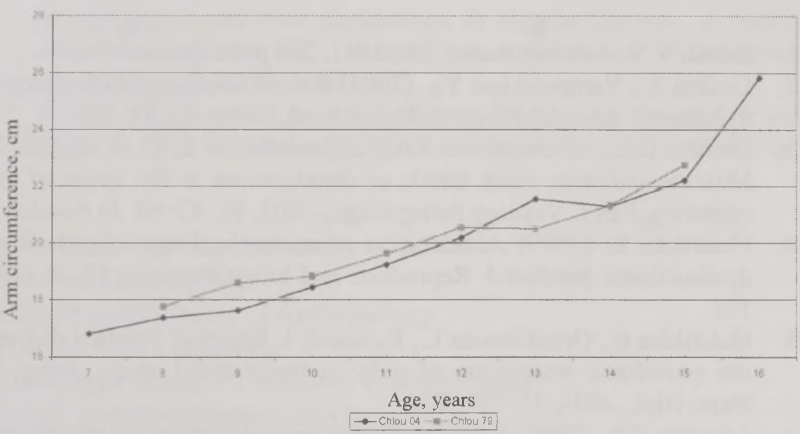


Figure 17. Growth curves of arm circumference in Abkhazian boys of Chlou village in two generations

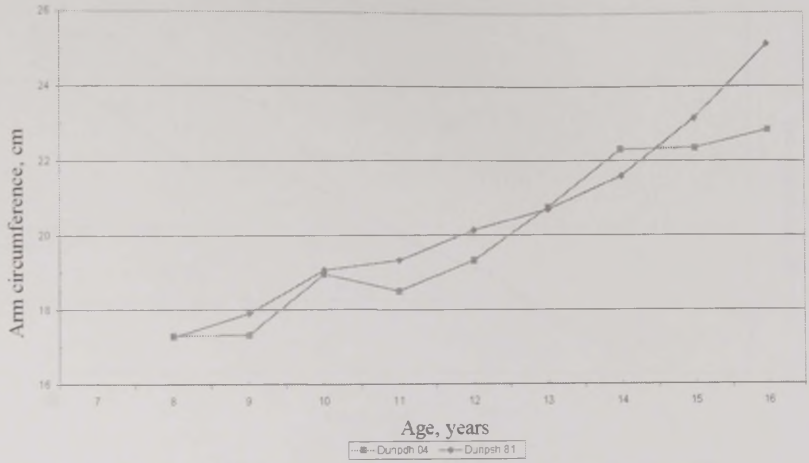


Figure 18. Growth curves of arm circumference in Abkhazian boys of Duripsh village in two generations

REFERENCES

1. Bunak V.V. Anthropometry. M., 1941. 368 p. *In Russia*
2. Godina E., Yampolskaya Yu. (2004) Recent secular growth changes in Moscow schoolchildren. Anthrop. Kozl., 2004, 45, 51–57.
3. Godina E.Z., Khomyakova I.A., Zadorozhnaya L.V. et al. (2003) Moscow children: main trends of development at the verge of the centuries. Part I. Voprosy antropologii, 2003, 91, 42–60. *In Russian*
4. Hulanicka B. (1999) Acceleration of menarcheal age of girls from dysfunctional families J. Reproduct. and Infant Psychol., 17, 2, 119–132.
5. Hulanicka B., Gronkiewicz L., Koniarek J. Effect of Familial distress om growthand maturation of girls: A longitudinal study. Amer. J. Hum. Biol., 2001, 13, 771–776.
6. Johnston F.E. (2002) Social and economic influences on growth and secular trends. In Human Growth and Development, Ed. N.Cameron. Elsevier Science, 197–212.
7. Komlos J., Baur M. (2004) From the tallest to (one of) the fattest: the enigmatic fate of the American population in the 20th century. Economics and Human Biology, 2, 57–74.

8. Kozlov V.I. (1987) Ed. Abkhazian Longevity. M. Nauka. 1987, 294 p. *In Russian.*
9. Miklashevskaya N.N. (1987) Growth and development of Abkhazian children and adolescents. In Abkhazian Longevity. M. Nauka, 1987, 100–107. *In Russian*
10. Miklashevskaya N.N., Solovyeva V.S., Guilyarova O.A., and Peskina M.Yu. (1982) Somatic development of children and adolescents in Abkhazian population. In Phenomenon of Longevity. Anthropo-ethnological Object of Study. M. Nauka, 1982, 160–169. *In Russian*
11. Nikityuk B.A. (1989) Aceleration of development (causes mechanisms, characteristics, and effects). In Growth and Development. Ed. A.I.Shnirelman., 3, 1989, M.:VINITI, 5–76. *In Russian*
12. Padez C., Fernandez T., Mourao I., Moreira P., Rosado V. (2004) Prevalence of overweight and obesity in 7–9-year-old Portuguese children: Trends in body mass index from 1970 to 2002. Am. J. Hum. Biol., 16, 670–678.
13. Shamba R.P.(2004) Dynamics and age-sex structure of rural population of Gudautsky rayon. In Caucasus: history, culture, tradition and language. Sukhum. Publishing House GPP, 2004, 352–357. *In Russian*
14. Tanner J.M. (1986) Growth as a mirror of the condition of society: Secular trends and class distinctions. In Human Growth. A Multidisciplinary review. Ed. A.Demirjan. London and Philadelphia. Taylor&Francis, 1986, 3–34.
15. Weiner J.S., Lourie J.A. (1969) Human Biology. A Guide to Field Methods. Oxford. Edinburgh. Blackwell Scientific Publ. 1969. 578 p.

Address for correspondence:
Professor Elena Godina
Institute and Museum of Anthropology
Moscow State University
Mokhovaya Street, 11, Moscow 125009 Russia
E-mail: godina@antropos.msu.ru

Papers on Anthropology XVI, 2007, pp. 122–131

MILITARY STATURE VARIATION DURING THE 19TH CENTURY: NAPOLEONIC VERSUS GERMAN SOLDIERS OF WORLD WAR[1]

Rimantas Jankauskas, Žydrūnė Palubeckaitė-Miliauskienė, Arūnas Barkus, Agnius Urbanavičius

Department of Anatomy, Histology and Anthropology, Vilnius University, Čiurlionio 21, Vilnius LT- 03101, Lithuania

ABSTRACT

As Europe experienced industrial transition in the 19th century, it had a profound impact on the standards of living and it was reflected in the marked changes of demographic indices. One could expect certain reflections in the stature of military conscripts as well. Well-documented skeletal samples could serve as an independent source to validate this hypothesis. The aim of this study was to compare the stature variation of soldiers originating mostly from Western and Central Europe who died due to various causes in Lithuania in 1812 and in 1915.

The first skeletal sample was from the mass grave excavated in Vilnius in 2002; these were the soldiers of the Napoleonic Great Army which died in December 1812 during disastrous retreat from Moscow. The Great Army consisted of recruits from almost all Western and Central Europe. The second sample consisted of the remains of the German soldiers who died in the field hospital in 1915–1917 and were exhumed for reburial in 2005.

Sex and age estimation was performed using conventional morphological criteria. The stature of individuals was estimated according to the measurements of long bones (humerus and femur) using three methods – Trotter and Gleser (1958), Olivier et al. (1978) and Nainys (1972). In total, sample 1 consisted of 193, sample 2–770 male skeletons.

No statistically significant differences between the two samples were found: the estimated stature (and min.-max. range) of the total sample 1 was, according to the three above listed methods, 171.6 (156.6–185.2), 171.0 (155.3–183.2) and 169.1 (155.3–181.5) cm, sample 2 – 171.4 (155.4–188.8), 169.5 (153.3–187.4), and 168.3 (153.8–185.7) cm, correspondingly. The comparison of the stature differences between age groups in both samples revealed only statistically insignificant tendencies (more pronounced in the Napoleonic sample) – the youngest (up to 20 years) and the oldest (over 40 years) tended to be taller. If methodological errors are excluded, we conclude that such an absence of stature differences between the males born at the end of the 18^{th} and the 19^{th} century suggests the absence of the significant impact of socioeconomic changes during the century. Minor age-related stature fluctuations probably reflect selective recruitment (conscription of only the most fit teenagers) and social differences (officers originating from higher social strata in the oldest group).

Key words: Stature, military, Napoleonic wars, 1st World War

INTRODUCTION

Investigations of human growth and development, as a rule, are seeking one ultimate goal – a better understanding of growth regularities and deeper knowledge of the factors exerting influence on the complex process of human growth and its ultimate result – the adult stature [2, 25]. Final body height is achieved as a result of a combination of genetic and environmental factors. In modern Western societies, about 20% of variation in body height is due to environmental variation [23]. In poorer and more stressful environments, when insufficient nutrition and diseases, especially infectious, played a more significant role [6, 7, 13], this proportion was probably larger, with a lower heritability of body height as well as larger socioeconomic body height differences. The significance of the living standards and the subsequent childhood environment improvement is seen in body height increase during the 20th century. The impact of socioeconomic factors is a very complex phenomenon, but it is almost universally established that the growth and maturation of the children of lower classes is delayed, and this delay was more marked in the past [17]. Some investigators indicate that this phenomenon of acceleration was more marked among males [5].

Notwithstanding numerous studies, the precise weight of genome-environment interactions resulting stature in particular environments remains unclear. However, the possibilities of experimental testing of hypotheses concerning human growth regularities are limited. Studies of the past populations can bring more light – the history of humanity has already created such conditions that cannot be replicated by any experiment. On the other hand, a better understanding of the inter-populational and diachronic differences of human growth in the past enhances our knowledge of recent anthropometric data [7, 11]. Series of studies have been conducted on historical sources [1, 3, 14, 24] and on skeletal populations [8, 9, 10, 16, 30].

As Europe experienced industrial revolution and subsequent demographic transition in the 19th century [4], it had a profound impact on the standards of living and it was reflected in the marked changes of demographic indices, one could expect certain reflections in the stature of military conscripts as well. Well-documented skeletal samples could serve as an independent source to validate this hypothesis. The aim of this study was to compare the stature variation of soldiers originating mostly from Western and Central Europe who died due to various causes in Lithuania in 1812 and in 1915–1917.

MATERIALS AND METHODS

The first skeletal sample was from the mass grave excavated in Vilnius in 2002; these were the soldiers of the Napoleonic Great Army who died in December 1812 during disastrous retreat from Moscow. The Great Army consisted of recruits from almost all Western and Central Europe [22]. This mass grave contained the estimated minimal number of 3,269 individuals.

The second sample consisted of the remains of the German soldiers who died in the field hospital in Panevėžys (Northern Lithuania). In the summer of 2005, exhumation and identification before subsequent reburial was performed. Historical data indicate that in the autumn of 1915 the building of local gymnasium was transformed into a military hospital, and casualities were buried in its garden. The hospital functioned until the German army withdrawal in the winter of 1918. Archaeological finds include ID tags, rings with names engraved on them, coins, daggers and buttons, crucifixes, eagles that used to adorn the soldiers' helmets, medical instruments. In total, the remains of 830 German soldiers have been discovered. Most of the remains belong to males up to 30 years of age. There were, however, burials of five females.

Sex and age estimation was performed using conventional morphological criteria [29]. The stature of individuals was estimated according to the measurements of long bones (humerus and femur) using three methods – Trotter and Gleser [26], Olivier et al. (1978) [19] and Nainys (1972) [18].

The data of only male individuals was taken for comparison. Both samples were subdivided into the following age groups: up to 20 years; 20–25 years; 25–30 years; 30–40 years; over 40 years. Statistical analysis was performed using SPSS 10.0 statistical package. Univariate data for each age group and total samples were calculated; for intersample comparisons, ANOVA procedure was used.

RESULTS AND DISCUSSION

The summary of the results of the estimated stature according to all the three methods is presented in Tables 1, 2 and 3. No statistically significant differences between the two samples were found: the estimated stature (and min.–max. range) of the total sample of Napoleonic soldiers was, according to Trotter-Gleser, 171.6 (156.6–185.2), according to Olivier – 171.0 (155.3–183.2) and according to Nainys – 169.1 (155.3–181.5) cm, the sample of German soldiers, correspondingly – 171.4 (155.4–188.8), 169.5 (153.3–187.4), and 168.3 (153.8–185.7) cm, correspondingly. Only the data of the Nainys method revealed statistically significant ($p < 0.05$) difference – Napoleonic soldiers were on average 0.8 cm taller. The comparison of the stature differences between age groups in both samples revealed only statistically insignificant tendencies (more pronounced in the Napoleonic sample) – the youngest (up to 20 years) and the oldest (over 40 years) tended to be taller. For the Napoleonic case, this could be a reflection of conscription rules: males below 154 cm were considered not suitable for the military service; according to the rules of that period, the regular age for conscription was the age of 20–25 years (younger ones were considered still physically immature and having not attained their final height, older than 30 already started to have joint problems) – this would mean that only the most fit teenagers could be enlisted. Later on, recruits were distributed to regiments according to their stature, too: the tallest (over 178 cm) were taken for heavy cavalry, 173–178 cm – young Imperial Guards, 169–173 cm – artillery, 165–169 cm – light cavalry, below 169 cm – infantry and other troops (Th.Vette, personal comm.). The importance of the selection for military service in the Napoleonic period can be illustrated by the fact that the average height of the recruits of this age bracket born at the end of the 18^{th} century was 163.6 cm [27]. The oldest ones could be the officers, coming from the higher social strata.

Regretfully, the stature standards for conscription to the German army were unknown to us.

The data on the military stature from other countries indicate that, for example, in the 19^{th} century Estonia, the average stature of conscripts increased from 164.5 to 168.9 cm [1]. In Sweden, notwithstanding the significant increase of nutrition quality (introduction of potatoes), sanitary measures (smallpox vaccination) that resulted in the significant decrease of child mortality [21], there was a general tendency for the stature increase at least in the beginning of the century, but this was not uniform and prone to significant fluctuations [20]. One of the results of anthropometric research was the elucidation of an impact of long-term and short-term economic cycles during the 19^{th} century which was reflected on American and European heights, starting with a moderate increase in the average height at the beginning of the 19th century, followed by a decrease in the middle of the century, while at the end of the century, there was an increase up to the level higher than in the first half of the century [28]. For example, Komlos (1987) [15] reports an average decline of 1.4 cm for the West Point cadets between 1820 and 1860.

Summing up, if methodological errors are excluded, we conclude that such an absence of stature differences between the males born at the end of the 18^{th} (Napoleonic soldiers) and the 19^{th} century (German soldiers) could suggest the absence of the significant impact of socio-economic changes during the century, or the result of long-term fluctuation – the data presented in this paper simply did not embrace the stature decrease in the middle of the 19th century, described by other authors. Besides, we cannot completely exclude differential survival of Napoleonic soldiers: those who died in Vilnius in December 1812 had already survived a long disastrous march back from Moscow. Minor age-related stature fluctuations probably reflect selective recruitment (conscription of only the most fit teenagers) and social differences (officers originating from higher social strata in the oldest group).

Table 1. Reconstructed stature (according to Trotter-Gleser) in two military samples (in cm; N – sample size; M – mean; S – standard deviation; min.–max. – range of variation)

Age group (years)	Napoleonic soldiers				German soldiers				Difference
	N	M	S	Min.–Max.	N	M	S	Min.–Max.	
≤ 20	18	172.8	4.8	164.7–185.2	43	172.2	5.0	161.0–181.1	> 0.05
20–25	71	170.8	4.6	158.8–182.3	268	171.4	5.5	156.9–187.4	> 0.05
25–30	46	171.8	5.5	156.6–183.0	248	171.2	4.9	155.4–188.8	> 0.05
30–40	32	172.2	5.6	159.1–181.4	193	171.4	4.8	155.9–183.2	> 0.05
≥ 40	9	174.1	4.1	170.2–181.6	18	171.6	7.0	158.1–188.3	> 0.05
Total*	181	171.6	5.1	156.6–185.2	770	171.4	5.1	155.4–188.8	> 0.05

*including individuals with undetermined age group

Table 2. Reconstructed stature (according to Olivier) in two military samples (in cm; N – sample size; M – mean; S – standard deviation; min.–max. – range of variation)

Age group (years)	Napoleonic soldiers				German soldiers				Difference
	N	M	S	Min.–Max.	N	M	S	Min.–Max.	
≤ 20	18	170.8	5.1	161.2–183.2	43	170.2	5.2	158.0–178.4	> 0.05
20–25	71	169.2	4.6	157.5–181.4	268	169.4	5.6	154.6–185.9	> 0.05
25–30	46	170.4	5.5	155.3–181.9	248	169.3	5.0	153.9–187.4	> 0.05
30–40	32	170.4	5.8	155.5–179.8	193	169.5	4.9	153.3–181.6	> 0.05
≥ 40	9	172.4	4.2	167.6–180.6	18	169.9	7.2	155.9–181.8	> 0.05
Total*	182	170.0	5.1	155.3–183.2	770	169.5	5.3	153.3–187.4	> 0.05

*including individuals with undetermined age group

Table 3. Reconstructed stature (according to Nainys) in two military samples (in cm; N – sample size; M – mean; S – standard deviation; min.–max. – range of variation)

Age group (years)	Napoleonic soldiers				German soldiers				Difference
	N	M	S	Min.–Max.	N	M	S	Min.–Max.	
≤ 20	18	170.8	5.1	161.2–183.2	43	168.9	4.9	157.0–177.6	> 0.05
20–25	71	169.2	4.6	157.5–181.4	268	168.2	5.1	154.6–182.8	> 0.05
25–30	46	170.4	5.5	155.3–181.9	248	168.1	4.5	154.9–185.7	> 0.05
30–40	32	170.4	5.8	155.5–179.8	193	168.3	4.5	153.8–179.1	> 0.05
≥ 40	9	172.4	4.2	167.6–180.6	18	168.9	6.8	155.9–181.1	> 0.05
Total*	193	169.1	4.7	155.3–181.5	770	168.3	4.8	153.8–185.7	= 0.034

*including individuals with undetermined age group

REFERENCES

1. Aarma L. (1987) Põhja-Eesti meeste pikkus. Võrdlev ajaloolis-statistiline uurimus Eestimaa kumermangust aastail 1811–1874 nekrutiks värvatute andmeil. Tallinn. Eesti Raamat. 191 p.
2. Bogin B. (1999) Patterns of human growth. Cambridge. Cambridge University Press.
3. Brabec M. (2005) Analysis of periodic fluctuations of the height of Swedish soldiers in 18th and 19th centuries. Economics and Human Biology, 3, 1–16.
4. Caldwell J.C., Caldwell B.K., Caldwell P., McDonald P.F., Schindlmayr Th. (2006). Demographic Transition Theory. Dordrecht. The Netherlands. Springer.
5. Cole T.J. (2003) The secular trend in human physical growth: a biological view. Economics and Human Biology 1, 161–168.
6. Crooks D.L. (1994) Relationship between environment and growth for Mopan children in Belize. Am. J. Hum. Biol., 6, 571–584.
7. Eveleth P.B., Tanner J.M. (1990) Worldwide variation in human growth, 2nd ed. Cambridge. Cambridge University Press.
8. Gerhards G. (2005) Secular variations in the body stature of the inhabitants of Latvia (7th millennium BC – 20th c. AD). Acta Medica Lituanica, 12, 33–39.
9. Jankauskas R. (1990) Secular changes of body proportions in Lithuania during two last millennia. Sbornik nar.muz. v Praze, Rada B, Prir.vedy., 46, 173–175.
10. Jankauskas R., Kozlovskaya M. (1999) Biosocial differentiation in Lithuanian Iron Age population. Anthropologie. XXXVII/2, 177–185.
11. Johnston F.E. (1969) Approaches to the study of developmental variability in human skeletal populations. Am J. Phys. Anthrop., 31, 335–342.
12. Johnston F.E., Zimmer L.O. (1989) Assessment of growth and Age in the immature skeleton In: Iscan M.Y., Kennedy K. (eds.). Reconstruction of life from skeleton. Alan R. Liss, Inc., 11–22.
13. King S.H., Ulijaszek S.J. (1999) Invisible insults during growth and development: contemporary theories and past populations. In: Hoppa R.D., FitzGerald Ch.M. (eds.) Human growth in the past: studies from bones and teeth. Cambridge University Press, 161–182.
14. Komlos J. (1986) Patterns of children's growth in East-central Europe in the 18th century. Am. Hum. Biol., 13, 33–48.

15. Komlos, J. (1987) The height and weight of West Point cadets: dietary change in Antebellum America. J. Econ. History, 47, 897–927.
16. Kunter M. (1994) Körper und sociale Umwelt: Mitelalterliche Skelettfunde als sozialbiologische Dokumente. Spieger der Forschung, 1, 35–57.
17. Mays S. (1998) The archaeology of human bones. Routledge. London and New York.
18. Nainys J.-V. (1972) Identifikacija ličnosti po proksimal'nym kostiam konečnostei. Vilnius. 158 p.
19. Olivier G., Aaron C., Fully G., Tissier G. (1978) New estimation of stature and cranial capacity in modern man. J. Hum. Evol. 7, 513–518.
20. Sandberg L.G., Steckel R.H. (1980). Soldier, Soldier, what Made You Grow so Tall? A Study of Height, Health and Nutrition in Sweden, 1720–1881. Economy and History XXIII, 91–105.
21. Sandberg L.G., Steckel R.H. (1987) Heights and economic history: the Swedish case. Annals of Human Biology, 14, 101–110.
22. Signoli M., Ardagna Y., Adalian P., Devriendt W., Lalys L., Rigeade C., Vette T., Kuncevicius A., Poskiene J., Barkus A., Palubeckaite Z., Garmus A., Pugaciauskas V., Jankauskas R., Dutour O. (2004). Discovery of a mass grave of Napoleonic period in Lithuania (1812, Vilnius). COMPTES RENDUS PALEVOL, 3, 219–227.
23. Silventoinen K. (2003) Determinants of variation in adult body height. J. Biosoc. Sci., 35, 263–285.
24. Steegman A. T. Jr. (1985) British military stature: growth cessation, selective recruiting, secular trends, nutrition at birth, cold and occupation. Hum. Biol., 57, 77–95.
25. Tanner J. M. (1990) Fetus into man. Cambridge. Harvard University Press.
26. Trotter M., Gleser G.C. (1958) A re-evaluation of estimation of stature based on measurements of stature taken during life and of long bones after death. Amer J Phys Anthropol, 16, 79–123.
27. Weir D. (1997) Economic Welfare and Physical well-Being in France, 1750–1990, In: Steckel R., Floud R. (eds.). Health and Welfare during Industrialization. The University of Chicago Press, 161–200.
28. Woitek H. (2003) Height cycles in the 18th and 19th centuries. Economics and Human Biology, 1, 243–257.

29. Workshop of European anthropologists 1980. Recommendations for age and sex diagnoses of skeletons. J Human Evol, 9, 517–549.
30. Wurm H. (1983) Socialspezifische Körperhöhenentwicklung von der Wölkerwanderumg bis zum 17. Jh. im Bereich des Deutschen Reiches unter besonderer Berücksichtigung der Adessicht. Homo, 34, 177–193.

Address for correspondence:
Rimantas Jankauskas,
Department of Anatomy, Histology and Anthropology
Faculty of Medicine, Vilnius University
Ciurlionio 21, Vilnius 03101, Lithuania
E- mail: rimantas.jankauskas@mf.vu.lt

Papers on Anthropology XVI, 2007, pp. 132–138

55 YEARS OF ANTHROPOLOGICAL RESEARCH AT THE INSTITUTE OF HISTORY

Leiu Heapost

Institute of History, Tallinn University, Tallinn, Estonia

This year 55 years will pass from the beginning of regular anthropological research at the Institute of History, which used to be affiliated to the Estonian Academy of Sciences and now forms part of Tallinn University. This event is closely connected with the general development of physical anthropology in Estonia, particularly with the activities of the founder of systematic anthropology in Estonia Juhan Aul and his first student in paleoanthropology Karin Mark (1922–1999). This was also a sign of the necessity of anthropological research for the development of Estonian studies in general.

The first anthropological description of Estonians was given by Academician Karl E. v. Baer in his doctoral dissertation in 1814. Although during the following one hundred years anthropological research developed, the conclusions drawn on very scanty material were of haphazard nature and even spread wrong opinions about Estonians.

Extensive anthropological research of Estonians began in the period of independent statehood in the 1920s–1930s. Thorough anthropometric measurements carried out by the founder of systematic anthropology Juhan Aul from 1932–1936 made Estonians one of the somatologically most profoundly researched nations. As a result, an objective overview was gained of Estonians' anthropological characteristics and their racial composition. In 1938 J. Aul provided an overview of anthropological research in Estonia until then and set aims for the future. As one of the tasks, he envisaged the analysis of paleoanthropological material collected by archaeologists. Although research continued, unfortunately the years of war followed soon.

In the 1940s J. Aul's first student in paleoanthropology and his assistant was **Karin Mark**. Already as a student she began to systematize and analyze the skeletons excavated by the archaeologists of the Institute of History and defended her graduation thesis on this material. This was followed by Stalinist repressions against genetics and anthropology as a science and against scholars who practised them.

Practical need for anthropological research persisted. In the 1950s, one of the priorities for the archaeologists of the Institute of History, led by Academician Harri Moora, was studying the ethnogenesis of Estonians. To study this issue, researchers from other areas were recruited, including Karin Mark who did her postgraduate studies in paleoanthropology at the Institute. In 1952 she was employed by the Institute as an anthropologist whose task was to study the ethnic history of the Estonian people on the basis of paleoanthropological materials. From that time onwards, research in physical anthropology at the Institute of History has been closely related to archaeology, ethnology and other studies of primeval history and ethnic history of Estonians. K. Mark has a special role in it as all her work was devoted to studying the ethnogenesis of Estonians and all the other Finno-Ugric peoples.

Having worked through the whole craniological material gathered by archaeologists, which was still scanty for drawing conclusions, she also conducted archaeological excavations herself at medieval village cemeteries. For comparison, she also measured Lithuanian craniological material. As early as in the 1950s, she presented her conception of formation of the anthropological types of present-day Estonians, which, in principle, has remained valid to the present.

To obtain additional data for retrospective treatment of problems of ethnogenesis, K. Mark started in the 1950s, in addition to craniological research, somatological studies. She participated in the Baltic countries' joint expedition to Estonia, Latvia and Lithuania. This resulted in the publication of a monograph written by K. Mark in cooperation with M. Vitov and N. Cheboksarov (1959). She also started collection of somatological material from Finno-Ugrians as well as from their neighbouring peoples in order to explain the origin of Finno-Ugric peoples. From 1955–1976, K. Mark collected unique material on somatology of all Finno-Ugric peoples. Approximately 13,000 people were measured (133 ethnic and territorial groups, which included 20 Indo-European and Turkic groups for comparison).

Relating the collected sample material to the data of archaeology and language history, she completed the study *Zur Herkunft der finnisch-ugrischen Völker vom Standpunkt der Anthropologie* (1970) and a study on the anthropology of Baltic-Finnic peoples (1975). She also wrote a number of research papers on several Finno-Ugric peoples. Unfortunately, she was not able to finish the comprehensive study she had started. This was left for her colleagues to do.

In the 1970s the scope of themes of anthropological research at the Institute of History broadened. Under the supervision of K. Mark, population genetic and odontological studies started. In 1970, J. Aul's student **Leiu Heapost**, who had graduated from the University of Tartu, took up postgraduate studies at the Institute. Her research areas were school students' physical development, its relations to different social, environmental and other factors, manifestations of acceleration in physical development, etc. During her postgraduate studies, she collected population genetic material during expeditions in Estonia and from Hungarians in the Transcarpathian region. She determined blood groups in eight blood group systems, phenylthiocarbamide taste sensitivity and red-green colour blindness. Earlier she had conducted population genetic studies of West Siberian Khants, Mansi and Komi Zyriac, participating in the 1967 expedition of the Institute of History led by K. Mark. She also participated in anthropological studies of Tallinn school students. She continued her population genetic studies when working at the Institute of History as a research fellow.

In 1968 **Galina Sarap** (1940–1993), who had graduated from Leningrad University, started working at the Institute as a senior laboratory assistant (later as a research fellow). She specialized in ethnic odontology under the supervision of the well-known Russian odontologist Alexander Zubov. From 1972 she collected odontological material at expeditions of the Institute of History from schoolchildren in Estonia and from Transcarpathian Hungarians. Besides the analysis of contemporary odontological material from the ethnic aspect, G. Sarap also studied pathological changes in teeth (the spread of caries). She also started to research the dental features of the paleoanthropological material of the Institute in order to establish the formation of odontological types in present-day Estonians. However, she was not able to complete these studies.

The complex anthropological expeditions organized by the Institute of History began in the 1970s and, with the participation of

K. Mark, lasted until 1980. Collection of odontological material also continued in the following year. L. Heapost continued collecting population genetic material even later – during the expeditions organized by the Institute of History and blood transfusion centres of Tallinn and Tartu. Material was collected from all the regions of Estonia. In 1977–1978 geneticists from the Institute of General and Molecular Pathology of the University of Tartu also participated in an anthropological expedition.

The collected somatological materials comprise 21 territorial groups (2074 individuals), population genetic materials – 39 groups (up to 6430 individuals within different systems) and odontological materials – 25 groups (2373 individuals).

For comparison, L. Heapost also collected population genetic material from Vepsians and Latvians.

The research results have been published in the book by K. Mark, L. Heapost and G. Sarap *Anthropology of Estonias in relation to problems of ethnogenesis* (*Eestlaste antropoloogia seoses etnogeneesi küsimustega*, 1994). The authors treat the material according to territorial groups and different regions based on the territorial division of Estonia according to dialects.

In the 1990s, **Leiu Heapost** continued the main trends of anthrological research that had became established at the Institute of History. As new trends, studying of adults' somatometric measurements and changes in body proportions (acceleration) appeared. In paleoanthropology, the new trends were craniometric and osteometric studies of Estonian archaeological populations. This made it possible to reconstruct the stature and body build and to follow the dynamics of stature and body build during the last 800 years. Paleodemographic studies also started.

After the retirement of K. Mark, **Raili Allmäe** joined the Institute of History as an anthropologist in 1968. Her first task was participation in the excavations of 14^{th}–17^{th}-century graves at St. Barbara cemetery in Tallinn and analysis of the collected anthropological material. Then she studied 14^{th}–18^{th}-century osteological material from Tääksi cemetery in central Estonia. This resulted in a versatile (craniological, odontological, osteometric with reconstruction of stature) anthropological characterization of the paleopopulation of Tääksi cemetery, which she defended as her Master's thesis. She also provided an overview of the dental and cranial pathologies of the Tääksi population and analyzed the skeleton population paleodemographically.

The anthropological material of Tääksi and St. Barbara cemeteries made it possible to compare medieval and modern children's growth rates and provide an overview of stature and sexual dimorphism in Estonia in the 13^{th}–18^{th} centuries.

During the last decade, R. Allmäe has mostly analysed osteological material from cremation burials, which is particularly essential for studying the settlement history and funeral rites of Iron Age Estonia.

Jana Limbo-Simovart started her odontological studies at the Institute of History by analysing the morphological and ethnic characteristics of dentition (2003). In recent times, she has mainly paid attention to sexual dimorphism of teeth and metabolic stress markers expressed in teeth. The regularities expressed in the sexual dimorphism of teeth can be used for determining the sex of individuals. By comparative analysis of metabolic stress markers and dental pathologies of different skeleton populations, it is possible to draw conclusions about the health of people in the past and the environmental factors influencing them.

Ken Kalling participated in anthropological research of the Institute of History in the late 1980s and early 1990s, acquiring here the primary skills necessary for anthropological research. He participated in the archaeological and anthropological research of Lillemäe and St. John's Church cemeteries in Tartu. Based on the material of St. John's Church cemetery he wrote several research papers and defended his Master's thesis. He also worked on the osteological material of Viimsi stone barrow.

Jonathan Kalman worked at the Institute as an anthropologist from 1999–2001. His research results broadened the knowledge of the number of Estonia's Bronze and Early Iron Age population, pathological phenomena on bones and their possible causes. This helped to explain the substantial role of living conditions for human populations.

Along with anthropologists, **Liivi Aarma**, one of the historians working at the Institute, has provided an overview based on archival data of the stature of North Estonian men serving in the Russian Army in the 18^{th}–19^{th} centuries. The paper was published in 1987, edited by Leiu Heapost and Endel Laul.

Besides their research work, the anthropologists of the Institute of History have lectured on selected chapters of anthropology to students of the humanities and natural sciences at the University of Tartu and Tallinn University (formerly Tallinn Pedagogical Institute) as well as to school students in Tallinn. The Institute has been a place for practical training for young people whose research interests are related to paleoanthropology. Toomas Kivisild wrote his Masters dissertation (under the supervision of Leiu Heapost) having researched the non-metric features of skulls from the Institute's craniological collections. Jana Limbo-Simovart worked with the odontological material of Pada cemetery of the 12^{th}–13^{th} centuries and gave an odontological characterization of the population in her Master's thesis, etc. The Institute's paleoanthropological collections have also been used by several foreign researchers as comparative material or for gaining practical experience. Primarily, the Institute of History with its anthropological collections has been a place for practical training for young Estonian anthropologists and archaeologists. Likewise, the anthropologists of the Institute have participated in expeditions organized by researchers from other countries in Estonia and elsewhere.

The principal research trend of the anthropologists of the Institute of History has been ethnic anthropology with craniological and somatological research. In the 1970s new trends of research appeared (population genetics, odontology). In the 1980s and mainly in the 1990s and later osteological research appeared, along with paleopathological and paleodemographic studies. During the last decade, a new trend has been analysis of osteological material from cremation burials.

In conclusion, it could be said that the Institute of History is the only institution in Estonia where the anthropological trend of research has consistently developed for more than half of a century. The work initiated by J. Aul and his ideas have borne good fruit at the Institute.

For major publications by the anthropologists of the Institute of History see:

1. Eesti arheoloogia bibliograafia 1986–1996. Estonian archeological bibliography 1986–1996. Tallinn 2000.
2. Eesti arheoloogia bibliograafia 1997–2004. Estonian archeological bibliography 1997–2004. Tallinn 2005.

3. Heapost L. 2002. 80 years from the birth of the Estonian anthropologist Karin Mark. – Papers on Anthropology, XI. Tartu, 11–18.
4. Хеапост Л. 2002. Карин Юлиусовна Марк (к 80-летию со дня рождения) 24.03.1922.– 04.12.1999. – Вестник антропологии, 9. Москва, 169–179.
5. Leiu Heapost. Bibliograafia 1972–2006. Toimetaja G. Veldre. Eesti Looduseuurijate Selts, Tartu 2006.

Address for correspondence:
Leiu Heapost
Institute of History, Tallinn University
Tallinn, 13817, Ümera 2–131
E- mail: leiu.heapost@ai.ee

Papers on Anthropology XVI, 2007, pp. 139–146

ESTONIAN NATIONAL NORMS OF HEIGHT, WEIGHT AND BODY MASS INDEX FOR MEN AND WOMEN AGED 20–70 YEARS

Helje Kaarma, Mart Lintsi, Liidia Saluste, Säde Koskel, Andres Arend

Centre for Physical Anthropology, Institute of Anatomy, University of Tartu, Estonia

Key words: women's and men's anthropometry, height, weight, body mass index

INTRODUCTION

Estonia has long-standing traditions of anthropological studies, the foundation to which was laid by Prof. Juhan Aul [1, 2]. He measured approximately 50,000 people (schoolchildren, women, men) and established respective norms for the pre-war Republic of Estonia. During the Soviet regime, anthropological studies were continued, although it was impossible to elaborate specifically Estonian norms.

In newly independent Estonia anthropological research acquired a new practical slant. In 1993 the Centre for Physical Anthropology was established at the University of Tartu and in 1995 the Estonian Anthropometric Register at the Ministry of Social Affairs of the Republic of Estonia. Anthropometric databases have made it possible to calculate growth curves of height and weight for children aged 2–18 years (n=20,376) [3]. At present, these are used by schools and health care institutions as national norms. J. Aul's data on schoolgirls' body build in the 1930s have been compared with J. Kasmel's data of the present (n=3,000) [4]. The Centre for Physical Anthropology established an anthropological consulting room in Maarjamõisa Outpatient Clinic. From 1998–2001 data were collected there on the height, weight and body fat content (by Omron BF 300 body fat monitor) of the adult population of Tartu – 1475 women and 517 men [5].

In 2003–2005 the Estonian Anthropometric Register, under the auspices of the Ministry of Social Affairs, started systematic collection of height, weight and body mass index data of adult Estonian men and women aged 20–70 years. An overview of the work is presented below.

MATERIAL AND METHODS

In cooperation with family physicians, height and weight data were collected from 20–70-year-old Estonians who did not suffer from any chronic diseases or disabilities. The material was collected from Tallinn, Tartu, East Estonia and West Estonia. The East Estonian region included the counties of Ida-Virumaa, Jõgevamaa, Tartumaa (excluding the town of Tartu), Põlvamaa and Võrumaa. West Estonia included the counties of Läänemaa, Raplamaa, Saaremaa, Hiiumaa and Pärnumaa. The plan was to collect data of 5-year age groups (from 20–24 to 55–59, and 60–70), 100 men and 100 women in each age group equally from all the four regions – Tallinn, Tartu, East Estonia and West Estonia, a total of 7200 persons. Actually, the data of 8621 Estonians were collected.

The data are not identifiable (no names or personal codes were recorded); neither do they include any other delicate personal data. The randomness of the sample was ensured by the random selection of family physicians (their selection was approved regionally).

The qualifications of family physicians (training in anthropometric measuring and practical experience) ensured sufficient correctness of measurement results. Consultant to the study was Professor Emeritus Ene-Margit Tiit; statistical analysis of data was performed by Master of Mathematical Statistics Säde Koskel.

RESULTS AND DISCUSSION

Tables 1 and 2 reveal a well-known trend – aging, both in men and women, causes an increase in average weight, decrease in average height and, therefore, also an increase in the body mass index increases. Comparing our data in Table 3 [6] with the data of Saluste (1998–2001) [5], we can see that these tendencies are similar.

It is interesting to compare Aul's data from 1940 on men's and women's height (Aul, 1977) with ours. During 67 years, the height of 30–40-year-old men has increased by 5 cm and that of women by 4.4 cm.

Comparison of the data of the present article with those of Aul (1940) [1] and Saluste (1990–2001) [5] is given in Table 3.

CONCLUSIONS

Repeated anthropological studies of Estonians within 67 years show the continuation of internationally recognized age-related tendencies. As the studies involve the whole territory of Estonia, we can consider these data as national norms and apply them in medicine and health promotion.

REFERENCES

1. Aul J. (1940) Anthropologische Forschungen in Eesti. Loodusuurijate Seltsi Aruanded, XLVII (1). Tartu.
2. Aul J. (1977) Über die Sexualdimorphismus der anthropometrischen Merkmale von Schulkindern, Jugendlichen und Erwachsenen. 28, 4, 201–216.
3. Grünberg H., Adojaan B., Thetloff M. (1998) Kasvamine ja kasvuhäired. Metoodiline juhend laste füüsilise arengu hindamiseks. Tartu Ülikool.
4. Kaarma J., Kasmel J., Koskel S., Tiit E.-M. (2003) Changes in schoolgirls' body measurements during 30 year period. Growth, Development & Aging, 67, 95–105.
5. Saluste L., Koskel S. (2002) Body build and body fat content of Tartu adult males and females in 1998–2001 (preliminary review) (in Estonian). Eesti Antropomeetriaregistri Aastaraamat 2002, 204–212.
6. Tartu Ülikooli Füüsilise Antropoloogia Keskuse ja Tervise Arengu Instituudi vahel 28–07.2005. a. sõlmitud lepingu lõpparuanne. Tartu, 2005.

Table 1. Mean values of adult males' (aged 20–70 years) weight, height and body mass index

Age	N	Min	Max	Mean	SD	Percentiles									
Weight						3%	5%	10%	25%	50%	75%	85%	90%	95%	97%
20–24	521	43.00	123.70	77.38	12.41	62.00	63.00	65.00	70.00	77.00	87.00	95.00	98.00	103.00	106.00
25–29	454	48.00	149.70	82.20	14.21	62.00	64.00	66.10	75.00	80.60	89.00	94.00	101.00	113.00	123.00
30–34	467	56.00	132.00	84.41	13.55	64.00	65.00	68.00	75.00	82.05	93.00	100.00	104.80	114.00	120.00
35–39	411	50.00	151.00	86.54	15.66	59.00	64.00	68.00	75.00	83.00	96.00	103.10	105.00	117.00	126.00
40–44	442	60.00	144.00	87.28	14.61	69.00	69.00	71.00	78.00	83.00	96.60	103.00	105.50	111.00	120.00
45–49	434	54.00	144.00	87.20	13.65	65.00	67.00	69.25	77.00	84.95	96.00	101.00	105.00	112.40	120.00
50–54	407	49.00	142.90	86.68	13.66	65.00	68.00	72.00	78.00	85.00	95.00	100.00	102.70	112.50	117.00
55–59	406	54.00	139.00	86.88	14.64	62.00	68.00	72.00	80.00	86.00	96.00	99.00	105.00	110.00	119.00
60–70	492	53.00	140.00	85.98	14.70	60.00	64.00	69.00	76.70	85.00	95.00	102.00	107.00	116.20	126.00
Height															
20–24	521	156.00	205.00	180.94	7.42	167.00	170.00	174.00	178.00	182.00	187.00	190.00	193.00	195.00	196.00
25–29	454	160.50	200.00	180.83	6.54	168.00	170.00	174.00	178.00	181.00	185.00	188.00	189.00	191.00	194.00
30–34	467	164.00	200.00	180.58	6.20	170.00	172.00	174.00	177.20	181.00	185.00	188.00	190.00	191.00	193.50
35–39	411	158.00	203.00	180.06	6.69	169.00	169.00	170.00	178.00	180.00	184.00	188.00	189.00	190.00	192.00
40–44	442	158.30	200.00	179.10	6.82	167.00	168.00	170.00	175.00	180.00	186.00	187.50	188.00	190.00	191.00
45–49	434	159.50	200.00	178.51	6.75	166.00	166.00	169.00	175.00	179.75	183.00	185.00	186.75	188.00	191.00
50–54	407	155.00	197.00	177.59	6.47	169.00	169.00	170.00	174.00	178.40	184.00	186.50	188.00	191.00	192.00
55–59	406	156.00	196.00	176.80	6.67	163.00	165.00	169.00	173.00	178.00	182.00	183.50	186.30	189.00	190.00
60–70	492	156.00	197.00	174.96	6.70	161.00	163.00	167.00	170.00	175.00	179.00	182.00	185.00	187.00	188.00

Body mass index															
20–24	521	16.46	38.55	23.61	3.30	18.61	19.20	20.53	21.46	23.15	25.77	27.17	29.07	30.93	31.60
25–29	454	16.86	47.78	25.09	3.79	19.74	20.03	20.96	23.10	24.80	26.58	28.09	29.34	34.54	35.10
30–34	467	18.08	38.37	25.84	3.59	20.01	20.83	22.09	23.20	24.93	27.44	29.69	31.41	33.24	34.57
35–39	411	15.78	44.57	26.64	4.27	19.80	20.49	21.46	23.15	25.27	28.86	31.21	32.75	34.95	37.22
40–44	442	18.52	43.58	27.18	4.07	21.39	21.72	22.53	23.91	26.31	28.77	30.49	31.79	35.37	36.16
45–49	434	17.24	43.47	27.35	3.92	20.98	21.06	22.62	24.40	26.83	28.95	30.67	32.28	33.96	35.94
50–54	407	17.86	43.23	27.45	3.84	20.75	21.53	22.16	23.81	26.70	29.80	31.13	32.11	34.88	35.15
55–59	406	17.97	42.43	27.76	4.22	21.88	22.46	23.20	25.08	27.22	29.95	31.77	33.56	36.17	37.64
60–70	492	17.24	45.20	28.07	4.48	20.23	21.30	22.76	24.79	28.07	30.57	31.99	33.77	37.83	40.56

Table 2. Mean values of adult females' (aged 20–70 years) weight, height and body mass index

Age	N	Min	Max	Mean	SD	Percentiles									
Weight						3%	5%	10%	25%	50%	75%	85%	90%	95%	97%
20–24	622	38.00	102.80	60.77	9.02	45.50	49.00	52.00	55.00	59.00	65.00	68.00	70.00	76.00	80.00
25–29	555	40.00	118.00	62.94	11.09	47.20	49.00	53.00	56.00	59.50	66.00	70.50	74.00	79.00	84.00
30–34	508	40.00	130.00	66.08	13.07	50.00	50.10	52.00	56.65	61.00	68.80	75.00	80.00	85.00	96.00
35–39	493	44.00	124.00	67.94	12.86	50.00	52.00	56.00	59.00	65.00	73.00	80.10	84.00	90.00	93.00
40–44	506	42.80	140.00	70.25	13.36	54.00	55.00	57.00	60.20	68.00	75.00	80.00	85.00	89.00	90.00
45–49	488	44.00	130.00	72.35	13.62	47.00	54.00	58.00	63.00	68.00	75.00	83.00	87.20	95.00	97.00
50–54	479	45.00	132.70	72.86	12.76	51.00	53.10	57.00	63.00	68.40	79.00	84.00	88.00	90.00	95.00
55–59	420	47.00	135.50	75.82	15.10	52.50	53.00	58.00	62.00	73.00	82.00	87.00	92.00	97.20	101.00
60–70	516	41.00	128.70	75.92	14.34	54.00	55.00	58.70	64.50	75.40	85.00	93.00	96.00	102.00	107.00
Height															
20–24	622	144.20	186.40	167.44	6.05	159.50	160.00	161.00	164.00	169.50	173.00	175.00	176.00	179.00	179.50
25–29	555	148.00	185.00	166.91	6.13	158.00	159.00	160.00	164.00	167.00	170.00	174.00	176.00	178.00	183.00
30–34	508	146.00	185.50	166.97	6.01	157.50	158.00	160.00	164.00	168.00	172.00	176.00	176.50	180.00	181.00
35–39	493	150.00	184.00	166.40	5.81	160.00	160.00	160.00	164.00	167.50	171.00	173.00	175.20	177.50	179.30
40–44	506	147.60	189.00	166.00	5.57	158.90	160.00	162.50	164.00	168.00	171.00	173.00	173.00	175.00	176.00
45–49	488	138.00	190.00	164.69	6.19	156.00	157.00	158.80	162.00	168.00	170.00	174.00	176.00	178.00	179.00
50–54	479	150.00	182.00	164.04	5.34	154.00	155.00	159.00	161.50	164.00	169.00	170.00	171.00	172.00	176.00
55–59	420	147.50	180.00	163.35	5.37	153.00	154.00	156.00	160.00	164.00	168.00	170.00	171.00	173.00	173.00
60–70	516	143.00	180.00	162.03	5.78	153.00	154.00	156.00	160.00	162.00	166.00	168.00	170.00	172.00	174.00

Body mass index

20–24	622	14.46	35.36	21.67	2.96	17.43	17.63	18.18	19.49	20.90	22.31	23.66	24.09	25.95	27.06
25–29	555	15.64	40.96	22.56	3.62	17.99	18.22	18.75	20.20	21.45	23.53	24.54	24.99	25.77	27.76
30–34	508	16.14	47.87	23.70	4.51	17.11	18.07	19.00	20.11	21.65	24.07	25.66	26.47	29.72	33.70
35–39	493	15.88	45.00	24.52	4.43	18.89	19.05	20.07	21.56	23.01	25.65	27.34	30.86	33.06	34.21
40–44	506	15.63	47.32	25.51	4.86	19.47	20.07	20.45	22.04	23.53	26.26	28.44	29.41	32.27	33.50
45–49	488	17.26	49.84	26.73	5.17	18.31	19.72	21.19	22.15	24.75	26.85	29.03	30.80	33.61	35.70
50–54	479	17.99	47.58	27.10	4.74	19.36	19.72	20.53	22.68	25.16	29.31	30.58	31.63	34.16	37.11
55–59	420	17.89	50.69	28.43	5.60	19.88	20.35	21.51	23.23	26.77	30.42	31.69	34.95	37.99	38.02
60–70	516	16.85	46.71	28.91	5.28	20.90	21.08	21.99	24.52	28.84	32.13	33.73	36.81	38.46	39.78

Table 3. Height, weight and body mass index of adult men and women in the samples of Aul (1940), Saluste (1998–2001) and Kaarma (2005)

age	height					
	Aul		Saluste		Kaarma	
	men	women	men	women	men	women
<30	175.83	162.57	180.4	166.5	180.83	166.91
<40	174.60	161.92	179.5	165.1	180.06	166.40
60 and older	–		171.8	160.0	174.96	162.03
	weight					
	Aul		Saluste		Kaarma	
	men	women	men	women	men	women
<30	–		78.2	61.4	82.20	62.94
<40			85.0	65.5	86.54	67.94
60 and older			86.2	70.3	85.98	75.92
	body mass index					
	Aul		Saluste		Kaarma	
	men	women	men	women	men	women
<30	–		24.0	22.1	25.09	22.56
<40			26.3	24.0	26.64	24.52
60 and older			29.1	27.3	28.07	28.91

Address for correspondence:
Helje Kaarma Dr. Sc., Dr. med.
University of Tartu, Faculty of Medicine
Institute of Anatomy
Centre for Physical Anthropology
Lossi street 38 Old Anatomicum
Tartu 51 003, Estonia
E-mail: antrop@ut.ee

Papers on Anthropology XVI, 2007, pp. 147–169

BODY COMPOSITION: VARIATIONS DURING THE LIFE-SPAN AND ASSOCIATION WITH MANIFESTATIONS OF AGING

L Kalichman[1*], *E Kobyliansky*[2,3*]

[1] Department of Physical Therapy, The Stanley Steyer School of Health Professions, Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel 69978

[2] Human Population Biology Research Unit, Department of Anatomy and Anthropology, Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel 69978

[3] Lilian and Marcel Pollak Chair of Biological Anthropology, Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel 69978

ABSTRACT

The aim of this large, cross-sectional study was to describe the age- and sex-related variations of the somatotype, employing Heath and Carter's method, in the Chuvasha population residing in a rural region in central Russia. The second aim was to evaluate the association between the somatotype and different manifestations of aging, including blood pressure and indices of skeletal aging such as cortical index, radiographic hand osteoarthritis and the osseometric score.

The investigated cohort included 802 males aged 18–89 years (mean 46.9) and 738 females aged 18–90 years (mean 48.6).

Sex differences of somatotypes appear to be the strongest for endomorphy, with generally higher values in women. Endomorphy in males remained virtually unchanged after 30 years of age, but endomorphy in females kept increasing up to the 6th decade, and then subsequently decreasing. The largest difference of all somatotype components appeared between the ages 18–30 and 31–40. Thereafter, somatotypes remained practically unchanged. Mesomorphy continued to increase until the 5th decade in both sexes, while in females, endomorphy continuously increased until their

6th decade. In the 7th and 8th decades, a decrease in mean values was observed. Mesomorphy and ectomorphy showed opposite age-related trends.

The results of our study clearly suggest that in physique investigations, the somatotypes need to be studied in each sex separately; and in the studies of the young population, they also need to be adjusted to age. The present study provides convincing evidence for a connection between the indices of aging such as blood pressure and skeletal aging characteristics and physique characteristics. People with robust body build had higher mean values of SBP, DBP, TotOA and Osseometric score, while scrawny persons presented the lowest values. This last finding could hopefully be used as a diagnostic tool as well as a preventive measure in the management of hypertension, osteoarthritis and osteoporosis.

Key words: body composition, variations of aging, somatotypes

INTRODUCTION

Somatotype is frequently used as a composite method of physique assessment defining the body type through the analysis of metric characters. Several somatotyping methods have been proposed by the scientific community during the last century such as: Sheldon's (1950) [53], Kretschmer's (1921) [37], Deriabin's (1985, 1991) [12,13] and others. Today, the most employed method is Heath and Carter's anthropometric somatotype (Carter and Heath, 1990; Heath and Carter; 1967) [8,17]. This mathematical method uses a three-component index of the somatotype, including *endomorphy* (measuring relative fatness), *mesomorphy* (measuring musculoskeletal components) and *ectomorphy* (measuring longitudinal characteristics of the body). The following publications of this somatotyping method, numerous studies have attempted to reveal a possible association between somatotypes and pathological conditions (e.g., Malina, et al. 1997; Katzmarzyk et al., 1999; Williams et al., 2000; Eiben et al., 2004; Kalichman et al., 2004, 2005) [43,28,62,22,24]. The somatotype has often been used to study morphometric variations in children (Rebato et al., 1996; Monyeki et al., 2002; Tambovtseva and Zhukova, 2005) [52,44,58], young adults (Carter and Parizkova, 1978;

Bhuiyan et al., 2003) [9,4] and the elderly (Herrera et al., 2004; Buffa et al., 2005) [18,6]. However, we found very few publications concerning somatotype variations during adulthood (Bailey et al., 1982; Singal and Sidhu, 1984; Gaur and Singh, 1997; Katzmarzyk and Malina, 1999) [3,54,16,28]. Studying somatotype variations during adulthood is vital in understanding the aging process as well as comparisons between different populations. There are also potential clinical applications in understanding the relationship between body build, nutritional status, and health conditions (Malina, 1997; Williams et al., 2000; Kalichman et al., 2004, 2005) [43,62,22,24]. For example, the interrelationship between Heath-Carter (H-C) somatotypes (Carter and Heath, 1990) [8] and blood pressure was addressed in several recent studies (Apanasevich et al., 1990; Valkov et al., 1996; Malina et al., 1997; Katzmarzyk et al., 1999; Toselli et al., 2001; Koleva et al., 2002) [1,61,43,28,60,36]. Valkov et al. (1996) [61] reported that while arterial hypertension was encountered in 31 % of subjects in their endomorphic and mesomorphic groups, none of their ectomorphic subjects had elevated arterial pressure. Koleva et al. (2002) [36], using cluster analysis, demonstrated that men and women with the highest endomorphy and mesomorphy and the lowest ectomorphy, comprised a category of individuals who suffered most frequently from arterial hypertension. According to Apanasevich et al. (1990) [1], the prevalence of arterial hypertension increases consistently on passing over from asthenia (tall persons with long extremities and small amount of fat) to hypersthenia (persons with a robust body and short extremities). Their study, however, merely investigated the connection between physique and hypertension, and there are only very few studies that explored the possible association between physique and BP in healthy individuals, to wit: Malina et al. (1997) [43] and Katzmarzyk et al. (1999) [28], the latter two comprising a part of the Quebec Family Study. These investigators found that somatotypes could predict systolic BP (SBP) and diastolic BP (DBP) in males. According to Malina et al. (1997) [43], individuals with high SBP and DBP were more endomorphic and mesomorphic and less ectomorphic, whereas the people with a better cardiovascular risk profile were more ectomorphic and less endomorphic or mesomorphic.

Our present study has been performed in the Chuvash population that was not previously studied for age- and sex-related variations of the somatotype. The Chuvashes are a rural Caucasian population, living in central Russia and characterized by the homogeneity of genetic, environmental and occupational conditions. They have lived under the same environmental conditions for at least 3 generations and have not been exposed to outside influences, such as the genetic flow (Tischkov, 1994) [59]. They have been used as a model population and been intensively studied for such age-related conditions such as osteoarthritis, osteoporosis, blood pressure variations and other types of morbidities (Livshits et al., 2002a; Kalichman et al., 2002, 2004) [38,20,22] and for various genetic studies (e.g., Livshits at al., 1998, 2002b; Kalichman et al., 2003; Suk et al., 2005) [41,21,57]. The evaluation of age-related physique variations can contribute to the better understanding of the aging process in general and of the etiology of age-related morbidities in particular.

The first aim of this study was to describe the age-related variations of the somatotype employing Heath and Carter's method and to evaluate differences in males and females. The study consisted of a cross-sectional large sample of Chuvash subjects from a rural region in Central Russia. The second aim was to evaluate the association between the somatotype and different manifestations of aging, including blood pressure and indices of skeletal aging such as cortical index, radiographic hand osteoarthritis and osseometric score.

METHODS

Sample: The population sample consists of native Chuvashes residing in numerous small villages in the Chuvash Autonomic Republic of the Russian Federation. The data were gathered in three expeditions undertaken during August/September of 1994 (563 individuals), May/June of 1999 (732 individuals) and September 2002 (245 individuals). The expeditions were part of the Chuvash Skeletal Aging Study (ChuSAS) project the main aim of which was to investigate the different aspects of skeletal aging in the Chuvash population. The same team of investigators collected the information and performed all the measurements in the three expeditions. All the studied individuals were randomly recruited, i.e., regardless of the readings of any of the measured variables. The investigated cohort included 793 males aged 18–80 years (mean 46.56) and 735 females aged 18–80 years (mean 48.54) (Figure 1).

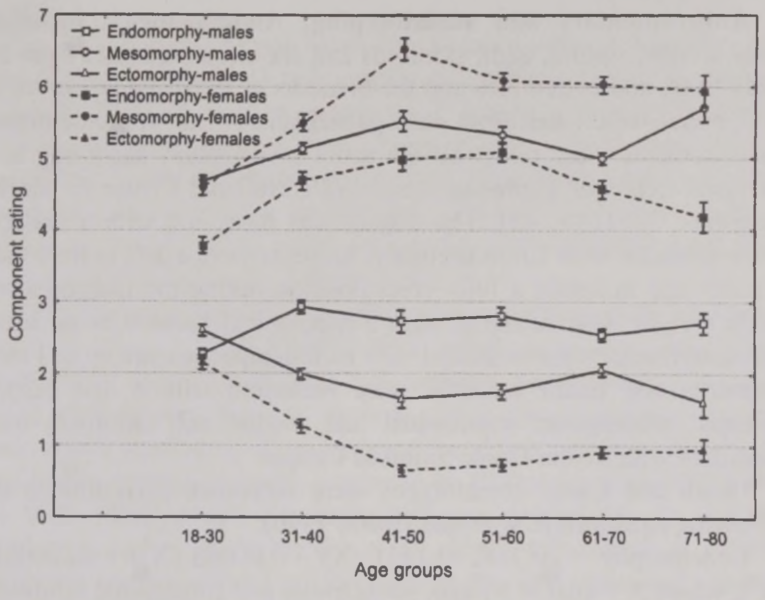


Figure 1. Whiskers plot: Mean value and standard errors of somototype components in males and females.

Ethnically, Chuvashes comprise a European population that lives in the Volga region of Russia; the inhabitants had migrated to this region during the 7th and 8th centuries. The Chuvash ethnic group was formed during the last quarter of the first millennium AD in the forested or hilly portions of the Volga riverside; their ancestors were likely Bulgars from the Volga and the Kama riverside who had intermarried with the local Finno-Ugor tribes (Tischkov, 1994) [59].

The study participants shared similar living and economic conditions, agriculture being their principal source of livelihood. The data collected included sex, age, and occupation. Most individuals are employed in agriculture or in other physical labor. Data on chronic morbidity and medical treatment were also included in the questionnaire compiled for this study. No one had taken hormone replacement therapy or steroid medication. Anthropometry was performed on all the participants. All the procedures were consensual; the subjects signed a written informed consent form. The entire project was approved by the Helsinki Ethics Committee of Tel-Aviv University, Tel Aviv, Israel.

Anthropometry and somatotyping: Anthropometry, including body weight, stature, eight skinfolds and six circumferences from the body trunk and extremities and the breadths of the distal epiphyses of long bones were taken from each participant. All the aforementioned measurements were taken by the same investigator, according to a standard technique (Lohman et al., 1988; National Center for Health Statistics, 2004) [42,45]. The stature was measured with a portable anthropometer with 1 mm accuracy. Subjects were asked to hold their breadth and maintain a fully erect position during the measurement. Body weight was measured with a mechanical balance beam scale. Circumferences were measured with a cloth tape measure up to 1 mm. Humerus and femur breadths were measured with a dial caliper. Triceps, subscapular, supraspinal and medial calf skinfolds were measured with a Slim Guide Skinfold Caliper.

Heath and Carter somatotypes were computed according to the following equations (Carter and Heath, 1990):

Endomorphy = –0.7182+0.1451 (X) – 0.00068 (X^2) + 0.0000014 (X^3), where X = sum of triceps, subscapular and supraspinal skinfolds.

Mesomorphy = (0.858 humerus breadth)+(0.601 femur breadth)+ (0.188 corrected arm girth)+(0.161corrected calf girth)-(0.131stature) +4.5, where corrected arm and calf girths are limb circumferences minus the triceps and calf skinfolds, respectively.

Ectomorphy = (HWR x 0.732)–28.58. HWR is a height-weight ratio equivalent to height/$\sqrt[3]{\text{weight}}$. When HWR was less than 40.75 but more than 38.25, ectomorphy was calculated from the equation HWR x 0.463–17.63. When HWR was equal to or less than 38.25, a rating of 0.1 was given.

BP measurements: BP measurements were taken on the left arm of each participant while seated after a 10-minute rest. Using a standard mercury sphygmomanometer and a stethoscope, the same nurse performed the measurements twice at 5-minutes apart on each subject, and the average of the two readings was considered the estimate of the SBP and DBP.

Evaluation of skeletal aging traits: Plain radiographs of both hands were taken from each study participant using a standard radiographic technique, as described in detail by Livshits et al. (1996) [39]. Hands were placed on the same film-containing plate to avoid any film or development variation. The X-ray source was located 100 cm above and the exposure was 25 mAs without intensifying screens at 50kV.

The reason why we used hands for the evaluation of skeletal aging were as follows: 1) Hand radiography is relatively harmless; 2) One X-ray picture of the hand encompasses 27 complete bones, and at least 15 joints of each hand: 4 distal interphalangeal, 4 proximal interphalangeal, 5 metacarpophalangeal, first carpo-metacarpal and first interphalangeal joints; 3) Bones and joints of the hand are less exposed to loads, and so their changes are more directly connected with internal factors than other joints are.

In the present study, we focused on four skeletal aging characteristics, to wit: 1) cortical index (CI), which represents hand bone geometry; 2) the index of hand osteoarthritis development (TotOA); and 3) the synthetic index of skeletal aging, that is, the osseometric score, which combines both osteoporosis and osteoarthritis changes of hand bones. It was originally suggested by Pavlovsky (1987) [47] and has been implemented for biological age evaluations in various population studies (Kobyliansky et al., 1995; Livshits et al., 1996; Pavlovsky and Kobyliansky, 1997) [35,39,48]. The value and validity of the osseometric score are expounded in recent publications (Kobyliansky et al., 2000; Karasik et al., 1999, 2000; Kalichman et al., 2006, 2007) [34,26,27,23].

In accordance with standard methodology (e.g., Plato et al., 1994) [49], the width of the bone in the middle of the diaphysis (D, mm) and the width of the medullary canal in the middle of the diaphysis (d, mm) of the II–IV metacarpal bones on the left and right hands (six indices in total) were measured, using a digitized Ultra-Cal caliper (F. V. Fowler Co., USA) linked to a personal computer. The CI for each individual, and for each bone, was computed as follows: $CI = (D-d)/D$. The average value of all CIs was used in the further analysis.

The development of osteoarthritis in each individual was judged by the standard Kellgren and Lawrence grading scheme, which utilizes photographs from the Atlas of Standard Radiographs (Kellgren and Lawrence, 1963) [32]. The measure for the severity of osteoarthritis is defined by the appearance of several joint degeneration characteristics, such as osteophytes, joint space loss, subchondral sclerosis, subchondral cysts, lateral deformity and cortical collapse (Kellgren and Lawrence, 1957, 1963) [31,32]. This method assigns one of five grades (0–4) of osteoarthritis at various joint sites, including the hand. In our study, 15 joints per hand were examined, so the total range for each hand was 0–60. The total individual osteoarthritis score (TotOA) (sum score of all 30 joints) was used in further analyses.

The osseometric score entails the descriptive criteria of the skeletal age, and it was estimated for each radiograph, as described in detail by Pavlovsky and Kobyliansky (1997) [48]. In brief, the occurrence of the following five features was recorded in order to derive an individual osseometric score: (1) osteophytes or nodes of Heberden in the periarticular regions of the bone and at sites of muscle-tendon attachment; (2) manifestations of osteoporosis, such as juxta-articular osteopenia or the decreased number and the increased thickness of trabeculae; (3) loci of osteosclerosis; (4) non-traumatic articular deformities; and (5) the enlargement of the tufts on the distal phalanges. The phalanges of the 2^{nd}–5^{th} fingers were examined. The presence of a given element, but not its level of development, was documented for each osseometric score estimate. The number of the elements involved in the rearrangement of the hand bones and joints with age was recorded as one sum, without the differentiation into individual types. All the scores were determined for both hands of each individual and were then combined as a sum for subsequent analyses.

Statistical analysis: All the statistical calculations were performed using STATISTICA 6.0 for Windows (StatSoft Inc, 2001). The descriptive statistics of age, anthropometric variables and somatotypes were calculated for both sexes.

Age and sex differences were evaluated by dividing the sample into 6 age groups: ≤30 years, 31–40 years, 41–50 years, 51–60 years, 61–70 years and 71–80 years old. One-way ANOVA with somatotype components as a dependent variable and sex as a grouping value was used to evaluate sex differences.

To evaluate differences between age groups, we used also one-way ANOVA (Cressie et al., 1986) [10] for each somatotype component and for males and females separately. The somatotype components were dependent variables and age groups were a grouping value. To show the differences between each pair of age groups, as well as between sexes we built the Whiskers plot.

Canonical correlations were computed to assess quantitatively the association between the various combinations of somatotype characteristics and different manifestation of aging such as skeletal aging traits (CI, TotOA and Osseometric score) as well as the combined trait of SBP and DBP. In the canonical correlation analysis, three Heath and Carter somatotypes represented the first array of variables while each of the aging traits represented the second array.

We also used another approach to identify the groups of individuals with similar body types and to differentiate them from other such groups. For this we used the K-means cluster analysis, dividing the sample into three clusters according to the H-C system of somatotyping. K-means cluster analysis is an analysis of variance 'in reverse'. The program starts with k random clusters, and then moves objects between these clusters with the aim of (1) minimizing variability within clusters and (2) maximizing variability between clusters. Next, we examined the null hypothesis of no difference in blood pressure or CI, TotOA, and the Osseometric score between the individuals belonging to the different clusters of the body type, using the General ANOVA.

RESULTS

Table 1 provides the baseline data for each studied trait according to gender. The mean values and the variation of all the variables in the present study were within the span of normal variation for each given trait (for men and women). The number of males and females in each age group is shown in Table 2. The correlations between the somatotype components in our study were statistically significant ($p<0.05$): endomorphy-mesomorphy: 0.60, endomorphy-ectomorphy: –0.74, mesomorphy-ectomorphy: –0.82.

Sex variation: All the somatotype components showed statistically significant differences between the sexes in all the age groups with the exception of mesomorphy, which did not show any significant difference between sexes in the age groups 18–30 and 71–80 (Figure 1). Whiskers plot, demonstrates the mean values of the somatotype components of the different age/sex groups with the most prominent differences appearing for endomorphy, with higher mean values in women. The differences were highest in ages 41–60; the lowest in ages 71–80. Mesomorphy was also higher in females than in males in most age groups, however the differences were less prominent and reached significance only between ages 31 and 70. Ectomorphic differences in males and females were significant and nearly the same in all age groups. The mean values, as opposed to other somatotype values, were higher in males than in females in all age groups.

Table 1. Characteristics of the Chuvash sample

Characteristics	Male			**Female**		
	n	**Mean**	**Range**	*n*	**Mean**	**Range**
Age (years)	793	46.56	18–80	735	48.64	18–80
Stature (cm)	778	166	143–191	722	154	139–177
Weight (kg)	778	64.1	40.0–100.3	720	60.0	33.0–116.5
BMI (kg/m²)	778	23.2	15.5–36.4	720	25.2	15.3–44.5
Endom	749	2.64	0.26–6.93	705	4.55	0.93–8.74
Mesom	701	5.08	1.49–8.50	692	5.70	1.39–11.66
Ectom	776	2.06	0.10–6.08	719	1.16	0.08–5.68
SBP (mm Hg)	732	128.79	80–230	678	129.00	80–210
DBP (mm Hg)	732	78.18	50–120	678	78.08	50–120
CI	663	0.52	0.19–0.82	605	0.51	0.20–0.83
TotOA	663	25.08	0.00–76.00	605	27.03	0.00–99.00
Osseometric score	663	9.39	0.00–41.00	605	10.66	0.00–36.00

BMI – Body mass index. Endom – endomorphy – measures relative fatness, Mesom – mesomorphy – measuring musculoskeletal components, and Ectom – ectomorphy – measuring longitudinal characteristics of the body, all somatotypes of Heath-Carter method. SBP – Systolic blood pressure, DBP – Diastolic blood pressure, CI – cortical index, TotOA- index of hand osteoarthritis development.

Table 2. Sex differences (results of one way ANOVA) of somatotype components in six age groups; differences between age groups (results of one way ANOVA) (last row)

	N		Endomorphy			Mesomorphy			Ectomorphy		
	Males	Females	Male Mean(SD)	Female Mean(SD)	p-value (sex)	Male Mean(SD)	Female Mean(SD)	p-value (sex)	Male Mean(SD)	Female Mean(SD)	p-value (sex)
18-30	178	151	2.27(0.98)	3.78(1.44)	**<0.01**	4.68(1.04)	4.59(1.35)	0.51	2.60(1.11)	2.15(1.29)	**<0.01**
31-40	185	119	2.93(1.23)	4.68(1.45)	**<0.01**	5.13(1.02)	5.49(1.35)	**0.01**	1.99(1.03)	1.27(1.04)	**<0.01**
41-50	63	91	2.73(1.23)	4.97(1.46)	**<0.01**	5.52(1.11)	6.53(1.49)	**<0.01**	1.65(1.01)	0.65(0.76)	**<0.01**
51-60	123	149	2.81(1.33)	5.08(1.57)	**<0.01**	5.33(1.16)	6.08(1.46)	**<0.01**	1.75(1.19)	0.73(0.99)	**<0.01**
61-70	201	171	2.55(1.23)	4.57(1.67)	**<0.01**	4.99(1.15)	6.02(1.54)	**<0.01**	2.06(1.31)	0.92(1.04)	**<0.01**
71-80	43	54	2.71(0.97)	4.19(1.57)	**<0.01**	5.70(1.23)	5.94(1.61)	0.47	1.61(1.33)	0.95(1.11)	**<0.01**
p-value (age)			**0.000**	**0.000**	–	**0.000**	**0.000**	–	**0.000**	**0.000**	–

SD – standard deviation. Statistically significant (p<0.05) p-values marked bold.

Age variations: the mean values and the standard deviations of the somatotypes in each age group for both sexes, as well as comparisons between age groups, are shown in Table 2. There were statistically significant differences ($p<0.01$) between the age groups in all somatotype components and in both sexes. The mean value of endomorphy in males was significantly higher in the ages 31–40 than in the ages 18–30, but endomorphy in other groups of males was statistically similar. In females, the mean value of endomorphy was significantly lower in the ages 18–30 than in all the other age groups, except for the ages 71–80. No differences were found in female endomorphy between the ages 31–40, 41–50, 51–60 and 61–70. The mean values of mesomorphy were significantly higher in the ages 31–40 than in 18–30, in both sexes, continuing to increase in the ages 41–50 (the change being statistically significant only in females). From the age 50 onwards, the mean values of mesomorphy decreased in both sexes, however the changes were statistically non-significant. The patterns of change of ectomorphy mean values were almost similar in both sexes. The mean values became significantly lower between the ages 18–30, 31–40 and 41–50. As of the age 50, there were almost no changes in the mean values of ectomorphy.

Association with indices of aging: Thanks to our findings somatotypes can change with age and there are differences between sexes, the following analyses we performed after the adjustment of all the studied variables to sex, age and age^2. Table 3 provides the results of the canonical correlation analysis. Canonical weights and factor structures of the first roots in each array of variables are presented. Where the right set had only one variable, the canonical weight and factor structure of this set was equal to 1 in each of the analyses. The factor structure indicated how the original variables correlated with the respective canonical variables and reasonably explained the relationships between the corresponding traits. As we can see from Table 3, all the aging indices, showed significant canonical correlations with the set of Heath and Carter somatotypes. The highest correlation coefficient was obtained for the set of blood pressure measurements ($r=0.28$, $p<0.001$) and the osseometric score ($r= 0.27$, $p<0.001$).

Table 3. Results of the Canonical correlation analysis (according to Heath and Carter somatotyping method): canonical weights, factor structure canonical correlations (all variables were adjusted for sex, age and age^2) are presented

Right set	CI		TotOA		Osseometric score		SBP		–0.76	–0.96
							DBP		–0.36	–0.77
Left set	**CW**	**FS**	**CW**	**FS**	**CW**	**FS**	**CW**	**FS**	**CW**	**FS**
Endom	–0.26	–0.79	–0.98	–0.96	0.06	–0.46	–0.39	–0.86		
Mesom	1.31	–0.23	0.51	–0.29	–1.09	–0.99	–0.23	–0.83		
Ectom	1.63	0.68	0.33	0.63	–0.07	0.83	0.49	0.95		
Canon. R	**0.12**		**0.18**		**0.27**		**0.28**			

CW – canonical weights; FS – factor scores; Canon. R – canonical correlation coefficient. For all other abbreviations see table 1 and Appendix 1. All the significant correlation coefficients at p< 0.01 appear in bold.

Differences between clusters: The results of the K-means cluster analysis of body somatotypes are shown graphically. Thus, Figure 2 presents the clusters (histograms of means) according the H-C system of somatotyping. As can be seen from the graph of the H-C somatotyping, cluster 1 includes individuals with low values of endo- and mesomorphy and high values of ectomorphy, which means that the subjects in this group are thin and tall with an undeveloped muscular system – *slender type*; cluster 2 encompasses individuals with the mean population values in all their somatotypes – *mixed type*; and cluster 3 includes heavy, muscular and short people – the *full-bodied type*.

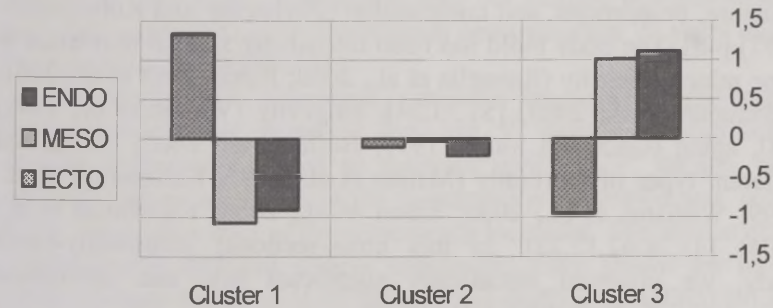


Figure 2. Clusters (histograms of means) that were obtained from Heath-Carter's somatotypes.

The results of ANOVA (Table 4), which evaluated differences in aging-related indices between H-C somatotype clusters, reveal statistically significant differences between the clusters (p<0.001) for both the SBP and DBP variables; here the individuals with the highest values for SBP and DBP belonged to cluster 3, and those with the lowest – to cluster 1. TotOA and Osseometric score showed the similar results, the highest mean values were in individuals who belonged to cluster 3, and the lowest – to cluster 1. CI showed no statistically significant differences between clusters.

Table 4. Results of General ANOVA (according to Heath-Carter somatotyping): p-values, mean and standard error values given for each cluster

Variables	p-value	Cluster 1	Cluster 2	Cluster 3
SBP	**<0.0001**	–0.23±0.04	0.11±0.05	0.32±0.06
DBP	**<0.0001**	–0.26±0.05	–0.04±0.04	0.17±0.06
CI	0.07	–0.06±0.05	–0.02±0.04	0.10±0.05
TotOA	**0.0001**	–0.13±0.05	–0.01±0.05	0.19±0.06
Osseometric score	**<0.0001**	–0.13±0.05	–0.04±0.04	0.23±0.05

p< 0.01 appear in bold.

DISCUSSION

During the human life span, the body significantly changes in size, structure, proportions, and composition (Pavlovsky and Kobyliansky, 1997) [48]. The body build has been intensively studied in relation to bone mineral density (Ravaglia et al., 2000; Kirchengast et al., 2001; Kalichman et al., 2005) [51,33,24], longevity (Wilson et al., 1990) [63], aging (Gaur and Singh, 1997; Buffa et al., 2005) [16,6], and different types of morbidity (Malina et al., 1997; Katzmarzyk et al., 1999; Williams et al., 2000; Eiben et al., 2004; Kalichman et al., 2004) [43,28,62,12,22]. In this cross-sectional community-based study, we observed statistically significant sex- and age-related differences of somatotype components.

Sex differences: In our sample, the sex differences of somatotypes appeared to be strongest for endomorphy, with generally higher values in women (Table 2, Figure 1), consistent with previous findings that women have a higher total fat mass than men (Pavlovsky and Kobyliansky, 1997) [48]. We also noted that patterns (directions) of age-related somatotype changes were generally similar in males and females. However, in females, the changes of the mean values of somatotype components were more prominent. Male endomorphy remained almost unchanged after age 30, but the female's increased until the 6^{th} decade, thereafter decreasing. The age group 18–30 revealed virtually no differences in mesomorphy and very small differences in ectomorphy between males and females. In addition, we observed a reduction of sexual dimorphism in all somatotype components after age 70. These findings are consistent with Buffa's et al. (2005) [6] study of a Sardinian population.

Age-related trends: The largest difference of all somatotype components was between the ages of 18–30 and 31–40. Subsequently, the somatotype remained virtually unchanged. The mesomorphy continued to increase until the 5th decade, in both sexes, while the endomorphy in females, continuously increased until the 6^{th} decade. During the 7^{th} and 8^{th} decades, we observed a decrease in the mean values of endomorphy in females, in accordance with Arking (1998) [2] and Buffa et al. (2005) [6] who indicated a constant increase of weight, the BMI, and fat mass, followed by an inversion of this tendency in the advanced age. The age at which a normal decrease of body weight occurs has not been clearly defined due to the wide individual and interpopulation variability characterizing the aging process. A number of studies place this inversion at approximately 60 years (Elia, 2001) [15], concurring with our results; whereas another study designates the age of inversion at approximately 75 years of age (Perissinotto et al., 2002). [50]

Mesomorphy and ectomorphy showed the opposite age-related trends. Mesomorphy increased until the 5^{th} decade in both sexes, whereas ectomorphy tended to decrease until the 5^{th} decade. Subsequently, the mean values of the mesomorphy decreased and, accordingly, the mean values of the ectomorphy increased. The studies of the somatotypes in different elderly populations have shown the results parallel to ours. Bailey et al. (1982) [3] and Buffa et al. (2005) [6] in a Canadian study, reported a decrease of endomorphy and mesomorphy after 60 years of age accompanied by an increase of ectomorphy. Gaur and Singh (1997) [16] reported the same trend in a sample of Indian men, where the variation occurred after 55 years of age.

The opposite trend in age related changes of ectomorphy and endomorphy, obtained in the present study, can be partially explained by the negative correlations between the somatotype components. The correlations obtained in our study are very similar to those previously reported by Katzmarzyk et al. (2000) [29]: endomorphy-mesomorphy: 0:59; endomorphy-ectomorphy: –0:75; and mesomorphy-ectomorphy: –0:79. Therefore endomorphy and ectomorphy could be viewed as being on opposite ends of the same continuum: leanness –fatness.

In our study, patterns of change in ectomorphy mean values were almost similar in both sexes. The mean values became significantly lower between the ages 18–30, 31–40 and 41–50. From the age 50 onwards there was almost no change in the mean values of ectomorphy. The reduced development of ectomorphy corresponded to the decreased linearity of the body, i.e., the greater mass in relation to a smaller height. We did not expect a decrease in the linear parameters of the body in the ages 18–50, therefore, the observed phenomenon can be explained by the increase in the body mass (that was actually observed in the same ages, see endomorphy) with no change in longitudinal parameters, or by secular trends of increasing the stature in younger individuals in the population (Bodzsar and Susanne, 1998) [5].

Diversity in the somatotype components in different ages observed in a cross-sectional study can reflect two trends: 1) the change of body composition with age, 2) the interpopulation secular trends of the body physique. The use of cross-sectional samples does not allow us to distinguish between the two causes. Therefore, the results of this study should be compared to the results of investigations in other populations and with longitudinal data.

Association with blood pressure: The statistically significant canonical correlation of blood pressure with the H-C somatotype was clearly observed in our study (Table 3), with the correlation coefficient 0.28. The latter finding is consistent with the results of Toselli et al. (2001), which, despite their statistical insignificance, showed similarity to ours. The canonical correlation analysis also allowed us to uncover that the joint characteristics of SBP and DBP could be predicted by a combination of somatotype components.

As mentioned above, we divided our sample into three clusters based on H-C somatotype (Figure 2). We found statistically significant differences between those clusters vis-à-vis the BP traits (Table 4). The persons belonging to Cluster 3 according to H-C (i.e. full-bodied type) had the highest mean values of SBP and DBP, while those belonging to cluster 1 showed the lowest values. Our results are in a good concordance with those of Malina et al. (1997) [43] and of Koleva et al. (2002) [36], except that the latter investigations studied people suffering from clinical hypertension, whereas we investigated people representing the full spectrum of blood pressure values. Even so, our results indirectly confirm the conclusions of Apanasevich et al. (1990) [1] and Valkov et al. (1996) [61] that high ectomorphy and mesomorphy somatotypes pose a risk factor for hypertension.

Association with skeletal aging traits: In our current study, the geometric features of bones were represented by the metacarpal CI, which describes the ratio between the combined cortical thickness on both sides of the bone image and the total diameter of the bone. A decrease in the cortical thickness is one of the major indicators of the osteoporosis onset and is also among the risk factors for bone fractures (Plato et al., 1994; Kobyliansky et al., 1996) [49]. In our study we found a statistically significant canonical correlation between CI and the set of H-C somatotypes.

The associations between body weight and the BMI and osteoarthritis, e.g., osteoarthritis development in the hip, have also received mention elsewhere (Oliveria et al., 1999) [46], but the claims were less compelling. Inconsistent results have also been reported concerning the association between the BMI and hand osteoarthritis (Davis et al., 1990; Carman et al., 1994; Hochberg et al., 1995; Oliveria et al., 1999) [11,7,19,46]. Sturmer et al. (2000) [56] observed overweight to be strongly associated with bilateral knee osteoarthritis, but no association was found with hip osteoarthritis or generalized osteoarthritis; they concluded that obesity seems to be a mechanical rather than a systematic risk factor for osteoarthritis. Our study shows that, after the adjustment for age and sex, the index of hand osteoarthritis showed the statistically significant canonical correlation with the set of H-D somatotypes (r=0.18). We also found that individuals with a robust body type higher values of TotOA, then the individuals with the mean values of somatotypes or mostly ectomorphyc individuals. Since the hand joints do not bear the weight of the body, it would be rather difficult to imagine how body weight would affect them. We concur with Sturmer et al. (2000) [56] who maintain that obesity is one of the factors that increases the load on the weight-bearing joints, such as the knees. Our finding is thus in accordance with Carman et al. (1994) [7], who showed that baseline obesity was significantly associated with a 23-year incidence of osteoarthritis of the hands among the subjects who were disease-free at their entrance examination. It provides us a possibility to suggest that in addition to mechanical forces, the basic metabolism level can also influence the osteoarthritis development.

As mentioned above, the osseometric score describes the skeletal changes of the hand bones and joints, and it has demonstrated a very high correlation with the biological age (Kobyliansky et al., 1995; Karasik et al., 1999) [35,27]. The age-adjusted osseometric score is actually a measure of the rate of the aging process, and as we have shown, this measure significantly correlated with set of H-C somatotypes ($r=0.27$). Here, as well the robust individuals showed the higher values of the Osseometric score.

CONCLUSIONS

The present study demonstrates that the somatotype, being an index of physique, can be useful in epidemiologic studies of aging and age-related conditions. The use of the somatotype method appears promising especially in the study of age related conditions, that strongly associated with the body composition, such as the blood pressure variation (Kalichman et al., 2004) [22] and the skeletal aging manifestations as osteoporosis and osteoarthritis (Kalichman et al., 2005) [24]. The results of our study clearly suggest that in physique investigations the somatotypes need to be studied in each sex separately; and in the studies of young population it needs also to be adjusted to age.

The present study provides convincing evidence for a connection between the indices of aging such as blood pressure and skeletal aging characteristics and physique characteristics. The people with a robust body build had higher mean values of SBP, DBP, TotOA and the Osseometric score, while scrawny persons presented the lowest values. This last finding could hopefully be used as a diagnostic tool, as well as a preventive measure in the management of hypertension, osteoarthritis and osteoporosis.

REFERENCES

1. Apanasevich VV, Zborovskii EI, Kozlov ID, Fomina RF, Avramenko TV. (1990) Ischemic heart disease in people of different somatotypes. Ter Arkh, 68, 47–9.
2. Arking, R. (1998) Biology of aging. Sunderland, MA. Sinauer Associates, Inc.
3. Bailey, D.A., Carter, J.E.L., Mirwarld, R. (1982) Somatotypes of Canadian men and women. Hum. Biol., 54, 813–828.
4. Bhuiyan, A.R., Gustat, J., Srinivasan, S.R., Berenson, G.S. (2003). Differences in body shape representations among young adults from a biracial (Black-White), semirural community: the Bogalusa Heart Study. Am. J. Epidemiol., 158, 792–797.
5. Bodzsar, E.B., Susanne. C. (1998) Secular growth changes in Europe. Budapest. Eötvös University Press.
6. Buffa, R., Succa, V., Garau, D., Marini, E., Floris, G. (2005) Variations of somatotype in elderly Sardinians. Am. J. Hum. Biol., 17, 403–411.
7. Carman WJ, Sowers MF, Hawthrone VM, Weissfeld LA. (1994) Obesity as risk factor for osteoarthritis of the hand and wrist: a prospective study. Am J Epidemiol, 139,119–129.
8. Carter, J.E.L, Heath, B.H. (1990) Somatotyping: development and applications. Cambridge. England. Cambridge University Press.
9. Carter, J.E., Parizkova, J. (1978) Changes in somatotypes of European males between 17 and 24 years. Am. J. Phys. Anthropol, 48, 251–254.
10. Cressie, N.A.C., Withers, R.T., Craig, N.P. (1986) The statistical analysis of somatotype data. Yrbk. Phys. Anthropol, 29, 197–208.
11. Davis, M.A., Ettinger, W.H., Neuhaus, J.M. (1990) Obesity and osteoarthritis of the knee: evidence from the national health and nutrition examination survey (NHANES I). Semin Arthritis Rheum, 20, 34–41.
12. Deriabin, V.E. (1985) Construction of a typology for distribution of body mass by body segments in men using the main component method. Nauchnye Dokumenti Vysshei Shkoly Biologicheskoi Nauki, 6, 62–67.

13. Deriabin, V.E. (1991) The use of component analysis for assessing the physical development of men. Nauchnye Dokumenti Vysshei Shkoly Biologicheskoi Nauki, 7, 70–78.
14. Eiben, O.G., Buday, J., Bosze, P. (2004) Physique of patients with carcinoma of the female genital tract. Eur. J. Gynaecol. Oncol., 25, 683–638.
15. Elia, M. (2001) Obesity in the elderly. Obes. Res., 9 (Suppl 4), 244–248.
16. Gaur, R., Singh, R.P. (1997) Age differences in somatotype of Gartwali males 17–60 years of age. Am. J. Hum. Biol., 9, 285–290.
17. Heath, B.H., Carter, J.E. (1967) A modified somatotype method. Am. J. Phys. Anthropol., 27, 57–74.
18. Herrera, H., Rebato, E., Herna´ndez, R., Herna´ndez-Valera, Y., Alfonso-Sa´nchez, M.A (2004) Relationship between somatotype and blood pressure in a group of institutionalized Venezuelan elders. Gerontology, 50, 223–229.
19. Hochberg, M.C., Lane, N.E., Pressman, A.R., Genant, H.K., Scott, J.C., Nevitt, M.C. (1995) The association of radiographic changes of osteoarthritis of the hand and hip in elderly women. J Rheumatol, 22, 2291–2294.
20. Kalichman, L., Cohen, Z., Kobyliansky, E., Livshits, G. (2002) Interrelationship between bone aging traits and basic anthropometric characteristics. Am. J. Hum. Biol., 14, 380–390.
21. Kalichman, L., Kobyliansky, E., Malkin, I., Yakovenko, K., Livshits, G. (2003) Search for linkage between hand osteoarthritis and 11q 12–13 chromosomal segment. Osteoarthritis Cartilage., 11, 561–568.
22. Kalichman, L., Kobyliansky, E., Livshits, G. (2004) Association between somatotypes and blood pressure. Ann. Human. Biol., 31, 466–476.
23. Kalichman, L., Livshits, G., Kobyliansky, E. (2006) Association between morbidity and skeletal biomarkers of biological aging. Hum Biol., 78, 77–88.
24. Kalichman, L., Malkin, I., Kobyliansky, E. (2005) Association between physique characteristics and hand skeletal aging status. Am. J. Phys. Anthopol. (Epub ahead of print).
25. Kalichman, L., Malkin, I., Livshits, G., Pavlovsky, O., Batsevich, V., Kobyliansky, E. (2007). Variation of skeletal biomarkers of biological aging in a Chuvashian population: longitudinal study. Am J Hum Biol., 19, 74–81.

26. Karasik, D., Otremski, I., Barach, I., Yakovenko, K., Batsevich, V., Pavlovsky, O., Kobyliansky, E., Livshits, G. (1999) Comparative analysis of age prediction by markers of bone change in the hand assessed by roentgenography. Am J Human Biol., 11, 31–43.
27. Karasik, D., Pavlovsky, O., Batsevich, V., Livshits, G., Kobyliansky, E. (2000) Use of the hand bones roentgenographs in the prediction of age in nine human populations. Anthropol Anz., 58, 199–214.
28. Katzmarzyk, P.T., Malina, R.M. (1999) Body size and physique among Canadians of First Nation and European ancestry. Am. J. Phys. Anthropol., 108, 161–172.
29. Katzmarzyk, P.T., Malina, R.M., Perusse, L., Rice, T., Province, M.A., Rao, D.C., Bouchard, C. (2000) Familial resemblance for physique: heritability for somatotype components. Ann Hum Biol., 27, 467–477.
30. Katzmarzyk, P.T., Malina, R.M., Song, T.M., Bouchard, C. (1999) Physique, subcutaneous fat, adipose tissue distribution, and risk factors in the Quebec Family Study. Int. J. Obes. Relat. Metab. Disord., 23, 476–484.
31. Kellgren, J.H., Lawrence, J.S. (1957) Radiologic assessment of osteoarthrosis. Ann Rheum Dis., 16, 494–501.
32. Kellgren, J.H., Lawrence, J.S. (1963) Atlas of standard radiographs: The epidemiology of chronic rheumatism. Vol. 2. Oxford. Blackwell Scientific Publications.
33. Kirchengast, S., Peterson, B., Hauser, G., Knogler, W. (2001) Body composition characteristics are associated with the bone density of the proximal femur end in middle- and old-aged women and men. Maturitas, 39, 133–145.
34. Kobyliansky, E., Karasik, D., Belkin, V., Livshits, G. (2000) Bone ageing: genetics versus environment. Ann Hum Biol., 27, 433–451.
35. Kobyliansky, E., Livshits, G., Pavlovsky, O. (1995) Population biology of human aging: methods of assessment and sex variation. Hum Biol., 67, 87–109.
36. Koleva, M., Nacheva, A., Boev, M. (2002). Somatotype and disease prevalence in adults. Rev Environ Health, 17, 65–84.
37. Kretschmer, E. (1921) Physique and character: An investigation of the nature of constitution and the theory of temperament. New York. Harcourt Brace.
38. Livshits, G., Karasik, D., Kobyliansky, E. (2002a.) Complex segregation analysis of the radiographic phalanges bone mineral density and their age-related changes. J. Bone Miner. Res., 17, 152–161.

39. Livshits, G., Pavlovsky, O.M., Kobyliansky, E. (1996) Population biology of human aging: segregation analysis of bone aging characteristics. Hum Biol., 68, 539–554.
40. Livshits, G., Roset, A., Yakovenko, K., Trofimov, S., Kobyliansky, E. (2002) Genetics of human body size and shape: body proportions and indices. Ann. Hum. Biol., 29, 271–289.
41. Livshits, G., Yakovenko, K., Ginsburg, E., Kobyliansky, E. (1998) Genetics of human body size and shape: pleiotropic and independent genetic determinants of adiposity. Ann. Hum. Biol., 25, 221–236.
42. Lohman, T.G., Roche, A.F., Martorell, R. (1988) Anthropometric standardization reference manual. Champaign, IL: Human Kinetics.
43. Malina, R.M., Katzmarzyk, P.T., Song, T.M.K., Theriault, G., Bouchard, C. (1997) Somatotype and cardiovascular risk factors in healthy adults. Am. J. Hum. Biol., 9, 11–19.
44. Monyeki, K.D., Toriola, A.L., de Ridder, J.H., Kemper, H.C., Steyn, N.P., Nthangeni, M.E., Twisk, J.W., van Lenthe, F.J. (2002) Stability of somatotypes in 4 to 10 year-old rural South African girls. Ann. Hum. Biol., 29, 37–49.
45. National Center for Health Statistics. NHANES Anthropometry Procedures Manual. 2004. http://www.cdc.gov/nchs/data/nhanes/nhanes_01_02/body_measures_year_3.pdf.
46. Oliveria, S.A., Felson, D.T., Cirillo, P.A., Reed, J.I., Walker, A.M. (1999) Body weight, body mass index, and incident symptomatic osteoarthritis of the hand, hip, and knee. Epidemiology, l0, 161–166.
47. Pavlovsky, O.M. (1987. Biological age of man (in Russian). Moscow: Moscow University Press.
48. Pavlovsky, O., Kobyliansky, E. (1997) Population biology of human aging. Firenze, Italy: Angelo Pontecoroboli Editore. Publishing House.
49. Plato, C.C., Fox, K.M, Tobin, J.D. (1994) Skeletal changes in human aging. In: Crews DR, Garruto RM, editors. Biological anthropology and aging. New York. Oxford University Press, 272–300.
50. Perissinotto, E., Pisent, C., Sergi, G., Grigoletto, F. (2002) ILSA Working Group (Italian Longitudinal Study on Ageing). Anthropometric measurements in the elderly: age and gender differences. Br. J. Nutr., 87, 177–186.
51. Ravaglia, G., Forti, P., Maioli, F., Nesi, B., Pratelli, L., Cucinotta, D., Bastagli, L., Cavalli, G. (2000) Body composition, sex steroids, IGF-1, and bone mineral status in aging men. J. Gerontol. A Biol.,. Sci. Med. Sci., 55, M516–521.

52. Rebato, E., Rosique, J., Gonzalez Apraiz, A.(1996) Somatotypes of 14 to 19 years old urban boys and girls from Bilbao (Basque Country). Anthropol. Anz., 54, 135–147.
53. Sheldon, W.H. (1950) The somatotype, the morphophenotype and the morphogenotype. Cold Spring Harb Symp Quant Biol., 15, 373–82.
54. Singal, P., Sidhu, L.S. (1984) Age changes and comparison of somatotypes during 20 to 80 years in Jat-Sikh and Bania females of Punjab (India). Anthropol. Anz., 42, 281–289.
55. StatSoft Inc. (2001) STATISTICA (data analysis software system), version 6. www.statsoft.com.
56. Sturmer, T., Gunter, K.P, Brenner, H. (2000) Obesity, overweight and patterns of osteoarthritis: the Ulm osteoarthritis study. J Clin Epidemiol., 53, 307–313.
57. Suk, E.K., Malkin, I., Dahm, S., Kalichman, L., Ruf, N., Kobyliansky, E., Toliat, M., Rutsch, F., Nurnberg, P., Livshits, G. (2005) Association of ENPP1 gene polymorphisms with hand osteoarthritis in a Chuvasha population. Arthritis. Res. Ther., 7, R1082–1090.
58. Tambovtseva, R.V., Zhukova, S.G. (2005) Age-related changes of somatotype and body mass components in girls Morfologiia., 127, 48–51. (in Russian).
59. Tischkov, V.A. (1994) People of Russia. Encyclopedia. Moscow. Great Russian Encyclopedia Publ. House (in Russian).
60. Toselli, S., Tarazona-Santos, E., Pettener, D. (2001) Body size, composition, and blood pressure of high-altitude Quechua from the Peruvian central Andes. Am J Hum Biol., 13, 539–547.
61. Valkov, J., Matev, T., Hristov, I.(1996) Relationship between somatotype and some risk factors for ischemic heart disease. Folia Med (Plovdiv), 38, 17–21.
62. Williams, S.R.P., Goodfellow, J., Davies, B., Bell, W., McDowell, I., Jones, E. (2000) Somatotype and angiographically determined atherosclerotic coronary artery disease in men. Am. J. Hum. Biol., 12, 128–138.
63. Wilson, B.R., Olson, H.W., Sprague, H.A., Van Huss, W.D., Montoye, H.J. (1990) Somatotype and longevity of former university athletes and nonathletes. Res. Q. Exerc. Sport., 61, 1–6.

Address for correspondence:
Prof. Eugene Kobyliansky
PhD or Leonid Kalichman, PhD
E-mail: anatom14@post.tau.ac.il; kalihman@zahav.net.il

Papers on Anthropology XVI, 2007, pp. 170–179

RELATIONSHIP BETWEEN AGE AT MENARCHE AND ADULT BODY MASS INDEX (BMI)

Dzintra Kažoka, Jānis Vētra

Riga Stradiņš University, Institute of Anatomy and Anthropology,
Riga, Latvia, LV-1010

ABSTRACT

The aim of the present study was to investigate the relationship of age at menarche with adult the BMI during 2001–2005 among 863 females in the age from 18 to 65 and 66+ years in Latvia.

The data from this study included some anthropometrical measurements (body height (cm) and body weight (kg)). The age at menarche was obtained by a questionnaire. The body mass index (BMI) was calculated, and it was categorized as underweight, normal, overweight and obesity. All the women were divided into four categories by age at menarche (I (early) – before 11.99 years; II – 12.0–12.99 years, III – 13.0–13.99 years; IV (late) – older than 14 years) and into seven age groups (18–20, 21–25, 26–35, 36–45, 46–55, 56–65, 66+).

The mean age at menarche was 13.39±1.35 years. 40.7% of all the measured women matured at the age older than 14 years and 31.6% – at the age 13.0–13.99 years. Menarcheal age was inversely related to the adult levels of the BMI among adults in some age groups. Menarcheal age was not significantly related to adult height, but early maturers were shorter than late maturers.

The mean BMI was 23.29±4.58 kg/m^2. About 66.5% of women had normal body weight and 17.8% of women were overweight. The women with ages at menarche before 11.99 years and during 12.0–12.99 years showed higher mean BMI values compared with the BMI values of women matured after the age 13.0–13.99 years and older than the age 14. The mean ages of menarche of women with underweight and obesity showed a tendency that these women matured later than the women with a normal body weight and overweight.

Key words: female, menarche, anthropometric measurements, body mass index (BMI)

INTRODUCTION

The studies and the analysis of maturation time, body composition and their variations have always been interesting in human biology. The age at menarche is often used as an indicator of the pubertal maturation, and it is in fact the most reliable one among the biological indices to show ecological and social influences on growth and development [5]. It varies between individuals and between populations [2, 6, 7, 8]. The nature of the relationship between age at menarche and adult life anthropometric measures may be important in understanding the importance of this measure on disease in later life. The age at menarche of women has some significant effects on the body mass index (BMI). The BMI is widely used as an index of obesity in people from the school age children to adults, and it is an important factor in the onset of overweight and obesity [3, 9]. If there is a true causal link between the age at menarche and the adult BMI, it can be argued that this relationship plays a role in explaining the main trends between earlier and later obesity. Other factors across the life course may also explain or mediate the relation between the age of menarche and the adult BMI. No studies or few reports of the association of age at menarche and the adult BMI have taken in Latvia. The aim of the present study was to investigate the relationship between the coming time of menarche with the adult BMI for women in Latvia.

MATERIAL AND METHODS

The material comprised 873 women from 18 to 65 and 66+ years of age measured during the period 2001–2005 in Latvia. All anthropometric measurements were carried out according to the methodological recommendations by R. Martin and K. Saller [10], using the Swiss company's "Siber-Hegner and Co" anthropometric instruments.

In anthropometrical measurements the body height (cm) and the body weight (kg) were included. The body height was measured using a metal anthropometer. For the evaluation of the body weight, we used a portable scale with a 0.1 kg precision. All the anthropometric measurements were measured by the author of this study together with the medical nurses of the anthropology unit of the Institute of Anatomy and Anthropology (IAA). The age at menarche was obtained from a questionnaire. Women were asked to identify the year of their first menarche with the help of question such as, "Do you remember what age you were in when you started having menarche?" All the women were divided into four categories by the age at menarche: I (early) – before 11.99 years; II – 12.0–12.99 years, III – 13.0–13.99 years; IV (late) – older than 14 years. The body mass index (BMI) was calculated as the weight in kg/height in m^2. The BMI was categorized as underweight ($\leq$18.49 kg/m^2), normal (18.5–24.99 kg/m^2), overweight (25.0–29.99 kg/m^2) and obesity ($\geq$30.0 kg/m^2) according to the classification system recommended by the WHO [21]. Generation (age group) differences between the mean values of age at menarhe and the BMI showed the division of all the women by their present age into seven groups (18–20, 21–25, 26–35, 36–45, 46–55, 56–65, 66+). Data analysis was performed using SPSS 10.0 for Windows method at the Institute of Anatomy and Anthropology and Physics Department of Riga Stradiņš University.The standard statistical methods were used to present mean values, standard deviations, significances of mean values and correlations of intraindividual differences. The statistical significance of differences between age groups was tested using the Student's *t* test. The Pearson correlation coefficient (r) was used to determine the relationships between continous dependent variables. The level of significance was set at $p<0.01$; $p<0.05$; $p<0.001$.

RESULTS

The mean age of the studied women was 28.78±13.76 years. The mean age at menarche according to the BMI of women in Latvia was presented in Table 1. The means and standard deviations of various anthropometric values (body height, body weight and (BMI) according to the age at menarche of women was shown in Table 2.

Table 1. Mean age at menarche (years) according to body mass index (BMI) of women in Latvia (2001–2005)

BMI group	Women		Mean age at menarche±SD
	n	%	
Underweight (BMI≤18.49)	62	7.1	13.84±1.41
Normal (18.5≤BMI≤24.99)	581	66.5	13.32±1.37
Overweight (25.0≤BMI≤29.99)	155	17.8	13.43±1.17
Obesity (BMI≥30.0)	75	8.6	13.53±1.45
Total	873	100	13.39±1.35

n – number of women; SD – standard deviation

Table 2. Means and standard deviations of various anthropometric values according to age at menarche of women in Latvia (2001–2005)

Anthropometric value	Menarcheal age (years) group			
	≤11.99	12.0–12.99	13.0–13.99	≥14.0
n (%)	68 (7.8%)	174 (19.9%)	276 (31.6%)	355 (40.7%)
Body height, cm	163.61±6.03	164.77±6.28	165.80±6.48	165.09±6.95
Body weight, kg	63.25±12.28	63.29±11.68	63.62±12.36	63.01±12.32
BMI, kg/m^2	23.62±4.62	23.32±4.32	23.17±4.50	23.18±4.70

n – number of women

The age at menarche:

The mean age at menarche was 13.39±1.35 years (Table 1). This value ranged from the minimum 10.0 years to the maximum 19.0 years. 40.7% of all the measured women matured at the age older than 14.0 years and 31.6% – at the age 13.0–13.99 years (Table 2). 7.8% women matured before the age 11.99 years, but 19.9% women – at the age 12.0–12.99 years.

Body mass index (BMI):

In this study population the mean BMI was 23.29±4.58 kg/m^2 (Table 3). These BMI values ranged from the minimal 15.64 kg/m^2 (underweight) to the maximal 48.0 kg/m^2 (obesity). About 66.5 % of women had normal body weight and 17.8 % of women were overweight (Table 1). For all the women the prevalence of underweight was 7.1%, but the prevalence of obesity – 8.6%.

Table 3. Means, standard deviations of anthropometrical values for female in different age groups

Age group (years)	n	Body height (cm)	Body weight (kg)	Age at menarche (years)	BMI (kg/m^2)	p
18–20	349	166.76±6.37	59.91±8.84	13.30±1.35	21.52±2.83	*
21–25	201	165.56±6.23	59.51±9.24	13.29±1.25	21.69±3.17	**
26–35	94	165.06±6.35	64.31±12.34	13.27±1.34	23.59±4.27	n.s.
36–45	105	163.86±6.40	70.40±14.31	13.40±1.43	26.25±5.35	**
46–55	61	161.95±6.56	72.18±14.39	13.43±1.29	27.47±4.92	n.s.
56–65	44	160.65±5.20	73.16±13.58	14.16±1.35	28.31±4.94	*
66+	19	157.42±5.93	73.55±19.19	14.53±1.42	29.53±6.94	n.s.
Total	873	165.10±6.62	63.38±12.22	13.39±1.35	23.29±4.58	n.s.

n – number of women; p – statistically significance (age at menarche and BMI): * $p<0.05$; ** $p<0.01$;
n.s. – not significant

The age at menarche and the BMI:
The age at menarche was associated with the different categories of the BMI of adult women. The mean values of the age at menarche of women with underweight (13.84±1.41 years) and obesity (13.53±1.45 years) showed a tendency that these women matured later than the women with normal body weight (13.32±1.37 years) and overweight (13.43±1.17 years) (Table 1). Differences were statistically significant ($p<0.001$).

The women with ages at menarche before 11.99 years and during 12.0–12.99 years showed higher mean BMI values (23.62±4.62 kg/m^2 and 23.32±4.32 kg/m^2) compared with the BMI values of the women matured after age 13.0–13.99 years and older than the age 14 (23.17±4.50 kg/m^2 and 23.18±4.70 kg/m^2) (Table 2).

There was a statistically significant ($p<0.01$) and a negative ($r=-0.120$) correlation (data not shown) between the age at menarche and the BMI in the group of women with the normal BMI range. In the group of women with the age at menarche 12.0–12.99 was found statistically significant ($p<0.05$) and positive ($r=0,152$) correlation (data not shown) between the age at menarche and the BMI.

Body height and body weight:

Early menarche was associated with shorter women, but the late menarche was associated with taller women (Table 2). The mean body height was 165.10±6.62 cm (Table 3). The mean height reached maximum in the age-group 18–20, and it was 166.76±6.37 cm. Height was close to the normal distribution and showed a significant decrease with age ($p<0.01$). Older women were shorter than younger women. The body height reached a minimal value of 157.42±5.93 cm at age-group 66+ (Table 3).

The mean body weight was 63.38±12.22 kg (Table 3). The lesser mean values of the body weight were in the age-group 18–20 (59.91±8.84 kg) and in the age-group 21–25 (59.51±9.24 kg). The body weight increasing started after the age 25. Older women were heavier than younger women ($p<0.01$). The body weight reached a maximal value of 73.55±19.19 kg in the age-group 66+.

The age at menarche was positively associated (data not shown) with the body height and negatively associated with the body weight (all correlations were not significant).

Generation (age group) differences of the age at menarche and the BMI:

The mean BMI increased significantly with age ($p<0.01$). The mean values of the BMI ranged from the normal range until the age 35 (Table 3). After the age 35 all the mean values of the BMI showed overweight. The maximal mean value of the BMI (29.53±6.94 kg/m^2) was in the age-group 66+.

The BMI of the adult women was inversely associated with the mean age at menarche in some age groups of women (Table 3). There were statistically significant and negative associations between the age at menarche and the BMI in the next age groups: 18–20 years ($p<0.05$; $r=-0.108$), 21–25 years ($p<0.01$; $r=-0.219$), 36–45 years ($p<0.01$; $r=-0.212$) and 56–65 years ($p<0.05$; $r=-0.351$). In other age groups correlations between the age at menarche and the BMI were not found.

The mean values of age at menarche in some age groups of women showed the specific pattern of secular trend. The women born after 1970 were characterized by an intensive trend towards earlier sexual maturation than the women born after 1930 (Table 3). The period for women born after 1970 was characterized by the stability of the mean age at menarche (variation was small).

DISCUSSION

Obesity is a major public health problem. It is one of the major risk factors of many serious diseases such as hypertension, cerebrovascular and cardiovascular diseases, diabetes, breast cancer, colon cancer, respiratory problems, etc. [1, 15, 18]. Several methods are available to measure obesity, but in recent years the BMI is the most widely utilised indicator of it [16]. The BMI is widely used in general medicine around the world as an indicator expressing the level of obesity. The value of the BMI increases by age in the adult population. In our study the proportion of women with obesity increased after the age 35. In the younger age groups the means of the BMI remained in the non-obese range. The prevalence of obesity is increasing in adults worldwide [11, 14].

Individual variability in the tempo of growth, maturation and ageing can be very different. For a adult female the time of her first menstruation, an evident and easily observable symptom of maturity, is usually well remembered. The age at menarche is an indicator of physiological development and it has been studied extensively in many countries [13]. The age at menarche has been found to be associated with the biological, socioeconomic environment and genetical constitution. Menarche is the most applied criterion for estimations of sexual maturity as it is objective, thus comparisons between social classes, generations and populations are possible. In this study the mean value of menarche was 13.39 years. In Latvia the mean age at menarche showed a secular trend of earlier menstruation for women born after 1970 than for the women born after 1930.

The age at menarche plays an important role in determining the BMI. Early age at menarche, together with other indicators of early biological maturity, has been shown to be associated with the increased adult BMI [19]. Some studies found a negative relation between the age at menarche and the adult BMI, and the age at menarche has been declining at the same time as the adult BMI has been increasing, although the rate of decline has slowed or stopped in some countries in recent times [12, 20]. Whether early age at menarche is causally associated with increased adult obesity is unclear because many factors are related to both the age at menarche and adult obesity. The association between early menarche and adult obesity may be largely (or wholly) due to the association between earlier and later obesity.

Different factors across the life course may also explain the relationship between the age of menarche and the adult BMI. The socioeconomic status of women at birth and during adult life is associated with the BMI in adult life. The associations between the age at menarche and the adult BMI may be mediated by various interrelationships among hormones, sexual maturation and body fat. Various behavioural factors may also be important in this association, with an early puberty possibly resulting in the changes in eating habits or physical activity [17]. No studies of the association of age at menarche and the adult BMI have taken all of these factors into account simultaneously. This is the first time that the relationship between the age at menarche and the BMI has been reported in a population of adult women during the recent years in Latvia. There was an inverse association of the age at menarche with the BMI in some age groups. The women, who had a relatively early sexual maturation, showed a tendency of higher mean values of BMI. For example, Garn et al. [4] found that the women (ages 20 to 35 years), who reported menarche before the age 11.0 years, were heavier than those, who underwent menarche after 14.0 years. Our results showed that the women, who reported, that they underwent menarche before the age 11.99 years had, on average, higher adult levels of BMI than did the women, who underwent menarche after the age 14.0 years.

Although the biological mechanisms underlying the inverse association between the age at menarche and adult obesity are uncertain, it has been suggested that early maturing women may have a longer period of positive energy balance or that various endocrine factors influence both the rate of sexual maturation and the accumulation of body fat.

In conclusion, our findings indicated that the age at menarche of women had some significant effects on the BMI, it was an important factor in the onset of overweight and obesity. There was a biological determinant of the observed association between the age at menarche and the adult women BMI. In this study we found that early age at menarche was associated with the adult BMI in some age groups. More research is needed to further understand how the risk factors that occur early in life may be modified by adult lifestyle choices, since this could have important implications for reducing the burden of adult overweight and obesity.

REFERENCES

1. Burke G.L., Savage P.J., Manolino T.A., et al. (1992) Correlates of obesity in young black and white women: the CARDIA study. Am J Public Health, 82, 1621–1625.
2. Freedman D.S., Kettel K.L., Serduia M.K., et al. (2001) The relation of age at menarche to race, time period, and anthropometric dimensions: the Bogalusa Heart Study Pediatrics, 110, E43.
3. Frisancho A.R., Housh C.H. (1988) The relationship of maturity rate to body size and body proportions in children and adults. Hum Biol, 60, 759–770.
4. Garn S.M., Lavelle M., Rosenberg K.R., et al. (1986) Maturational timing as a factor in female fatness and obesity. Am J Clin Nutr, 43, 879–883.
5. Godina E. (1996) Age at menarche in the former Soviet Union. In: Bodzsar B.E., Susanne C. eds., Studies in Human Biology, Eötvös Univ. Press, Budapest, 215–220.
6. James W.P. (1996) The epidemiology of obesity. In: Chadwick D.J., Cardrew G., eds. The origins and consequences of obesity. Chichester, United Kingdom, John Wiley, 1–16.
7. Katsunori F., Shinichi D. (2003) Relationship between change in BMI with age and delayed menarche in female athletes. J Physiol Anthropol, 22, 2, 97–104.
8. Lahti-Koski M. (2001) Body mass index and obesity among adults in Finland. Academic Dissertation. Helsinki, National Public Health Institute.
9. Laitinen J., Power C., Jarvelin M.R. (2001) Family social class, maternal body mass index, childhood body mass index and age at menarche as predictors of adult obesity. Am J Clin Nutr, 74, 87–94.
10. Martin R., Saller K. (1957) Lehrbuch der Anthropologie. Stuttgart. Fischer, Bd. I.

11. Molarius A. (2003) The contribution of lifestyle factors to socio-economic differences in obesity in men and women – a population-based study in Sweden. Eur J Epidemiol, 18, 227–234.
12. Must A., Phillips S., Naumova E., et al. (2002) Recall of early menstrual history and menarcheal body size: after 30 years, how well do women remember? Am J Epidemiol, 155, 672–679.
13. Okasha M., McCarron P., McEwan J., et al. (2001) Age at menarche: secular trends and association with adult anthropometric measures. Ann Hum Biol, 28, 68–78.
14. Power C., Lake J.K., Cole T.J. (1997) Body mass index and height from childhood to adulthood in the 1958 British born cohort. Am J Clin Nutr, 66, 1094–1101.
15. Power C., Parsons T. (2002) Overweight and obesity from a life-course perspective. In: Kuh D., Hardy R., eds. A life course approach to women's health. Oxford, United Kingdom, Oxford University Press, 304–328.
16. Rissanen A.M. (1996) The economic and psychosocial consequences of obesity. Ciba Found Symp, 201, 194–201.
17. Sharma K., Talwar I., Sharma N. (1988) Age at menarche in relation to adult body size and physique. Ann Hum Biol, 15, 431–434.
18. Sherman B., Wallace R., Bean J., et al. (1981) Relationship of body weight to menarchal age and menopausal age: implications for breast cancer risk. J Clin Endocrinol Metab, 52, 48–493.
19. St George I.M., Williams S., Silva P.A. (1994) Body size and menarche: the Dunedin Study. J Adolesc Health, 15, 573–576.
20. Wellens R., Malina R.M., Roche A.F., et al. (1992) Body size and fatness in young adults in relation to age at menarche. Am J Hum Biol, 4, 783–787.
21. World Health Organization (1995) Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. Geneva. World Health Organization.

Address for correspondence:
Dzintra Kažoka
Riga Stradiņš University, Institute of Anatomy and Anthropology,
Kronvalda blv. 9, Riga, Latvia, LV-1010,
E-mail: dzintra_kazoka@inbox.lv, aai_anat@inbox.lv
Tel. +371 7323501
Fax. +371 7320862

Papers on Anthropology XVI, 2007, pp. 180–185

SIGNIFICANCE OF MORPHO-FUNCTIONAL PARTICULARITY OF THE TOOTH IN PRACTICAL ODONTOLOGY

Irina Konstantinovna Lutskaya, Natalia Vladimirovna Novak

Department of Therapeutic Dentistry,
the Belarusian Medical Academy of Post Graduate Education

INTRODUCTION

The knowledge of properties of hard dental tissues of different age groups has an important practical role. It presents scientific interest in the understanding the specificity of dental diseases.

In the present work about 20 parameters of permanent caries-free teeth were studied. Modern methods were used for the investigation of dental tissue structures. The enamel and dentin were examined with the light and electron microscope with the method of interferential contrast. Physical properties were studied by the mikrohardnes meter and the profilemeter. Chemical components were also examined. The speed of outward flow of the water was studied with vacuum a chamber. Physiological properties were researched by determining the resistance of enamel to acid etching. It is known that after the removal of the surface layer by etching the remaining enamel surface is porous. The profile of an enamel etching surface was used as a measure of surface roughness. The variation in the degree of tooth surface etching has been investigated.

It was established that the changes in properties of hard dental tissues with age include decrease in porosity, permeability, electricianactivity, the humidity content. It was also indicated that there was increase in the amount of calcium, microhardness, structural resistance to acid etching (in vitro). It is most impossible that the resistance of enamel to acid etching may be changed immediately by a different action on the organism and dental pulp. Decreased or increased enamel resistance levels were observed. Such changes exist under various types of local influence, i.e. chemical, mechanical, electrical. The decrease or increase also occur under the influence of general systemic factors (drags, stress) [5].

The enamel of age tooth differs by its minimal functional variability, i.e. the decrease in active resistance to acid etching (in vivo).

The phenomena of active resistance to acid etching of enamel of a live tooth were discovered in the recent years in our laboratory headed by professor Okushko. These phenomena are based on the outward flow of the enamel liquid.

We used this fact for making a biological test of enamel resistance to short-time acid etching. The method may by interesting for distinguishing between the patients who will develop caries from those who will not develop any new lesions [1].

It was proved that caries resistance of populations and individuals differs from each other with a high enamel resistance 'to acid by its own method. The period of high risk to caries is always connected with the decrease in enamel acid resistance. It is a basis for practical recommendations in the individual prognosis and preventive caries treatment within a period of about 12 (twelve) months. The system of individual preventive measures was thought to increase the host resistance to the acid attack in the risk group. This method allows us to choose the most suitable medical remedy to an individual to reduce the diseases risk.

The test enamel resistance to acid etching may be used for prognoses of caries development in the age groups from 3 to 30 years [2, 3].

Modern restoring methods are based on the use of composites having good physical, chemical, aesthetic characteristics and high adhesion to the hard tooth tissue.

The basis for making these materials is the knowledge of the structure of hard tooth tissue as well as its physical and chemical characteristics. Modern materials have to meet the requirements in accordance with these data.

Such physical characteristics of tooth enamel as its color, brightness and transparency depend on the natural dentin coloring and on the ability of the enamel to absorb and reflect sunbeams. These parameters have formed the basis for working out a standard scale of natural enamel hues – Vita. Removing of dental deposit before chasing the hue of the filling material helps to determine the normal state of a tooth. Besides, the dental deposit prevents from treating and filling a tooth [1].

Enamel microhardness (360 MPa) demands a composite with similar characteristics. The low hardness of a composite would result in the filling abrasion, high hardness would result in tooth-antagonist abrasion.

The resistance of the enamel against abrasive materials has been studied. Microroughness of the surface after applying toothbrushes, pastes and toothpowder does not exceed 2–5 micrometers. Composites have similar characteristics [4].

Enamel and dentin bending and tensile strength help to determine the peculiarity of filling materials to be produced.

Chemical characteristics of the enamel require the composites that resist the influence of the mouth medium and considerable pH changes on the enamel surface under the dental deposit (7.0–4 0).

Tooth treating techniques and restorative therapy are based on the peculiarities of the enamel and dentin structure. The structural elements of the enamel (prisms) form microroughness on the tooth surface. Adhesion of the filling and the tooth is possible because of the ability of a composite to fill in the microspaces and remain on the enamel surface. That is why after the necrotomy of dental caries the edges of the enamel must be prepared. As a result of this:

1. The tooth and composite contact area becomes larger.
2. The organic membrane preventing from the acid treatment of the enamel and from the adhesion of the composite to the non-organic enamel structure is removed.
3. And finally, the border of the dental tissue and the filling material is hidden by means of the filling height when the edge of the enamel is oblique.
4. The transverse section of the enamel prisms is obtained, that is necessary to create microroughness [6].

Adhesion of a composite is improved by strengthening the relief by means of the acid treatment of the enamel. Medical tests show that acid treatment destroys mostly the core and the periphery of prisms providing microroughness of about 5 to 12 micrometer [4, 7].

The choice of the acid treatment agents depends on the chemical structure of the enamel. For example, calcium and phosphorus that form the basis of hard tooth tissue are displaced by hydrogen ions. 33 per cent phosphorous acid which is widely used in practice applied within 1 minute forms necessary relief of the surface.

Adhesive bonds like fluid resins are used to fill in the microspaces.

Dentin preparation and treatment techniques are based on the morphological peculiarities of the tissue.

Dentinal tubules that penetrate dentin from the pulp to enamel are filled with the dental liquid. Any toxin can easily affect the pulp through the dentin and cause pulp inflammation. That is why it is necessary to protect the pulp from mechanical and chemical irritants. A drill constantly cooled with water is needed to prepare the dentin. The basic layer is put on before treating the enamel with an acid in order to avoid acid-dentin contact or denthesive after aching acid. The choice of medical and/or isolating padding is based on the following data:

The number of dentinal tubules close to the pulp is 75,000 per square millimeter. The tubules cover about 80 per cent of the dentin, i.e. the surface of the dentin resembles a sieve and thus, when there is a cavity reaching the pulp an oxide or hydroxide padding should be used to protect live tissue from the filling material [1, 8].

In the middle parts of the dentin the tubules cover about 40–50 per cent. The distance to the pulp chamber becomes larger (up to 2 millimeters) that is why the padding is not applied. But an isolating and protective layer of indifferent materials such as phosphate cements must be put on.

Lastly, when the cavity is small, the number of dentinal tubules is 10 to 20 per cent of the live dentin and the space from the filling to the cavity in a tooth is considerable. In this case putting an isolating layer of the lacquer on the dentin is enough. In any case, dentin and composite should not come into contact.

This is necessary as most composite rehabilitative materials are toxic and affect the pulp through the dentinal tubules opening in the mouth cavity.

The other reason for this is a considerable amount of dental liquid. It composes 10–12 per cent of the weight and about 20 per cent of the volume of the dentin. The smaller part of it is tied up (the hydrant membrane of the crystals), the bigger part is floating. This is tooth or dentinal liquid that moves with the speed of 4 mm per hour in centrifugal direction under the influence of the intentpulp pressure (24 mm mercury column) and capillary force. It constantly moistens the prepared dentin surface. As most composites are hydrophanous, they had to be isolated from the wet dentin surface.

The peculiarities of the dentin structure have let us to produce a group of materials hardening a composite by adhesion to dentin. An adhesive penetrates into dentinal tubules strengthening the ties of a filling and a tooth [8].

The color of a composite is chosen in the very beginning and depends on the color of the enamel and the dentin. The latter has much darker, brownish hues. The enamel is brighter and more transparent. A composite is applied in the same way, layer by layer.

The filling must be polished thoroughly in order to be as transparent and bright as the enamel itself. Mineral components have to be restored as the acid treatment of the enamel reduces their number. The study of the enamel made it possible to work out hard at tooth tissue remineralization methods. For this purpose the demineralized parts of the enamel are protected and mineralized with special lacquers, gels, solutions.

REFERENCES

1. Луцкая И.К. Практическая стоматология. Минск. Бел. Навука. 1999. 360с.
2. М.Л. Заксон, Г.Д. Овруцкий, М.И. Пясецкий и др. (1993). Практическая геронтостоматология. Киев. Здоровья. 266с.
3. Holmen L, Thyltrupt. et al. (1985) A scanning electron microscopic study of surface changes during development of artificial caries. Caries Rec., 19, 1, 11–21.
4. Fejerskov O. (1984) Surface ultrastructure of unerapted nature human enamel. Fejerskov O., Josephsen V.G., Nyvad B. Caries Res., 18, 4, 302–314.
5. Grisimov V.N. (1998) Optical model of Hunter-Schreger Gands phenomenon in human enamel. Proc. SPIE., 3564, 237–242.
6. Human physiology. Eds. R.F. Schmidt, G.Thews. 1989. London etc. Springer. 225p.

7. Seppa L. (1984) A scanning electron microscopic study of early subsurface Bacterial Penetration of Human Molar-fissure enamel. Arch. Oral. Biol., 29, 7, 503–506.
8. Winter R. (1993) Visualizing the natural dentition. J. Esthet. Dent., 5, 3, 102–117.

Address for correspondence:
Professor J.K. Lutskaja
220013, Belorussia, Minsk, P. Brovki street 3
E-mail:info@belmapo.edu.by

Papers on Anthropology XVI, 2007, pp. 186–197

RESULTS OF CURRENT AND SOME OLDER STUDIES ON THE ESTIMATION OF STATURE

Boris Neruda

Private Institute for Studies in Science and Medicine
D-54585 Esch, Germany

Key words: stature, estimation, review, regression equations

INTRODUCTION

Using the measures of the parts of the body in order to draw conclusions upon the whole body constitutes one of the oldest problems of anthropology. Historically, it was first tried to solve this problem by expressing the measured part of the body as a percentage of stature. Such attempts go back to the 18^{th} century, but it was only in the 19^{th} century, when developing natural sciences have greatly contributed to put these efforts on a scientific basis. Not only was the basis laid for the application of statistical methods, notably by Karl Pearson, but also the new and more refined techniques of measurement were invoked.

The methodology applied for estimating stature is determined (a) by the purpose of the investigation, (b) the type and accessibility of the material, and (c) the available means. All of these do influence the results and the validity of the conclusions drawn. The direct anthropometric measurements of the parts of the body are mainly used for this purpose. However, other bodily characteristics have also served as indirect measures and as a rough estimate of human stature, e.g. the visual estimation of a person's height either standing or lying down or from a picture, the pitch level of the voice, or the stride length in normal walking and while walking fast. These methods certainly do not give precise estimates, but they may serve as a first guide in identifying a person.

(a) There are many motivations for the estimation of stature. Apart from solely heuristic reasons in the disciplines like evolution, anthropology, ethnology and other fields of science a substantial interest emerged from criminology, forensic medicine and prosecution. Currently there is also an increasing demand in the stature estimation of the bedridden patients in intensive care units and nursing homes in order to provide the adequate medication or an essential nutritional regime.

(b) Human remains, either prehistoric or of recent origin, but incomplete due to animal destruction of the cadaver or other mutilation, represent the majority of cases where estimation of stature is sought. It is obvious that the results obtained from such investigations will be grossly influenced by the available bone fragments, and also by parameters often unknown, such as age, gender and ethnicity for instance.

(c) Basic measurements are almost always done by metering the distance between two predetermined points, according to anthropometric rules. The equipment used may be a very simple tape measure or a more sophisticated metering device or even x-ray or computer-tomographic apparatus. These advanced machines may provide a higher precision of a single measurement but it must be questioned whether this will result in a much more reliable prediction of a person's stature.

MATERIAL AND METHODS

Papers referenced in Medline relating to the estimation of height in adults from measurements of various parts of the body and from other salient features of men were collected. From these references only a selection together with some older yet important contributions were used in this overview.

RESULTS AND DISCUSSION

General remarks

Applying the least squares criterion Karl Pearson has proudly introduced linear regression which allows to predict a value for the dependent variable y according to a formula of the general form $y = k \cdot x + a$, where k is the slope of this linear equation and a its intercept [35].Such regressions are preferable since the variance of its predictive values is lower than for the percentage estimation technique already mentioned. Some examples for regressions to estimate stature from the length of the femur are listed in Table 1.

The large scatter in figures for slope k is evident, from which follows that for a measured femur length of e.g. 74.3 cm the pertinent stature for the smallest k in the table would be 171.8 cm and for the largest 179.3 cm as a mean. This result could be rated as reasonable. However, variability has been completely disregarded for this calculation.

An important feature of regression equations is the slope which should be small for a comparable set of bones because small k figures multiply the measurement errors of the independent variable the least. Long bones from the upper limb show somewhat higher figures for k than for the lower limb where femur is marginally better than tibia, but fibula is the worst (Figure 1). From the upper limb ulna should only exceptionally be used.

Though regression equations are a scientifically accepted tool in estimation procedures they lack universal applicability in predicting stature for several reasons: the underlying population may be inhomogeneous with respect to ethnic group, gender, age. It is well known that proportions of bones are different in different human races, furthermore that bodily build is dissimilar in males and females and finally that stature changes with older age. To this inherent inconsistency of the basic data other factors add such as measurement errors and too small a sample size. One would probably arrive at consistent results for the coefficients only for homogeneous sample sizes of more than 5000 individuals [51].

Table 1. Linear regressions for estimating stature from length of femur of white men published by different authors. Data are sorted with increasing slope k.

Slope k	Intercept a	Author
1,64	94,31	Breitinger [6]
1,88	81,31	Pearson [35]
2,10	71,85	Telkkä[45]
2,12	77,05	Dupertuis[11]
2,26	66,38	Genoves [16]
2,26	63,80	Mo Shitai [27]
2,31	56,58	Rother [39]
2,32	65,53	Trotter [48]
2,36	61,34	Lorke [26]
2,85	44,57	Eliakis [13]

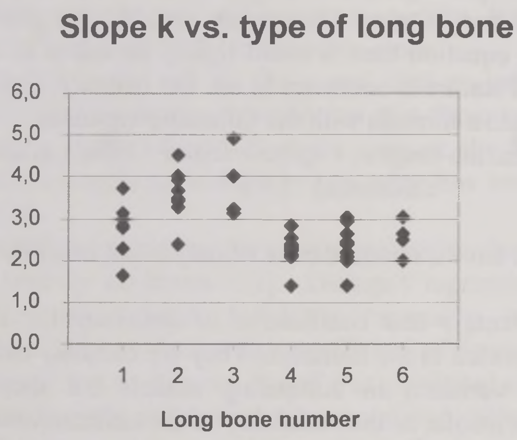


Figure 1. Slopes from different studies plotted against the type of long bone which served as independent variable in the regression equations. 1: humerus; 2: radius; 3: ulna; 4: femur; 5: tibia; 6: fibula. Data from [51].

Not unexpectedly many regression equations for the prediction of stature have been heavily criticised, therefore, on the following grounds, e.g. by Rösing who has crucially analysed 45 regression equations [38]. He postulates that

- the age distribution of the control group should correspond to the group to be estimated; older equations are generally based on populations with a lower mean age in this respect
- secular acceleration should be considered
- the control group should have a normal social structure and not just consist of students for example
- regression equations should comprise measurements of at least four long bones in order to allow formulating multiple regressions.

Depending on the purpose of the stature estimation the fourth requirement must be questioned because the improvement in precision between single and multiple regressions does not seem to be very great. Alternatively, if too many stature determining variables are needed to devise a regression equation then it could rightly be asked to which end an estimation of stature is necessary at all. For instance, Fully and Pineau have suggested a formula with the following variables:

$$\text{Stature} = 0.98\cdot(\text{basion-bregma} + \text{spine} + \text{femur} + \text{tibia} + \text{talus} + \text{calcaneus}) + 14.6$$

This estimate would have a standard error of only ± 2.0 cm [14].

Correlation coefficients r and coefficients of determination R^2 are widely used and reported in the literature. They are certainly useful in comparing stature variation in competing models but they lack practical application insofar as the variability of the estimate cannot be immediately guessed in terms of a given measure. A much better description of the variability is the standard error of the estimate (SEE) which centres at about ±3.5 cm for almost all regression formulae for stature estimation.

Computation has nowadays become an easy task as work stations and powerful software are available. This has produced a large amount of regression equations and other results, which demonstrate a high variability. Yet the many influencing variables have hampered formulating a generally applicable regression equation for stature estimation.

Long bones

The prediction of stature was most often performed on the long bones of the upper and especially of the lower limb. Most valuable and often referenced publications are those by Breitinger [6] in Germany and Trotter and Gleser in the United States who had the exceptional chance to compare the height of soldiers who were killed in World War II and later [47–49]. Though their results have been criticised they have been successfully applied by others later on.

Recently publications from Thailand [22], Portugal [10] and Bulgaria [37] have dealt with the same topic.

Munoz used x-ray examination and was able to show that from all long bones femur is best for male and tibia for female [28]. This again supports the notion that femur is most suitable. Tibia would be another good choice as can be seen from Figure 1 also.

An interesting aspect for estimating stature from tibia length was addressed by Dyar and Pelin [12,36]. They have classified their sample in three different height groups and as a results of their study recommended to use stature-group-specific formulae which they found to be more reliable for forensic cases.

Comparing the use of fibula and ulna as independent variables, Hilgermann and Schleyer concluded that there was no difference in predicting stature from either the one or the other [18]. This is somewhat surprising with regard to what has been said already (cf. Figure 1).

Regression equations for stature estimation from knee height have been recently reviewed [33]. Averaged regression coefficients and intercepts yielded the following regression equation: stature = 1.96·knee height + 64.3 with a coefficient of determination $R^2 = 0.700$ as a mean. It was also concluded that published regressions were not universally applicable and that geographical variation may exist even for the same ethnic population. Recently it was shown that in a clinical setting adequate estimates of stature would be obtained also with simple equipment like a tape measure [17].

There are also reports where stature was estimated from fragments of long bones[15,29–31,43]. Due to the extremely high values of standard deviations, the use of fragments may have no widespread use and would be applied only in exceptional cases.

OTHER BONES

Vertebral column

Jason and Taylor have communicated that the vertebral column or parts of it could be favourably used for stature estimation in cases where a corpse was mutilated or decapitated [20]. Their results again demonstrate the importance of the length of the vertebral column which is used as independent variable and hence determines the precision of the predicted stature. Similar results were obtained by Tibbetts who had to face a further problem with additional or missing vertebrae [46], and by Nagesh [32]. Pelin et al. from an x-ray study of sacral and coccygeal vertebrae also concluded that standard errors of the estimate ranging from 6.4 to 7.3 cm would indicate that the dimensions of these vertebrae comprise a reliable indicator of stature under certain circumstances.

Hand and foot

In several studies hand and foot length were shown to be reasonable measures for estimating stature with correlation coefficients of about 0.5 [42] and 0.7 [41]. Surprisingly, the latter study showed a much better multiple correlation coefficient with hand and foot lengths as explanatory variables if male and female data sets were combined (male: 0.838; female: 0.785; together: 0.928). But at the same time the standard error of the estimate was the highest within this group (SEE = 3.52 cm). As an simple estimate of stature, a multiplication table was presented by Jasuja et al. for foot and shoe lengths and breadth for an Indian population after grouping the original measurements into four classes [21]. A similar method was studied by Singh and Phookan for different ethnic groups from Assam [44]. A comparable study came from Turkey [34] and very recently from North India [24].

Skull

Anthropometry of the skull has also served to estimate stature, but may be useful in cases only where other bones are not available. SEEs ranged from 4.37 to 7.92 cm in a South African and a Japanese sample [8,40]

Scapula

Campobasso et al. have demonstrated in their paper that scapular measurements could also be reliably employed for the estimation of a person's height [7]. Multiple regressions using scapular maximum breadth together with the maximum length of the coracoid and maximum breadth together with the width of the glenoid cavity for men and women, respectively, yielded multiple r = 0.59 in both cases.

Calcaneus

This topic was covered by Holland [19] and recently by Bidmos [3,4] with satisfactory results in predicting stature.

OTHER BODILY CHARACTERISTICS

Span and demi-span

In patients where a direct measurement of stature is not possible due to scoliosis in old age or in those who are bedridden span and demi-span would be a suitable surrogate of stature [1,2,50]. Especially Aggarwal has reported very high correlation coefficients of in the order of 0.975, interestingly without any correlation with age [1].

Visual estimation of height

There are interesting studies on the visual estimation of height under a clinical aspect [9,25]. In the recent publication by Bloomfield et al. it has been ascertained that the majority of height estimates was within 10% of the measured values [5]. This might be sufficient under certain conditions of use, but the degree of inaccuracy was considered to be of clinical importance [25].

In another study participants were able to estimate the height of a person from realistic photographs with a correlation of 0.92 between estimated height and actual height [23].

CONCLUSIONS

The study of bodily proportions and their correlations has remained a lively task over the last century. It will certainly need an ever continuing effort to update older findings in order to stay abreast with changing demands in science and practical applications. This short overview aimed to outline older and recent progress in the field of stature estimation.

REFERENCES

1. Aggarwal A. N., Gupta D., Ezekiel L. M., Jindal S. K. (2000) Statistical estimation of height from arm span in north Indian subjects. Indian J Physiol Pharmacol 44, 3, 329–334.
2. Bassey E. J. (1986) Demi-span as a measure of skeletal size. Ann hum biol 13, 499–502.
3. Bidmos M. (2006) Adult stature reconstruction from the calcaneus of South Africans of European descent. J Clin Forensic Med 13, 5, 247–252.
4. Bidmos M., Asala S. (2005) Calcaneal measurement in estimation of stature of South African blacks. Am J Phys Anthropol 126, 3, 335–342.
5. Bloomfield R., Steel E., MacLennan G., Noble D. W. (2006) Accuracy of weight and height estimation in an intensive care unit: Implications for clinical practice and research. Crit Care Med 34, 8, 2153–2157.
6. Breitinger E. (1938) Zur Berechnung der Körperhöhe aus den langen Gliedmaßenknochen. Anthropol Anz 14, 249–274.
7. Campobasso C. P., Di Vella G., Introna F., Jr. (1998) Using scapular measurements in regression formulae for the estimation of stature. Boll Soc Ital Biol Sper 74, 7–8, 75–82.
8. Chiba M., Terazawa K. (1998) Estimation of stature from somatometry of skull. Forensic Sci Int 97, 2–3, 87–92.
9. Coe T. R., Halkes M., Houghton K., Jefferson D. (1999) The accuracy of visual estimation of weight and height in pre-operative supine patients. Anaesthesia 54, 6, 582–586.
10. De Mendonca M. C. (2000) Estimation of height from the length of long bones in a Portuguese adult population. Am J Phys Anthropol 112, 1, 39–48.

11. Dupertuis C. W., Hadden J. A., Jr. (1951) On the reconstruction of stature from long bones. Am J Phys Anthropol 9, 1, 15–53.
12. Duyar I., Pelin C. (2003) Body height estimation based on tibia length in different stature groups. Am J Phys Anthropol 122, 1, 23–27.
13. Eliakis D., Eliakis E. (1966) Détermiantion de la taille d'apres la mensuration des os longs. Ann Méd Lég 46, 403–421.
14. Fully G., Pineau H. (1960) Détermination de la stature au moyen du squelette. Ann Méd Lég 36, 266–273.
15. Gehring K.D., Graw M. (2001) Körperhöhenbestimmung anhand des Femurs und von Femurfragmenten. Arch Kriminol 207, 5–6, 170–180.
16. Genoves S. (1967) Proportionality of the long bones and their relation to stature among Mesoamericans. Am J Phys Anthropol 26, 1, 67–77.
17. Guzmán Hernánndez C. (2005) [Estimation of height from leg length measured with tape measure]. Nutr Hosp 20, 5, 358–363.
18. Hilgermann R., Schleyer F. (1974) Über die Eignung einer Körperhöhenberechnung an Hand der Ulna- und Fibulalängen, gemessen am Lebenden. Z Rechtsmed 74, 2, 117–120.
19. Holland T. D. (1995) Brief communication: estimation of adult stature from the calcaneus and talus. Am J Phys Anthropol 96, 3, 315–320.
20. Jason D.R., Taylor K. (1995) Estimation of stature from the length of the cervical, thoracic, and lumbar segments of the spine in American whites and blacks. J Forensic Sci 40, 1, 59–62.
21. Jasuja O. P., Singh J., Jain M. (1991) Estimation of stature from foot and shoe measurements by multiplication factors: a revised attempt. Forensic Sci Int 50, 2, 203–215.
22. Jitapunkul S., Benchajareonwong S. (1998) Long-bone measurement for height estimation in Thai adult subjects. J Med Assoc Thai 81, 6, 442–448.
23. Kato K., Higashiyama A. (1998) Estimation of height for persons in pictures. Percept Psychophys 60, 8, 1318–1328.
24. Krishan K., Sharma A. (2007) Estimation of stature from dimensions of hands and feet in a North Indian population. J Clin Forensic Legal Med
25. Leary T. S., Milner Q. J., Niblett D. J. (2000) The accuracy of the estimation of body weight and height in the intensive care unit. Eur J Anaesthesiol 17, 11, 698–703.

26. Lorke D., Münzner H. ,Walter E. (1953) Zur Rekonstruktion der Körpergröße eines Menschen aus den langen Gliedmaßenknochen. Dtsch Z ges gerichtl Med 42, 189–202.
27. Mo Shitai (1983) Estimation of stature by long bones of Chines male adults in South China. Anthropol sinica 2, 280–85.
28. Munoz J. I., Linares-Iglesias M., Suarez-Penaranda J. M., Mayo M., Miguens X., Rodriguez-Calvo M. S.,Concheiro L. (2001) Stature estimation from radiographically determined long bone length in a Spanish population sample. J Forensic Sci 46, 2, 363–366.
29. Mysorekar V. L., Verma P. K., Mandedkar A. N., Sarma T. C. (1980) Estimation of stature from parts of bones – lower end of femur and upper end of radius. Med Sci Law 20, 4, 283–286.
30. Mysorekar V. R., Nandedkar A. N., Sarma T. C. (1982) Estimation of stature from parts of humerus and radius. Med Sci Law 22, 3, 178–180.
31. Mysorekar V. R., Nandedkar A. N., Sarma T. C. (1984) Estimation of stature from parts of ulna and tibia. Med Sci Law 24, 2, 113–116.
32. Nagesh K. R., Pradeep K. G. (2006) Estimation of stature from vertebral column length in South Indians. Leg Med (Tokyo) 8, 5, 269–272.
33. Neruda B. (2004) Predicting stature from knee height. Compiled regressions from recent literature. Papers Anthropol XIII, 160–175.
34. Ozden H., Balci Y., Demirustu C., Turgut A., Ertugrul M. (2005) Stature and sex estimate using foot and shoe dimensions. Forensic Sci Int 147, 2–3, 181–184.
35. Pearson K. (1899) Mathematical contributions to the theory of evolution. V. On the reconstruction of the stature of prehistoric races. Trans R Soc, Ser A ,192, 169–244.
36. Pelin I. C., Duyar I. (2003) Estimating stature from tibia length: a comparison of methods. J Forensic Sci 48, 4, 708–712.
37. Radoinova D., Tenekedjiev K., Yordanov Y. (2002) Stature estimation from long bone lengths in Bulgarians. Homo 52, 3, 221–232.
38. Rösing F. W. (1988) Körperhöhenrekonstruktion aus Skelettmaßen. In: Knußmann R., Anthropolgie, Gustav Fischer, Stuttgart, 586–600.
39. Rother B. (1971) Möglichkeiten und Grenzen der Körperhöhenrekonstruktion aus den Maßen von Röhrenknochen. Dissertation, Universität Leipzig.
40. Ryan I., Bidmos M. A. (2007) Skeletal height reconstruction from measurements of the skull in indigenous South Africans. Forensic Sci Int 167, 1, 16–21.

41. Sanli S. G., Kizilkanat E. D., Boyan N., Ozsahin E. T., Bozkir M. G., Soames R., Erol H.,.Oguz O. (2005) Stature estimation based on hand length and foot length. Clin Anat 18, 8, 589–596.
42. Saxena S. K. (1984) A study of correlations and estimation of stature from hand length, hand breadth and sole length. Anthropol Anz 42, 4, 271–276.
43. Simmons T., Jantz R L, Bass W. M. (1990) Stature estimation from fragmentary femora: a revision of the Steele method. J Forensic Sci 35, 3, 628–636.
44. Singh T. S., Phookan M. N. (1993) Stature and footsize in four Thai communities of Assam, India. Anthropol Anz 51, 4, 349–355.
45. Telkka A. (1950) On the prediction of human stature from the long bones. Acta Anat (Basel) 9, 1–2, 103–117.
46. Tibbetts G. L. (1981) Estimation of stature from the vertebral column in American Blacks. J Forensic Sci 26, 4, 715–723.
47. Trotter M., Gleser G. C. (1952) Estimation of stature from long bones of American Whites and Negroes. Am J Phys Anthropol 10, 4, 463–514.
48. Trotter M., Gleser G. C. (1958) A re-evaluation of estimation of stature based on measurements of stature taken during life and of long bones after death. Am J Phys Anthropol 16, 1, 79–123.
49. Trotter M., Gleser G, C, (1977) Corrigenda to "estimation of stature from long limb bones of American Whites and Negroes," American Journal Physical Anthropology (1952). Am J Phys Anthropol 47, 2, 355–356.
50. Weinbrenner T., Vioque J., Barber X., Asensio L. (2006) Estimation of height and body mass index from demi-span in elderly individuals. Gerontology 52, 5, 275–281.
51. Wurm H. (1985) Zur Geschichte der Körperhöhenschätzung nach Skeletfunden (Körperhöhenschätzungen für Männer). Die vorgeschlagenen Ansätze zur Körperhöhenschätzung nach Skeletfunden seit der Mitte des 20. Jahrhunderts. Gegenbaurs Morphol Jahrb 131, 3, 383–432.

Address for correspondence:
Boris Neruda
Eschbergstrasse 28
D-54585 Esch
Fone +49 6597 9601 42, Fax +49 6597 9601 43
E-mail: boris.neruda@t-online.de

Papers on Anthropology XVI, 2007, pp. 198–209

LATVIAN INFANTS' CEPHALIC INDEX CHANGE DURING THE FIRST YEAR OF LIFE

Anita Oginska, Jānis Vētra, Māra Pilmane

Institute of Anatomy and Anthropology, Riga Stradins University

ABSTRACT

In December 2004, in the maternity hospital of the city of Riga anthropometric measuring of healthy new-borns was started. As by 1 January, 2007 the number of newborns measured was 503. Three measurements: head circumference, maximum width and maximum length of the cranium, were made to every child during one visit and the results were fixed in an inquiry form. The longitudinal or individualizing study method that involves anthropometric measurements in definite time moments at one and the same child was used.

The cephalic index for the newborn boys and girls is similar in value. In the first month it decreases for both – boys and girls. Then from the first to the sixth month the cephalic index grows faster during the first year of life, and later it is always bigger for boys than for girls. Dolichocephaly is not characteristic of newborn and infant boys in Latvia. The cephalic index at the age of one year both for boys and girls is comparatively smaller than for newborns. Brachiocephaly is the most common head shape in all referent ages. For girls this shape appears in the new–born's age, at the age of 6; but at the age of 9 and 12 months the most common is mesocephaly. However, at the age of 1 and 3 months dolichocephaly becomes more common. There is not any correlation between the head shape and the mother's weight, height, age and the way of delivery.

Key words: cephalic index, infants, anthropometry

INTRODUCTION

The children's growth and development are the two main investigated processes in the population's health [10]. In anthropometry, the cephalic index has been the favoured measurement. The human head shape and the cephalic index have the been objects of interest for scientists and practitioners since ages. There are a lot of scientific articles published on this subject, e.g. Sex Differences in Cephalic Index during Growth by Wilson D. Wallis and Ruth Sawtell Wallis [12]. Cephalic index (CI) is the ratio of the maximum width of the head to its maximum length multiplied by 100.

It is still sometimes used for estimating the age of fetuses for legal and obstetrical reasons, in which case the differences in the skull shapes between different populations are still of interest. Such an index is also used for animals.

The CI was defined by the Swedish professor of anatomy Anders Retzius (1796–1860) and first used in physical anthropology to classify ancient human remains found in Europe. It has been generally discredited since the study by Franz Boas at the turn of the $19^{th}/20^{th}$ century, and it became accepted in anthropology because the CI was a purely environmental component. Cephalic indices can be grouped as in the following table [15]:

Females	**Males**	**Scientific term**	**Meaning**	**Alternative term**
< 75%	< 65%	*dolichocephalic*	'long-headed'	*mesocranial*
75% to 80%	65% to 75%	*mesocephalic*	'medium-headed'	*mesaticephalic*
> 80%	> 75% (male)	*brachycephalic*	'short-headed'	*brachycranial*

Nowadays the head shape and the cephalic index are especially important in facial plastic and reconstructive surgery. The Cephalic index could also be one of the indicators to some congenital anomalies (e.g. the Crouzon Syndrome, the Apert Syndrome, etc.) [5].

In Latvia the most significant skull shape research is done by Raisa Denisova [13]. Also, the morphological status between ethnically mixed groups has been researched in Latvia by Kokare, Vetra and Krumina [14].

MATERIALS AND METHODS

Methods: 1. The longitudinal or individualizing study method that involves anthropometric measurements in definite time moments at one and the same child was used. 2. The maximum cranial length was measured by a spreading caliper: with the anterior caliper tip resting on glabella, the posterior tip was slide inferiorly along the medial line of occipital until the maximum width was reached (opisthocranion). The conventional technique keeps the caliper along the sagittal midline. 3. The maximum cranial width was measured by spreading calipers: both tips of the caliper were slid down the lateral slides of parietal bones, then moved forward and back until the maximum width was reached. 4. The head circumference was measured by a tape: the tape was encircled around the head covering glabella and opisthocranion. 5. The respondent himself filled in the questionnaire about the socio-economic conditions. 6. The statistical processing of material was done using the SPSS/PCT statistical programme and the factor analysis method estimated the family's socio-economic and the parents' biological influence on the newborns' and infants' physical development. The research structure in time is both prospective and retrospective – to find tendencies over the century, to show secular changes.

Material: 503 newborns and infants in the age of 1, 3, 6, 9, 12 months were measured anthropologically in the maternity hospital of Riga. Cranial measurements – the maximum width and the length of the head in the horizontal plane, or front to back – were made with the Martin's caliper; a special tape with millimetre sections was used to measure the head's circumference; the CI was calculated.

RESULTS

In December 2004 in the maternity hospital of the city of Riga anthropometric measuring of healthy newborns was started. As by 1 January, 2007 the number of newborns measured was 503: 256 girls (50.9%), 247 boys (49.1%). 395 from those were measured again at the age of 1 month, 393 – of 3 months, 385 – of 6 months, 379 – of 9 months and 375 at the age of one year. Three measurements: the head circumference, the maximum width and the maximum length of the cranium, were made to every child during one visit and the results were fixed in an inquiry form. At the first visit, the data of the child's parents, grandparents and upgrowth during prenatal period was acquired.

We presumed that the head shapes for new-born boys and girls are the same and there is no statistically significant correlation between gender and the head shape. Still the results show the opposite.

Table 1. Descriptive statistics showing the dynamics in infant's cephalic index in Latvia

Age, month	Boy					Girl				
	N	Min.	Max.	M	SD	N	Min.	Max.	M	SD
0	246	65.9	91.1	78.1	3.2	253	67.5	85.8	78.0	3.1
1	195	65.7	84.6	76.5	3.6	200	65.4	90.3	75.8	3.7
3	193	68.2	91.9	78.0	4.6	200	66.2	99.1	77.0	5.0
6	187	70.2	95.4	78.9	4.6	198	66.4	101.6	78.7	4.9
9	186	69.9	93.4	78.0	4.3	193	69.6	100.0	78.1	4.7
12	183	70.1	93.6	77.7	4.3	192	69.5	93.8	77.4	4.2

N – Number of observations, Min. – Minimum, Max. – Maximum, M – mean and SD – Standard deviation

In our research there was no dolichocephalic head shape observed for boys in any of age groups. Also, in international literature dolichocephaly was described as rarely encountered. The cephalic index in Latvia for newborns both – boys and girls was the same – 78%. Also, at the age of 1 month those indices were still the same – 76%. However, at the age of 3 months some differences appeared, when the cephalic index for boys was seen to be 78%, but for girls – 77%. At the age of 6 months this value was as following – for boys 80%, for girls – 79%. It can be seen that the cephalic index has grown faster for boys than for girls.

Table 2. Infant's head shape by gender and age in Latvia

Age, month	Infant's head shape						Total	
	Dolicocephalic		Mesocephalic		Brachicephalic			
	N	%	N	%	N	%	N	%
Boy								
0	–	–	37	12.3	209	23.5	246	20.7
1	–	–	75	25.0	120	13.5	195	16.4
3	–	–	53	17.7	140	15.7	193	16.2
6	–	–	38	12.7	149	16.7	187	15.7
9	–	–	47	15.7	139	15.6	186	15.6
12	–	–	50	16.7	133	14.9	183	15.4
Total	–	–	300	100.0	890	100.0	1190	100.0
Girl								
0	40	11.0	149	26.8	64	20.3	253	20.5
1	90	24.7	85	15.3	25	7.9	200	16.2
3	77	21.1	67	12.1	56	17.8	200	16.2
6	47	12.9	85	15.3	66	21.0	198	16.0
9	53	14.5	83	14.9	57	18.1	193	15.6
12	58	15.9	87	15.6	47	14.9	192	15.5
Total	365	100.0	556	100.0	315	100.0	1236	100.0

N – Number of observations and % – % within infant's head shape.

Paired Samples t Statistics shows that the cephalic index medial values for newborns are statistically meaningful, higher than at the age of 12 months ($t = 2.3$; $p = 0.022$) (Table 3).

Table 3. Cephalic index for newborns and at the age of 12 months

Cephalic index, %	Mean	N	Std. Deviation	Paired Samples Test	
				t	p
Newborns	78.0	371	3.0	2.296	0.022
At the age of 12 months	77.5	371	4.2		

The correlation was low, but statistically meaningful ($r = 0.347$; $p < 0.01$).

Paired Samples t Statistics showed no statistically meaningful difference in the cephalic index medium value for newborn boys ($t = 1.60$; $p = 0.111$) and girls ($t = 1.64$; $p = 0.102$) from cephalic index medium value at the age of twelve month (Table 4).

Table 4. Cephalic index for newborns and such at the age of 12 months in correlation by gender

Gender	Cephalic index, %	Mean	N	Std. Deviation	t	p
Boy	Newborns	78.19	182	2.84	1.601	0.111
	At the age of 12 months, %	77.69	182	4.25		
Girl	Newborns	77.87	189	3.13	1.642	0.102
	At the age of 12 months, %	77.36	189	4.18		

The correlation was low, but statistically meaningful both for boys ($r = 0.353$; $p < 0.01$) and girls ($r = 0.340$; $p < 0.01$).

Table 5. Differences of cephalic index by ages and gender

Age, month	Difference, %	
	Boy	Girl
0–1	–1.7 ± 0.2	–2.2 ± 0.2
1–3	1.5 ± 0.2	1.2 ± 0.2
3–6	1.0 ± 0.3	1.6 ± 0.3
6–9	–0.9 ± 0.3	–0.6 ± 0.3
9–12	–0.3 ± 0.3	–0.7 ± 0.3
0–12	–0.4 ± 0.3	–0.6± 0.3

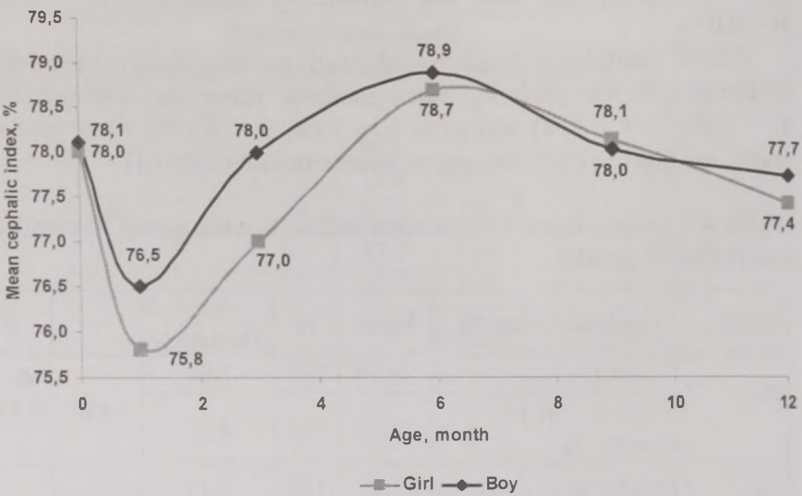


Figure 1. Mean cephalic index by age and gender in Latvia.

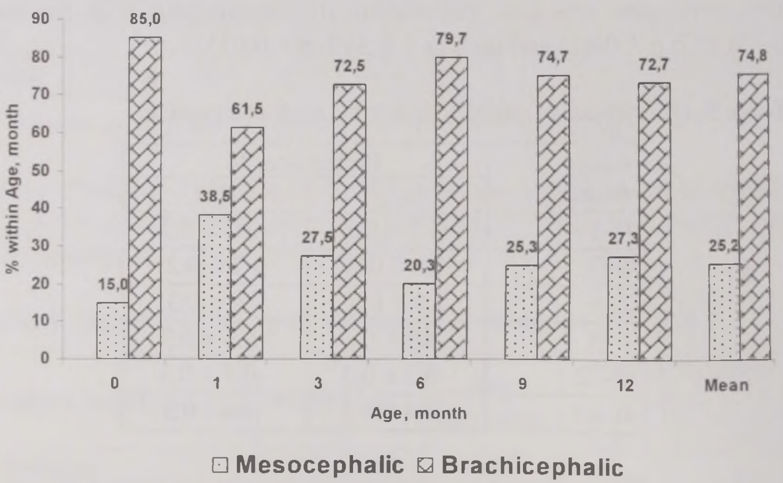


Figure 2. Boy's head shape distribution by age in Latvia.

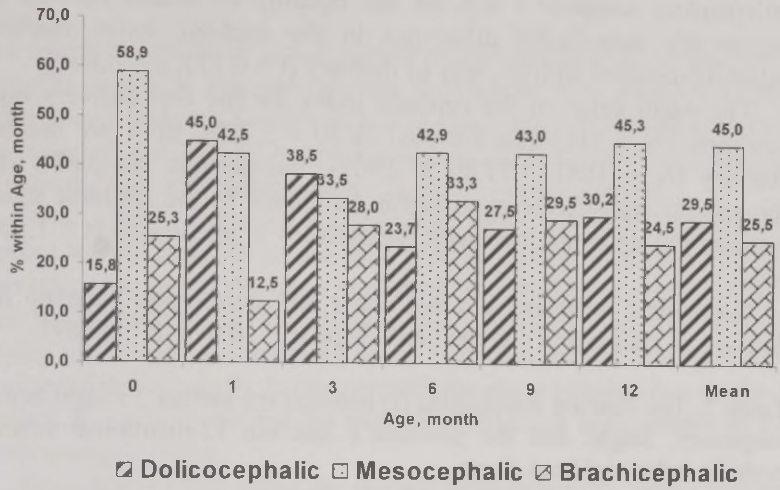


Figure 3. Girl's head shape distribution by age in Latvia.

In our research we found out that there was no correlation between the way of delivery and the head shape. The hypotheses that the way of delivery impacts the head shape was not affirmed. In our research the normal way of delivery was in 73.9% and the Caesarean section was used in 26.1% of the cases.

Table 6. Newborns head shape and way of delivery crosstabulation

New-borns head shape	Way of delivery				Total	
	Normal		Caesarean operation			
	N	%	N	%	N	%
Dolichocephalic	28	7.6	12	9.2	40	8.0
Mesocephalic	140	37.9	46	35.4	186	37.3
Brachicephalic	201	54.5	72	55.4	273	54.7
Total	369	100.0	130	100.0	499	100.0

The Chi-Square Test showed no correlation between the way of delivery and the head shape ($\chi^2 = 0.507$; $p = 0.776$).

The mean value of the cephalic index for normal born newborns was 78.02 ± 2.92%, from the Caesarean section – 78.08 ± 3.73%.

Independent samples' t test for the equality of means showed no statistically meaningful difference in the cephalic index medium values committed with the way of delivery (t = 0.175; p = 0.861).

The mean value of the cephalic index for the first delivery born newborns (N = 311) demonstrated 78.20 ± 3.28%, from just another delivery (N = 188) – 77.80 ± 2.90%. Independent samples t test showed no statistically meaningful difference in the cephalic index medium values committed with the delivery in succession (t = 1.529; p = 0.127).

Symmetric measures did not show any correlation between the delivery in succession and the head shape (r = –0.076; p = 0.089).

Table 7. The Pearson correlations (r) between the mother's weight before pregnancy, height and the newborn's and the 12-month-old infant's cephalic index and head shape

Variables		Mother's weight before pregnancy, kg	Mother's height, cm	New-born's head shape	Cephalic index at the age of 12 month, %
Mother's height, cm	r	0.378(**)			
	p	0.01			
	N	500			
Newborn's head shape	r	0.057	0.084		
	p	0.21	0.06		
	N	496	498		
Cephalic index at the age of 12 month, %	r	–0.002	0.008	0.221(**)	
	p	0.97	0.88	0.01	
	N	374	375	371	
Cephalic index of new-born, %	r	0.036	0.053	0.637(**)	0.347(**)
	p	0.42	0.24	0.01	0.01
	N	496	498	499	371

** Correlation is significant at the 0.01 level (2-tailed).

There was no statistically meaningful correlation found between the mother's weight and height and the newborn's and 12 months old baby's cephalic index and the head shape.

DISCUSSION

We found no reference to any similar researches in Latvian literature. For this reason it was not possible to compare our results with any other in our country. There was one research done by Krumina (1996) on newborn and infants' morphological and physical development, but it contained no information on the cephalic index dynamics.

It is widely discussed in literature what the main influencing factors for the head shape are. The type of putting infants to sleep is mentioned as one of the most important factors. The cephalic index is heavily influenced by the infant's sleep position, and the constant supine positioning is a frequent cause of deformational brachycephaly during infancy (2; 8; 9). In our research the sleep position has not been studied as we have not put the reasons of different head shapes as the main research object.

Some authors talk about *the normal* head shape (3). While making our study, we came up to a question – which one of the three possible head shapes, is supposed to be *normal*? Therefore we have the point of view that each of those shapes could be considered as normal if it only allows a child to grow and develop according to the rule of standard. Still it is known that the head shape is influenced by many intrauterine events and genetics. In some cases reconstructive surgery is needed to resolve craniofacial anomalies (5).

One thing that almost all the authors agree upon is that it is important to take into consideration gender when measuring the cephalic index (12). It was also proved in our studies.

CONCLUSIONS

The cephalic index for newborn boys and girls is similar in value. In the first month it decreases for both – boys and girls. Then from the first to the sixth month the cephalic index grows faster during the first year of life, and later it is always bigger for boys than for girls.

Dolichocephaly is not characteristic of newborn and infant boys in Latvia.

The cephalic index at the age of one year both for boys and girls is comparatively smaller than for newborns. Brachiocephaly is the most common head shape in all the referent ages. For girls this shape appears in the newborn's age, at the age of 6; but at the age of 9 and 12 months the most common is mesocephaly. However, at the age of 1 and 3 months dolichocephaly becomes more common.

There is not any correlation between the head shape and the mother's weight, height, age and the way of delivery.

REFERENCES

1. Bewer GI.,Barluschke R. (1989) The physical development of infants and small children 3. Head circumference, head length, length-width index-a longitudinal study. Artztl Jugendkd., 80(1), 12–21.
2. Graham John M. (2005) Deformational Brachycephaly in supine-sleeping infants.The Journal of Pediatrics. 146, 253–257.
3. Hutchinson B. Lynne, Hutchinson Luke A.D. (2004) Plagiocephaly and Brachycephaly in the First Two Years of Life:A Prospektive Cohort Study. Pediatrics 114, 4 October, 970–980 (doi:10.1542/peds. 2003-0668-F).
4. Jaeger U,Zeliner K. (1998) Is head size modified by environmental factors? Morphol Anthropol. 82(1), 59–66.
5. James D. Smith, Robert M. Bumsted, Pediatric Facial Plastic and Reconstructive Surgery. Kaven Press, New-York. 1993. 410 pp.
6. Kouchi M. (2000) Brachycephalization in Japan has ceased. Am Journal Phys Anthropol. 112 (3), 339–47.
7. Nicoletti I., Benso L., Gilli G. (2004) Physiological and Pathological auxology. Nicomp L.E., Gorgonzola, Italy
8. Paulova M, Blaha P. (2000) Influence of positioning of infants on long-term changes of cephalic dimensions. Central Europe Journal Public Health. 8 (2), 83–7.
9. Persing J., James H. (2003) Prevention and Management of Positional Skull Deformities in Infants. Pediatrics, 112, 199–202 DOI: 10.1542/peds.112.1.199.
10. Takaishi M. (1999) A longitudinal study of the physical growth of Japanese infants. National Center for Biotechnology Information. Annual Hum Biol. 26 (4), 353–63.
11. Todros T., Sancefelici C. (1985) Head shape and size and body weight in the newborn infant. Europe Journal Obstet Gynecol Reprod Biol. 19 (1), 1–5.

12. Wallis W. D., Wallis Sawtell R. (1946) Sex Differences in Cephalic Index during Growth, Southwestern Journal of Anthropology, 2, 1, 56 – 83.
13. Grāvere R., Zariņa G. (2000) Latvijas vēsturnieki. Antropoloģe profesore Dr. habil. hist. LZA goda locekle Raisa Denisova. Bibliogrāfija, darbabiedru veltījumi 70 gadu jubilejā. LU Latvijas vēstures institūta apgāds Riga.
14. Kokare I., Vētra J., Krūmiņa Dž. (2000) Par jauktu laulību pēcteču morfoloģiskā statusa īpatnībām Latvijā, Grāvere R., Zariņa G. Latvijas vēsturnieki. Antropoloģe profesore Dr. habil. hist. LZA goda locekle Raisa Denisova. Bibliogrāfija, darbabiedru veltījumi 70 gadu jubilejā. LU Latvijas vēstures institūta apgāds Riga, 133 – 149.
15. www.answers.com
16. www.dolichocephaly.info
17. www.plagiocephaly.org/headshape

Address for correspondence:
Anita Oginska
Dzirciema Street 16, Riga, LV-1007
E-mail: oginska_anita@dr.lv
Phone: (+371)2 9130622
Position: PhD student

Papers on Anthropology XVI, 2007, pp. 210–221

PHYSICAL EXAMINATION PARAMETERS AND HEALTH-RELATED BEHAVIOURS AMONG TARTU UNIVERSITY STUDENTS (ANTHROPOMETRIC PARAMETERS IN STUDENTS)

Maie Ojamaa, Anatoli Landõr, Nadežda Ignatjeva, Jaak Maaroos

Tartu University Hospital, Clinic of Sports Medicine and Rehabilitation, Puusepa 1a, Tartu 50406, Estonia

ABSTRACT

Physical activity and health-related behaviours have important health promoting effects with respect to cardiovascular diseases and coronary heart disease in particular. The aim of this study was to investigate anthropometric parameters and health-related behaviours among Tartu University students. Anthropometric measurements, arm force, vital capacity, exercise test on the bicycle ergometer (PWC_{170}) and a health-related behaviour questionnaire were carried out in 544 female and 258 male university students. The mean anthropometric parameters demonstrated a statistically significant increase, but the results show a decrease in weight in female students of the University of Tartu during the period between 1965 and 2002. Efforts towards weight control can be associated with healthy behavioural changes, increasing exercise and reducing fat intake. The established positive relationships between the anthropometric parameters are related to participation in sports and healthy behaviours. The aim of this study was to establish new standards of the anthropometric parameters for the Estonian university female and male students.

Key words: anthropometric parameters, health-related behaviours, physical activity, Tartu University students

INTRODUCTION

Coronary heart disease (CHD) is the leading cause of death among population in Estonia and Estonia occupies the forth position among the countries of the European Union regarding CHD mortality rates among male and female population (Eurostat 2006). Physical activity and health-related behaviours have important health promoting effects with respect to cardiovascular diseases and CHD in particular.

The aim of this study was to investigate anthropometric parameters and health-related behaviours among Tartu university students and to compare our data with those obtained in 1965 and to establish new standards for the evaluation of physical development.

MATERIAL AND METHODS

An intervention study of physical status and physical activity was carried out in 544 female and 258 male university undergraduates (University of Tartu). Anthropometric body measurements were performed using classical methods [3]. Body mass index (BMI) was calculated (kg/m^2) and the arm force of both the right and left hands was measured with the calibrated hand dynamometer DPU – 0.1–2 (Russia). Vital capacity was assessed using the spirometer Vitalograph (England). Body fat and the percentage of body fat mass were measured with the Body Fat Analyser BF 300 (Omron, Japan). All subjects underwent an exercise test on the bicycle ergometer Tunduri (Finland). Physical working capacity at a heart rate of 170 b/min (PWC_{170}) was calculated to characterize the aerobic fitness of the subjects. Exercise heart rate was measured with the Sport-tester Accurex Plus (Polar Electro OY, Finland). Blood pressure was determined by the disappearance of the Korotkoff sounds. A health-related behaviour questionnaire [5] was administered to 481 female and 258 male subjects.

Statistical analysis was performed using the software "Statistic". The mean values and the standard deviations for the normally distributed data were calculated using descriptive statistics.

RESULTS

The mean anthropometric parameters of the female students are presented in Table 1 and the male students in Table 2.

The mean anthropometric parameters of the female students (shoulder width, pelvic width, mean chest circumference, right and left arm force) demonstrated a statistically significant increase and only the mean data of weight showed a decrease for the female students of the University of Tartu in the period between 1965 and 2002 (Table 3). At present, female students are by 5.0 cm taller but mean weight loss during the same period is nearly 0.8 kg. The mean aerobic fitness (PWC_{170}) of the female subjects was 139.6 ± 38.0 W and the variability of this parameter was high (minimum 55 W, maximum 244 W). The all mean anthropometric parameters of the male students demonstrated a statistically significant increase in the same period (Table 4). At present, male students are by 5.7 cm taller and mean weight increase during the same period is nearly 6.0 kg. The mean aerobic fitness (PWC_{170}) of the male subjects in 2002 was 226.7 ± 53.5 W and the variability of this parameter was too high (minimum 142 W, maximum 323 W).

The results of the health-related behaviour questionnaire for the 481 studied female students (380 students from the Faculty of Medicine and 101 students from the Faculty of Exercise and Sport Sciences) are presented in the Table 5 and 258 male students (195 students from the Faculty of Medicine and 63 students from the Faculty of Exercise and Sport Sciences) in the Table 6.

Table 1. Anthropometric parameters of the female subjects (n = 544)

No	Parameters	Mean ($\bar{x}$ ± SD)	Minimum	Maximum
1.	Height (cm)	168.3 ± 5.61	150.0	183.2
2.	Weight (kg)	60.9 ± 8.62	43.0	103.0
3.	Shoulder width (cm)	37.3 ± 1.99	31.0	45.0
4.	Pelvic width (cm)	29.6 ± 2.21	23.0	43.0
5.	Mean chest circumference (cm)	87.9 ± 6.19	74.0	126.0
6.	Right hand dynamometry (kg)	36.4 ± 6.66	18.0	57.0
7.	Left hand dynamometry (kg)	34.7 ± 6.65	13.0	53.0
8.	BMI (kg/m^2)	21.37 ± 2.62	13.2	36.5
9.	Body fat (kg)	13.1 ± 5.4	5.0	44.0
10.	Percentage of body fat	20.6 ± 5.7	4.5	54.0
11.	Vital capacity (l)	3.68 ± 0.56	2.0	6.5
12.	PWC_{170} (W)	139.6 ± 38.0	55.6	244.0
13.	PWC_{170}/kg (W/kg)	2.32 ± 0.63	0.9	3.94
14.	Systolic blood pressure (mm Hg)	110.9 ± 10.9	80.0	143.0
15.	Diastolic blood pressure (mm Hg)	69.5 ± 9.5	45.0	110.0

Table 2. Mean anthropometrial parameters of the female university undergraduates with a 35 year interval ($\bar{x}$ ± SD)

No	Parameters	1998 – 2002 a. (n = 544)	1965 a. (n = 2364)	Dynamics	p
1.	Height (cm)	168.3 ± 5.61	163.3 ± 5.05	+ 5.0	***
2.	Weight (kg)	60.9 ± 8.62	61.7 ± 6.98	– 0.8	*
3.	Shoulder width (cm)	37.3 ± 1.99	36.0 ± 1.61	+ 1.3	***
4.	Pelvic width (cm)	29.6 ± 2.21	28.2 ± 1.52	+ 1.4	***
5.	Mean chest circumference (cm)	87.9 ± 6.19	84.9 ± 4.92	+ 3.0	***
6.	Right arm force (kg)	36.4 ± 6.66	32.6 ± 5.16	+ 3.8	***
7.	Left arm force (kg)	34.7 ± 6.65	29.8 ± 4.95	+ 4.9	***

p (*<0.05, **<0.01, ***<0.001)

Table 3. Anthropometric parameters of the male subjects (n = 258)

No	Parameters	Mean ($\bar{x} \pm SD$)	Minimum	Maximum
1.	Height (cm)	181.3 ± 6.64	168.0	200.0
2.	Weight (kg)	78.2 ± 10.15	58.0	110.0
3.	Shoulder width (cm)	41.9 ± 2.02	37.0	46.0
4.	Pelvic width (cm)	30.8 ± 2.22	26.0	40.0
5.	Mean chest circumference (cm)	97.5 ± 6.63	87.0	118.0
6.	Right hand dynamometry (kg)	64.7 ± 11.15	45.0	100.0
7.	Left hand dynamometry (kg)	61.4 ± 9.93	40.0	86.0
8.	BMI (kg/m^2)	23.6 ± 2.95	19.5	40.0
9.	Body fat (kg)	12.3 ± 4.33	7.0	21.0
10.	Percentage of body fat	16.3 ± 4.0	11.0	24.0
11.	Vital capacity (l)	5.33 ± 0.75	3.2	7.0
12.	PWC_{170} (W)	226.7 ± 53.5	142.0	323.0
13.	PWC_{170}/kg (W/kg)	2.75 ± 0.79	1.5	4.5

Table 4. Mean anthropometrial parameters of the male university undergraduates with a 35 year interval ($\bar{x} \pm SD$)

No	Parameters	1998–2002 a. (n = 258)	1965 a. (n = 2364)	Dynamics	p
1.	Height (cm)	181.9 ± 6.64	176.2 ± 6.08	+ 5.7	***
2.	Weight (kg)	78.2 ± 10.15	72.16 ± 7.18	+ 6.0	***
3.	Shoulder width (cm)	41.9 ± 2.02	39.8 ± 1.87	+ 2.1	***
4.	Pelvic width (cm)	30.79 ± 2.22	28.5 ± 1.55	+ 2.3	***
5.	Mean chest circumference (cm)	97.5 ± 6.63	94.5 ± 4.92	+ 3.0	***
6.	Right arm force (kg)	64.7 ± 11.15	55.6 ± 8.13	+ 9.1	***
7.	Left arm force (kg)	61.4 ± 9.93	51.5 ± 7.31	+ 9.9	***

p (***<0.001)

Table 5. Distribution of physical activity, dieting behaviours, cigarette smoking and BMI for the female students of the University of Tartu

No	Para-meters	Distribution of parameters	Altogether (n=481)		Faculty of Medicine (n=380)		Faculty of Exercise and Sport Sciences (n=101)	
			In all	%	In all	%	In all	%
1.	Physical activity	Very intensive physical activity	35	7.3	12	3.2	23	22.7**
		Intensive physical activity	73	15.2	35	9.5	38	37.7**
		Severe physical activity	56	11.6	36	9.5	20	19.8**
		Moderate physical activity	194	40.3	183	48.2	11	10.9**
		Mild physical activity	115	23.9	107	28.2	8	7.9**
		Physical inactivity	8	1.7	7	1.4	1	1.0
2.	Dieting behaviours	Avoiding saturated fat intake	47	9.8	26	6.8	21	20.8**
		10% saturated fat in diet	183	38.1	133	35.0	50	49.5**
		20% saturated fat in diet	203	42.2	177	46.6	26	25.7**
		30% saturated fat in diet	44	9.1	40	10.5	4	4.0*
		40% saturated fat in diet	4	0.8	4	1.1	0	0
		In diet >40% saturated fat	0	0	0	0	0	0
3.	Cigarette smoking	Non-smoking	441	91.7	349	91.8	92	91.1
		1–5 cigarettes per day	22	4.6	16	4.2	6	5.9
		6–10 cigarettes per day	16	3.3	13	3.4	3	3.0
		11–20 cigarettes per day	2	0.4	2	0.6	0	0
4.	BMI (kg/m^2)	< 19	48	10.0	37	9.7	11	10.9
		19–24	382	79.4	304	80.0	78	77.2
		25–27	42	8.7	30	7.9	12	11.9
		28–30	9	1.9	9	2.4	0	0

*p<0.05; **p<0.01

Table 6. Distribution of physical activity, dieting behaviours, cigarette smoking and BMI for the male students of the University of Tartu

No	Para-meters	Distribution of parameters	Altogether (n=258)		Faculty of Medicine (n=195)		Faculty of Exercise and Sport Sciences (n=63)	
			In all	%	In all	%	In all	%
1.	Physical activity	Very intensive physical activity	63	24.4	26	13.3	37	58.7**
		Intensive physical activity	54	20.9	32	16.5	22	34.9*
		Severe physical activity	32	12.4	29	14.9	3	4.8**
		Moderate physical activity	74	28.7	73	37.4	1	1.6**
		Mild physical activity	34	13.2	34	17.4	0	0
		Physical inactivity	1	0.4	1	0.5	0	0
2.	Dieting behaviours	Avoiding saturated fat intake	25	9.7	19	9.7	6	9.5
		10% saturated fat in diet	77	29.8	56	28.7	21	33.3
		20% saturated fat in diet	101	39.1	81	41.5	20	31.7
		30% saturated fat in diet	49	19.0	36	18.5	13	20.6
		40% saturated fat in diet	6	2.4	3	1.6	3	4.9
		In diet >40% saturated fat	0	0	0	0	0	0
3.	Cigarette smoking	Non-smoking	222	86.0	164	84.1	58	89.2
		1–5 cigarettes per day	15	5.8	12	6.2	3	4.6
		6–10 cigarettes per day	12	4.6	11	5.6	1	1.6
		11–20 cigarettes per day	9	3.6	8	4.1	1	1.6
4.	BMI (kg/m^2)	< 19	5	1.9	5	2.6	0	0
		19–24	139	53.5	110	56.4	29	46.0
		25–27	94	36.9	64	32.8	28	44.4
		28–30	17	6.6	11	5.6	6	9.6
		>30	5	1.9	5	2.6	0	0

*p<0.05; **p<0.01

DISCUSSION

Our results revealed a decrease in the mean data of weight among the female students and an increase in the other mean anthropometric parameters among the female and male students in the period between 1965 and 2002 [22]. Our data are comparable to the data of other studies conducted among the Estonian population in the same period [6, 9, 11–15, 18, 19, 21]. Some investigators have shown that during the period 1963–1994, the prevalence of overweight among young adults increased from 15% to 22% [23], in Finland in male population the prevalence of overweight in 1999 was 48% [10]. In our study overweight was found in 10.6% of the female students and in 43.5% of the male students. 1.9% of the male students were obese. Overweight is a risk factor for coronary heart disease, hypertension, dyslipidemia, diabetes mellitus, osteoarthritis and is associated with mortality rates. Namely BMI is the most sensitive predictor for the risk of cardiovascular diseases as hypertension and dyslipidemia [24]. In our study, the mean BMI of the female students was 21.4 and the male students was 23.6.

Different data suggest that good health is associated with eating behaviours and normal weight [2, 16]. In our investigation normal weight was found in 79.4% of the studied female and 53.5% of the studied male students (Table 5, 6). Weight-related behaviours are prevalent among female adolescents, in particular among adolescent girls. Weight control can be associated with healthy behavioural changes, including reducing fat and carbo-hydrate intake, and increasing exercise [8]. According to the results of the questionnaire, a significant proportion of the female students were trying to control weight. In our study 9.8% of the female students avoided saturated fat in their diet and 38% reduced saturated fat in their diet (Table 5). Among male students 9.7% of them avoided saturated fat in their diet and 30% reduced saturated fat in their diet, but a lot of male students did not decrease in energy intake (Table 6).

Sports participation is associated with multiple positive health behaviours. As different studies showed, subjects engaged in physical activity were less likely to be overweight [1, 4]. Participation in sports is associated with healthier dietary habits compared with sedentary subjects [17]. Sports participants were less likely than sedentary students to report cigarette smoking, using of drugs and attempting suicide [17]. Sports programmes have the potential to help the youth establish lifelong healthy physical activity patterns. In our study the percentage of non-smokers in students was high (Table 5, 6). Various data show that girls report being engaged in less physical activity than boys [7, 20]. In our study the female students participated more often in moderate and mild physical activity programmes, while the male students participated more often in intensive, severe and moderate physical activity programmes. Students from Faculty of Exercise and Sport Sciences participated more often in highly intensive/intensive physical activity programmes, while medical students were more likely to be engaged in moderate and mild intensity physical activity programmes.

In our study overweight was found in 10.6% of the female students and in 43.5% of the male students. 1.9% of the male students were obese. Most of the studied female students controlled weight with healthy behaviours, regular exercise and reducing fat intake. But a lot of the studied male students did not decrease energy intake. Students from Faculty of Exercise and Sport Sciences participated more often in regular physical activity programmes while medical students. Regular physical activity and health-related behaviours had a strong positive impact on the health-promoting component.

CONCLUSIONS

1. The mean anthropometric parameters for female and male students, except for weight of the female, revealed a statistically significant increase for the students of the University of Tartu after an interval of 35 years.
2. The established positive relationships between the anthropometric parameters are related to participation in sports and to healthy behaviours.
3. As a result of the study we established new anthropometric standards for the evaluation of physical development of female and male Estonian university students.

REFERENCES

1. Dowda M, Ainsworth BE. Addy CI, Saunders R, Riner W. (2001) Environmental Influences, Physical Activity, and Weight Status in 8- to 16-Year Olds. Archives Pediatrics & Adolescent Medicine, 155, 711–717.
2. Erickson SJ, Robinson TN, Haydel KF, Farish KJ. (2000) Are Overweight Children Unhappy? Body Mass Index, Depressive Symptoms, and Overweight Concerns in Elementary School Children. Archives Pediatrics & Adolescent Medicine, 154, 931–935.
3. Harries M, Williams C, Stanish WD, Micheli LJ. (1998) Oxford Textbook of Sports Medicine. Oxford University Press.
4. Heath GW, Pratt M, Warren CW. Kann L. (1994) Physical activity patterns in American high school students. Archives Pediatrics & Adolesent Medicine, 148, 1131–1136.
5. Hockey R. (1981) Physical fitness. The Pathway to Healthful Living. The C. V. Mosby Company. Toronto.
6. Janson T, Terasmaa T, Ignatjeva N. (2001) TÜ Kehakultuuriteaduskonna üliõpilaste tervise, kehalise võimekuse ja tervisenäitajate muutused bakalaureuseõppe vältel. Kehakultuuriteaduskonna teadus- ja õppemetoodiliste tööde kogumik X, 43–51.
7. Kasmel A. (2002) Kehaline aktiivsus. In: Kiivet R, Harro J. Eesti rahva tervis 1991-2000. Tartu, 40.
8. Krowchuk DP, Kreiter SR, Woods CR, Sinal SH, DuRant RH. (1998) Problem Dieting Behaviors Among Young Adolescents. Archives Pediatrics & Adolescent Medicine, 152, 884-888.
9. Landõr A, Maaroos J. (1999) Üliõpilaste antropomeetriliste näitajate võrdlusanalüüs. Eesti Antropomeetriaregistri Aastaraamat, 1999, 90-95.
10. Leino M., Raitakari OT, Porkka KV, Taimla S, Viinari JS. (1999) Association of education with cardiovascular risk factors inyoung adults: the cardiovascular Risk in Young Finns Study. International Journal of Epidemiology, 28, 667–675.
11. Lilienberg K, Saava M. (2001) Antropomeetriliste näitajate trendid Tallinna 14-aastastel kooliõpilastel. Eesti Antropomeetriaregistri Aastaraamat, 2001, 110–115.
12. Lintsi M, Aule R, Loko J, Nurmekivi A, Lemberg H, Kaarma H. (2000) TÜ Kehakultuuriteaduskonna üliõpilaskandidaatide antropomeetriliste tunnuste ja mõningate liigutusvõimete vahelistest seos-

test. Kehakultuuriteaduskonna teadus- ja õppemetoodiliste tööde kogumik VIII, 148-158.
13. Loolaid K, Kaarma H, Loolaid V, Saluse L. (2001) 15–16 aastaste Tartu tütarlaste antropomeetriliste andmete analüüs. Eesti Antropomeetriaregistri Aastaraamat, 2001, 149–158.
14. Maaroos J, Landõr A. (2001) Anthropometric indices and physical fitness in university undegraduates with different physical activity. Anthrop. Anz., 59, 157-163.
15. Maiste E, Matsin T, Täll S, Liik K, Paidre H, Aule R. (1997) Assessment of the levels of physical abilities in adolescents. Acta Medica Baltica, Vol 4 (1), 67–70.
16. Neumark-Sztainer D, Hannan PJ. (2000) Weight-Related Behaviors Among Adolescent Girls and Boys: Results From a National Survey. Archives Pediatrics & Adolescent Medicine, 154, 569–577.
17. Pate RR, Trost SG, Levin S, Dowda M. (2000) Sports Participation and Health-Related Behaviors Among US Youth. Archives Pediatrics & Adolescent Medicine, 154, 904-911.
18. Peterson J. (1999) 17–23-aastaste neidude antropomeetriliste andmete analüüs. Eesti Antropomeetriregistri Aastaraamat, 1999, 151–163.
19. Pihl E, Jürimäe T, Kaasik T. (1997) Effect of physical activity on cardiovascular health 18–25 year-old university student. Acta Medica Baltica, Vol 4 (1), 84–87.
20. Prochaska JJ, Sallis JF, Long B. (2001) A Physical Activity Screening Measure for Use with Adolescents in Primary Care. Archives Pediatrics & Adolescent Medicine, 155, 554–559.
21. Saluste L, Koskel S. (2002) Tartu linna täiskasvanud eesti meeste ja naiste kehaehitus ja rasvasisaldus aastatel 1998–2001. Eesti Antropomeetriregistri Aastaraamat, 2002, 204–212.
22. Tiik H. (1965) Eesti NSV üliõpilaste kehaline areng ja tervislik seisund. Dissertatsioon. Tartu.
23. Troiano RP, Flegal KM, Kuczmarski RJ, Campell SM, Johnson CL. (1995) Overweight Prevalence and Trends for Children and Adolescents: The National Health and Nutrition Examination Surveys, 1963 to 1991. Archives Pediatrics & Adolescent Medicine, 149, 1085–1091.
24. Volozh O, Solodkaja E, Abina J, Olferjev A. (1998) Vererõhu ja – lipiidide seos kehamassiindeksiga. Eesti Antropomeetriaregistri Aastaraamat, 1998, 90–95.

Address for correspondence:
Maie Ojamaa
SA TÜK spordimeditsiini ja taastusravi kliinik
Puusepa 1a, 50406, Tartu
E-mail: maie.ojamaa@kliinikum.ee
telefon tööl: 7318 277

Papers on Anthropology XVI, 2007, pp. 222–236

DENTAL STATUS OF TWO MILITARY SAMPLES: SOLDIERS OF NAPOLEON'S GREAT ARMY AND GERMAN SOLDIERS IN WORLD WAR I

Žydrūnė Palubeckaitė-Miliauskienė, Rimantas Jankauskas

Department of Anatomy, Histology and Anthropology, Faculty of Medicine, University of Vilnius, Lithuania

ABSTRACT

It is generally considered that military service in the 19th century army was detrimental to person`s health. Dental status is a good test of this supposition, because dental lesions occur in a short time and depend on several factors, including diet, hygiene and the general health of an individual. Two military populations, found during rescue excavations in Lithuania in 2002 and 2006, were taken for analysis. The first sample consists of the soldiers of Napoleon's Great Army, who died during the retreat from Russia in Vilnius in December 1812. The second sample represents German soldiers of the World War 1, who died in a military hospital in Panevėžys in 1915–1917. The general dental analysis, including that of dental wear, tooth loss, caries and abscesses, was used to evaluate the oral health status and the possible dietary patterns of recruits. Growth conditions in childhood were studied by scoring of linear enamel hypoplasia (LEH). In total, 293 adult males (6,528 teeth) from Napoleon's Great Army and 77 adult males (1,730 teeth) from the German Army were selected for the analysis; the majority of individuals were less than 35 years at the time of death. Results have revealed a moderate prevalence of caries in both samples. However, a higher prevalence of ante-mortem tooth loss and abscesses among soldiers of the World War 1 indicates a more aggressive rate of decay and, in general, worse oral health in the German Army. It is argued that the differences between populations reflect changes in dietary habits (e.g. the increased consumption of sugar and refined carbohydrates) at the end of the 19th century. An overall prevalence of hypoplasia was low in both samples suggesting a selection of the fittest individuals for military service. A statistically lower number of LEH in the German Army compared to Napoleon's soldiers could be a consequence of the overall decline in morbidity and mortality in Western Europe in the 19th century.

Key words: dental status, caries, diet, military population.

INTRODUCTION

The dental status analysis is a valuable tool in the evaluation of the health of people in the past. Such studies can provide information about individual's dental health, oral hygiene, diet and even growth conditions in childhood. Caries or dental decay is most often used for the assessment of oral health and dietary patterns. Clinical studies have revealed a correlation between caries and dietary products like sugar and starches, which are the most cariogenic [4]. Numerous paleopathological studies have found that the prevalence of caries in humans increased with the introduction of agricultural products, the greatest rise occurring in the late 19th century [1, 8, 11]. These changes were connected with a marked increase in sugar consumption and changes in flour-making technology [5, 19]. Since dental plaque is a necessary condition for decay to develop, the prevalence of caries also provides information about oral hygiene.

Periodontal disease and periapical abscesses mostly are the consequence of complications of caries, a condition that often leads to the subsequent antemortem tooth loss (AMTL). Such pathological conditions can serve as additional tools in the evaluation of dental health. Teeth can also be lost due to severe dental attrition, trauma, or extraction. Severe dental attrition and periodontal diseases were the main causes of AMTL in prehistoric populations [2, 12]. Medieval and modern populations show less pronounced tooth wear due to the changes in food preparation, thus dental diseases emerged as the crucial factor in antemortem tooth loss [8].

Dental studies can also provide information about life conditions in childhood. A nonspecific stress indicator – linear enamel hypoplasia (LEH) – is the most often used for this purpose. The condition appears due to disturbances in enamel formation during tooth development [22]. Enamel formation could cease due to various factors that affect a child's growth, e.g. weaning, malnutrition, infections, hereditary diseases, and others [17]. If the child recovers, enamel formation continues, leaving a line as a sign of experienced stress. As LEH reflects periods of nonspecific stress, it is considered a good indicator of growth conditions and general stress levels of a population [8, 22].

The military origin of our samples can provide information about the health and daily habits of the soldiers of that time. It is generally considered that life in the army of the 19th century was detrimental to ones health. It involved bad food, hard work, and an appalling lack of sanitation [24]. The dental status is a good test of the supposition about the health-destroying effect of military service, because dental lesions occur in a short time and depend on several factors, including diet, hygiene, and the general health of an individual. Our earlier study about Napoleon's Great Army soldiers [14] has revealed a low total prevalence of dental disease. However, a considerable amount of pulp caries and a high number of carious teeth in some individuals indicate a poor oral hygiene and increased vulnerability to disease. We argued that this was due to constant physical and nutritional stress [14]. A population of German soldiers of the World War 1 excavated in Panevėžys in 2006 provided a good opportunity to check if and how the health of the soldiers had changed in the beginning of the 20th century, compare with the first half of the 19th century. Furthermore, the end of the 19th century is characterized by great changes in dietary habits – an overall increase in the consumption of refined carbohydrates. Our study is a good possibility to survey how these secular trends reflected in the dental status of soldiers, especially because skeletal data about early industrial populations are scarce.

MATERIAL AND METHODS

Two military populations were used for the study. The first sample consists of the soldiers of Napoleon's Great Army, who died mostly from cold, exhaustion and starvation in December 1812 in Vilnius during Napoleon's Russian campaign. The individuals found in the mass grave (the estimated minimum number of individuals is 3,269, with males constituting over 96% of the sample) in Vilnius represent a unique sample of individuals from almost all the parts of Western and Central Europe from the early 19th century [21].

The second sample consists of German soldiers of the World War 1, who died in a military hospital in Panevėžys in 1915–1917 and were buried in a hospital cemetery (the total number of individuals is 830, with males constituting 99.4 % of the sample). These individuals represent Western and Central Europe from the early 20th century.

The age and sex of individual was determined according to standard morphological criteria [29]. In total, 293 adult males (6,528 permanent teeth) from Napoleon's Great Army and 77 adult males (1,730 permanent teeth) from the German Army were selected for the analysis. The dental status evaluation included teeth loss, attrition, caries, abscesses and enamel hypoplasia.

The incidence of tooth loss was determined in all the cases where the alveolar bone was present. A tooth was recorded as lost antemortem (before death) if its alveolus had been partly or completely closed. If there was no trace of alveolar remodeling, the tooth was recorded as lost postmortem (after death). The prevalence of antemortem tooth loss (AMTL) and postmortem tooth loss (PMTL) was computed on the basis of the number of teeth sockets available.

Dental attrition was recorded according to Smith [25]. Only the 1st and the 2nd molars (M1 and M2) were used for comparison. Results are shown as the average degree for a tooth category.

The presence of caries was determined macroscopically using a dental probe, by the commonly accepted clinical evaluation. A tooth was recorded as carious if there was a discoloration (brown spots) or disintegration of the external surface of the enamel or cementum. The prevalence of caries was computed on the basis of the number of teeth available. Dental fillings were recorded and added to caries prevalence. The results are shown as the total prevalence of caries, which is composed of decayed plus filled teeth.

Abscesses were recorded for all the teeth according to Brothwell [3]. The prevalence of abscesses was computed on the basis of teeth sockets available.

Linear enamel hypoplasia (LEH) was recorded macroscopically on all the permanent anterior teeth. The severity of hypoplasia was recorded according to Schultz [20]: 1st degree – mild, 2nd degree – moderate, 3rd degree – severe. The precise definition of the severity of the defect requires certain conditions (good light). Because LEH of a mild degree are not very clear, and recording of the defects was performed in different conditions (Napoleon's soldiers were analyzed in the laboratory, while the German soldiers – in the field of excavation), we decided to equate individuals with mild defects to the healthy ones. This will eliminate methodological differences in LEH scoring, and makes a comparison between the samples more reliable.

Statistical analyses were performed using the SPSS statistical package (chi-square test, Student's t-test, ANOVA procedures).

RESULTS

The age at death was low in both samples – 88% of Napoleon's soldiers and 82% of German soldiers were less than 35 years old at the time of death (Table 1). The age at death distribution of the two samples did not differ statistically. No statistical difference was found in the preservation of teeth of the two samples. Only 11.9% of the teeth of Napoleon's soldiers and 8.6% of the teeth of German soldiers were recorded as lost postmortem; the average number of preserved teeth per skull was 22.3 ± 5.9 and 22.5 ± 6.2, accordingly.

Table 1. Age structure of the populations included in the present study

Age group (years)	Napoleon's soldiers		German soldiers	
	n	%	n	%
<25	149	50.9	30	39.0
25–35	109	37.2	33	42.9
>35	35	12.0	14	18.1
Total	293	100	77	100

The overall dental attrition was low, although statistically significant differences were found – the soldiers of the Great Army had a greater average degree of attrition ($p<0.01$). The difference was statistically significant for both molars in all the age groups, except for the M2 in 25–35-year-oldage group (Figure. 1).

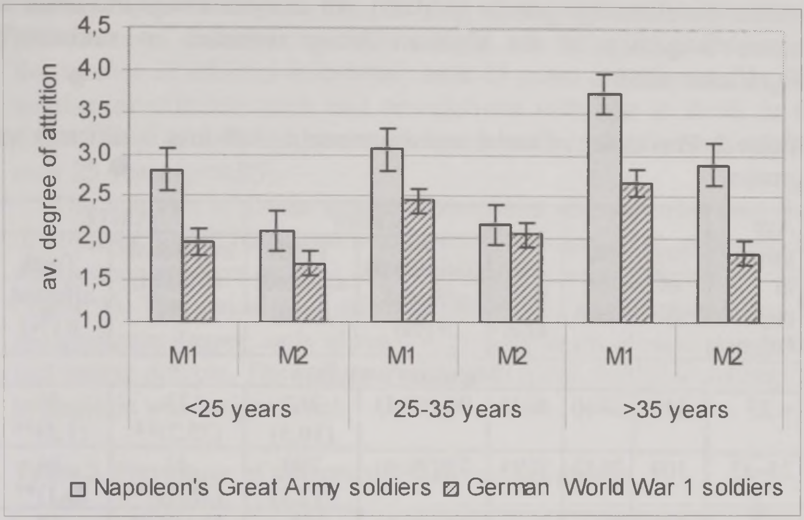


Figure. 1. Molar wear in different age groups (upper and lower dentition combined).

The analysis of the prevalence of antemortem tooth loss revealed statistically significant differences. Of all Napoleon's soldiers 33.1% had at least one tooth lost before death; in total, only 2.7% of the teeth were lost antemortem. While among German soldiers, 81.8% of individuals had AMTL and 14.9% of teeth were lost before death ($p<0.01$). Population differences in antemortem tooth loss were statistically significant in all ages at death groups (Table 2). The analysis of the influence of the age at death on the tooth loss revealed a statistically significant increase in AMTL with the age ($p<0.01$). Statistical differences were obtained among all the three agegroups at death in both samples.

No statistical differences were found in the prevalence of caries. About 70% of individuals in each population had at least one carious tooth. In total, 11.5% of teeth were affected (Table 2). No filling was found in the teeth of Napoleon's soldiers. Among German soldiers amalgam filled teeth constituted from 22.8% to 40.6% of decayed teeth, depending on the age at death. One 25–30 year and one 40–45 year individual had upper teeth prostheses. In the Great Army the number of affected individuals and affected teeth increased with age, but statistical differences were obtained only between the youngest versus the oldest age groups ($p<0.05$). An analysis of age influence on caries frequency in the German Army revealed no statistically significant pattern.

Table 2. Prevalence of caries and antemortem tooth loss in different age groups

Age group in population	No. of indiv.	No. of teeth	No. of sockets	Caries		AMTL	
				Individuals affected, n (%)	Teeth affected, n (%)	Individuals affected, n (%)	Teeth affected, n (%)
Napoleon's soldiers							
< 25	149	3460	4005	96 (64.4)	363 (10.5)	33 (22.2)**	60 (1.5)**
25–35	109	2352	2793	77 (70.6)	290 (12.3)	42 (38.5)**	84 (3.1)**
> 35	35	716	906	28 (80.0)	97 (13.6)	22 (62.9)	62 (6.8)**
Total	293	6528	7704	201 (68.6)	750 (11.5)	97 (33.1)**	206 (2.7)**
German soldiers							
< 25	30	771	901	22 (73.3)	75 (9.7)	20 (66.7)	64 (7.1)
25–35	33	708	974	26 (78.8)	92 (13.0)	31 (93.9)	175 (18.0)
> 35	14	251	387	8 (57.1)	32 (12.8)	12 (85.7)	98 (25.3)
Total	77	1730	2262	56 (72.7)	199 (11.5)	63 (81.8)	337 (14.9)

** Difference significant between populations in corresponding age group ($p<0.01$)

Statistically significant differences were found in the prevalence of abscesses. Of all Napoleon's soldiers, 18.4% had at least one periapical abscess; in total, only 1.2% of teeth were affected. While among the German soldiers, 32.5% of individuals and 2.5% of teeth were affected ($p<0.01$). Differences between populations were statistically significant in almost all age groups at death. (Table 3). The majority of affected individuals had 1–2 abscesses per mouth; only 1.7% of the Great Army and 3.9% of the German Army soldiers had multiple abscesses. The analysis of the age influence on the prevalence of abscesses revealed a slight, but insignificant increase in the number of affected individuals over 25 years in both samples. The number of affected teeth had no relations with age at death in the Great Army sample, but increased significantly in the German soldiers over 25 years ($p<0.05$).

The analysis of linear enamel hypoplasia also revealed statistical differences. Of all Napoleon's soldiers, 47.1% had LEH, while among the German soldiers only 23.4% of individuals were affected ($p<0.01$) (Table 4). The majority of affected individuals had the hypoplasia of the moderate degree; only about 6% of individuals in each population had severe defects. The influence of age at death on the prevalence of hypoplasia was insignificant.

Table 3. Prevalence of abscesses in different age groups

Age group in popu-lation	No. of indiv.	No. of sockets	Abscesses	
			Individuals affected, n (%)	Teeth affected, n (%)
Napoleon's soldiers				
< 25	149	4005	25 (16.8)	37 (1.1)
25–35	109	2793	22 (20.2)*	29 (1.2)**
> 35	35	906	7 (20.0)	10 (1.4)*
Total	293	7704	54 (18.4)**	76 (1.2)**
German soldiers				
< 25	30	901	7 (23.3)	10 (1.3)
25–35	33	974	13 (39.4)	25 (3.5)
> 35	14	387	5 (35.7)	9 (3.6)
Total	77	2262	25 (32.5)	44 (2.5)

* Difference significance between populations in the corresponding age group ($p<0.05$)

** Difference significance between populations in the corresponding age group ($p<0.01$)

Table 4. Prevalence of linear enamel hypoplasia in different age groups

Age group in population	No. of indiv.	LEH		
		Moderate, n (%)	Severe, n (%)	Moderate + severe, n (%)
Napoleon's soldiers				
< 25	149	67 (45.0)**	10 (6.7)	77 (51.7)**
25–35	109	43 (39.4)**	4 (3.7)	47 (43.1)*
> 35	35	12 (34.3)	2 (5.7)	14 (40.0)
Total	293	122 (41.6)**	16 (5.5)	138 (47.1)**
German soldiers				
< 25	30	6 (20.0)	2 (6.7)	8 (26.7)
25–35	33	5 (15.2)	2 (6.1)	7 (21.2)
> 35	14	2 (14.2)	1 (7.1)	3 (21.4)
Total	77	13 (16.9)	5 (6.5)	18 (23.3)

* Difference significance between populations in the corresponding age group ($p<0.05$)

** Difference significance between populations in the corresponding age group ($p<0.01$)

DISCUSSION

Our analysis has revealed that the soldiers of Napoleon's Great Army had statistically higher dental attrition, but a lower prevalence of abscesses and antemortem tooth loss compared to the German soldiers of the World War 1. The prevalence of caries was moderate and almost identical in both samples. The greatest difference between the populations was found in the prevalence of the antemortem tooth loss. It is noticeable that the youngest German soldiers had the same and even a higher number of lost teeth compared to the oldest individuals of the Napoleon's Army. One of the main causes of AMTL in medieval and early modern populations is the complication of caries [8]. A tooth can also be lost because of trauma, however, the great majority of teeth lost before death, were premolars and molars, teeth that are most frequently affected by caries. Taking this into account, we argue that German soldiers had suffered from dental decay more heavily than the individuals from Napoleon's Great Army.

The occurrence of the decay depends on several factors: oral hygiene, diet, the fluoridation level in drinking water and the immune system of an individual [4]. Oral hygiene, one of the most important factors in the prevention of caries nowadays, was practically neglected in the beginning of the 19th century. Regular tooth cleaning was not a widespread practice, and preventive dentistry hardly existed [19]. A list of knapsack contents of a French fusilier included 3 different brushes, but not one toothbrush [10]. Documental evidence stated that all the soldiers of the American Civil War should carry a toothbrush [28]. However, according to the authors, given that soldiers were often not required to wash their faces, it would be surprising to learn that dental hygiene was superlative. This could be supported by the fact that sanitary facilities in camps were limited [15, 24]. Thus, we think that dental hygiene cannot account for the differences in caries-AMTL prevalence between the two military populations.

Diet is another important factor in discussing the prevalence of decay. According to the literature, the wartime diet in the beginning of the 19th century relied heavily on carbohydrates, such as bread, flour, grout and potatoes, though sugar was not a common dietary item in military rations [18, 24, 28]. Fresh meat, vegetables, fruits and other products were served occasionally and in low quantities. This could explain why the caries rate of Napoleon's soldiers is close to that of the late medieval populations from North and Central Europe, which are characterized by poor oral hygiene and a diet based mostly on carbohydrates, but with low consumption of sugar [7, 9, 13, 23, 26] (Fig. 2).

In the end of the 19th century a great shift in dietary habits occurred. The progressive removal of duties highly increased the consumption of sugar, and technological improvements in baking industry allowed the production of fine white flour. In many industrial areas, white bread, jam and sweetened tea became a staple diet [5, 28]. As a result of increased consumption of sugar and refined carbohydrates, a marked increase in the frequency of caries occurred in the second half of the 19th century [5, 19]. It is plausible that changes in the dietary habits of civilians should have reflected in a daily ration of soldiers. A lower dental attrition of German soldiers compared to Napoleon's Army did indicate the use of more refined products. Taking this into account, one could expect a higher prevalence of caries in the German Army. We think that a much lower caries rate among German soldiers compared to their civilian contemporaries from Britain (Figure. 2) could be a consequence of an aggressive rate of decay and a subsequent loss of teeth in the military sample.

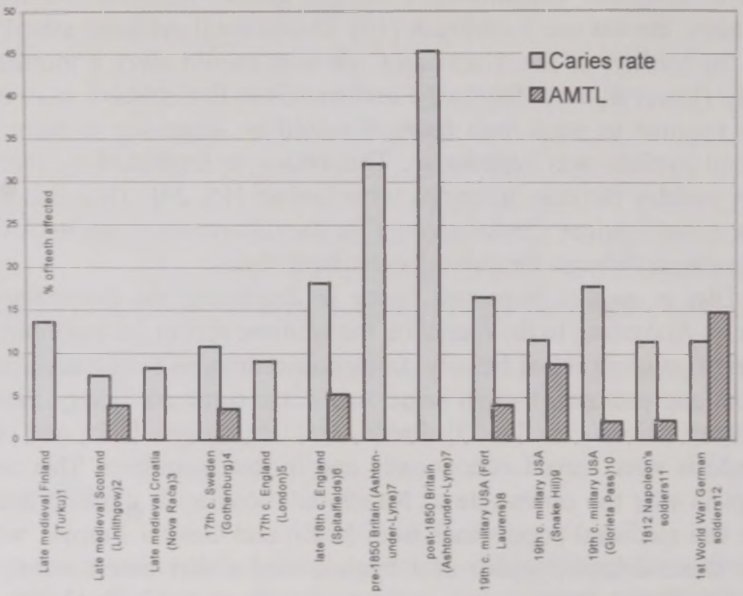


Figure. 2. Caries rate and antemortem tooth loss in selected late medieval and early modern populations in Europe, together with those of North American 19^{th} cen. military samples, and military populations included in the present study (only individuals of 16–35 years were selected).
[1][26]; [2][7]; [3][23]; [4][9]; [5][13]; [6][27]; [7][5]; [8,9,10][24]; [11,12]present study.

The diet of a front-line soldier was of poor quality and did not satisfy the caloric requirements for an adult man [24]. However, it could be substantially improved during the furlough or hospitalization, yet considering the great number of soldiers in the army, the local population was not always able to provide a sufficient amount of fresh food. Scurvy, an ailment commonly seen by field surgeons, could serve as a proof of a poor diet [28]. Poor sanitation in camps, intense physical and nutritional stress could weaken the immune system of individuals, and make them less resistant to oral disease, and herewith, increase the aggressiveness of caries.

Although medical treatment of caries was available since the 16th century, even at the beginning of the 20th century it was highly limited by their costs and the ability of the patients to pay [6, 19]. There is no evidence about regular medical dental care in the army during the World War 1. Military dentistry was limited to the extraction of teeth by surgeons or even by other soldiers. Although dentists served in hospitals, the cost of dental operations was more than the average soldier could pay, thus dental extractions were more economically feasible than dental fillings [28]. According to authors, an extraction of the tooth sometimes lead to a broken root, the situation that could cause an infection and other dental problems, such as abscesses. A high prevalence of antemortem tooth loss and abscesses among German soldiers indicate that pulling out decayed teeth was a common practice during the World War 1. However, a fairly high number of filled teeth and a few cases of dental prostheses suggest a different social status of soldiers.

The analysis of linear enamel hypoplasia has revealed a low incidence of the defects in both samples: 47.1% of Napoleon's soldiers and 23.3% of German soldiers had LEH. Our results were close to those of the 19th century North American military samples, where only about 26% of individuals were affected [24, 28]. A low prevalence of LEH is usually considered an indicator of better living conditions and less stressful growth [8, 22]. Literature sources indicate high standards for conscription into the army: only the healthiest individuals without diseases and bodily deformities were selected [15, 24]. Thus, the low prevalence of LEH in our sample most likely represents the fittest individuals. A statistically lower number of hypoplasia in the German Army compare to Napoleon's soldiers could be a consequence of the overall decline in morbidity and mortality in the 19th century Western Europe, as a result of an improvement in living standards, nutrition and health care [15, 16].

Summing up, the analysis of the two military populations has revealed that German soldiers had a higher total prevalence of dental disease compared to Napoleon's soldiers. A higher prevalence of antemortem tooth loss and abscesses among soldiers of the World War 1 indicates a more aggressive rate of caries. We argue that the differences between the populations reflect changes in dietary habits (e.g. increased consumption of sugar and refined carbohydrates) at the end of the 19th century. A low number of hypoplasia suggests a selection of the fittest individuals for military service.

REFERENCES

1. Alexandersen V. (2003) Dental variation and change through time in Nordic populations. In: A tooth for a tooth: Seminar for odontologists, osteologists and archaeologists, May 28th 1998. University of Lund, Institute of Archaeology Report Series, 87, 9–36.
2. Bennike P. (1985) Palaeopathology of Danish skeletons: a comparative study of demography, disease and injury. Akademisk Forlag.
3. Brothwell D. R. (1972) Digging up bones: the excavation, treatment and study of human skeletal remains. Trustees of the British Museum. London.
4. Burt B. A., Ismail A. I. (1986) Diet, nutrition, and food cariogenecity. J Dent Res, 65, 1475–1484.
5. Corbett M. E., Moore W. J. (1976) Distribution of dental caries in ancient British populations: IV. The 19th century. Caries Res, 10, 401–414.
6. Czarnetzki A., Ehrhardt S. (1900) Re-dating the Chinese amalgam-filling of teeth in Europe. Int J Anthropol 5, 4, 325–332.
7. Kerr N. W., Bruce M. F., Cross J. F. (1990) Caries experience in mediaeval Scots. Amer J Phys Anthropol, 83, 69–76.
8. Larsen C. S. (1997) Bioarchaeology: interpreting behavior from the human skeleton. Cambridge University Press.
9. Lingström P., Borrman H. (1999) Distribution of dental caries in an early 17th century Swedish population with special reference to diet. Int J Osteoarchaeol, 9, 395–403.
10. Magueron L. J. (1897–1906) Campagne De Russie. Henri Charles-Lavauzelle: Paris. Available at: http://www.napoleon-series.org/military/organization/c_knapsack.html
11. Mays S. (1998) The archaeology of human bones. Routledge. London and New York.
12. Meiklejohn C., Zvelebil M. (1991) Health status of European populations at the agricultural transition and the implications for the adoption of farming. In: Health in past societies: biocultural

interpretations of human skeletal remains in archaeological contexts. BAR International Series 567, 129–145.

13. Moore W. J., Corbett M. E. (1975) Distribution of dental caries in ancient British populations: III. The 17th century. Caries Res, 9, 163–175.
14. Palubeckaitė Ž., Jankauskas R., Ardagna Y., Macia Y., Rigeade C., Signoli M., Dutour O. (2006) Dental Status of Napoleon's Great Army's (1812) mass burial of soldiers in Vilnius: childhood peculiarities and adult dietary habits. Int J Osteoarchaeol, 16, 355–365.
15. Padiak J. (2005) The role of morbidity in the mortality decline of the nineteenth century: evidence from the military population at Gibraltar 1818–1899. Journal of the history of medicine, 60, 1, 73–95.
16. Perrenoud A. (1997) Child Mortality in Francophone Europe: state of knowledge. In: Infant and child mortality in the past. Calderon Press. Oxford. 22–37.
17. Pindborg J. J. (1970) Pathology of the dental hard tissues. Copenhagen.
18. Pugačiauskas V. (2004) Napoleonas ir Vilnius: karinio gyvenimo kasdienybės bruožai. Arlila. Vilnius.
19. Saunders S. R., De Vito C., Katzenberg M. A. (1997) Dental caries in nineteenth century upper Canada. Amer J Phys Anthropol, 104, 71–87.
20. Schultz M. (1988) Paläopathologische Diagnostik. In Anthropologie: handbuch der vergleichenden biologie des menshen. Gustav Fisher Verlag. Stuttgart. 480–496.
21. Signoli M., Ardagna Y., Adalian P., Devriendt W., Lalys L., Rigeade C., Vette T., Kuncevicius A., Poskiene J., Barkus A., Palubeckaite Z., Garmus A., Pugaciauskas V., Jankauskas R., Dutour O. (2004) Discovery of a mass grave of Napoleonic period in Lithuania (1812, Vilnius). Comptes Rendus Palevol, 3, 219–227.
22. Skinner M., Goodman A. H. (1992) Anthropological uses of developmental defects of enamel. In: Skeletal biology of past peoples: research methods. New York. 153–174.
23. Šlaus M. (2000) Biocultural analysis of sex differences in mortality profiles and stress levels in the late Medieval population from Nova Rača, Croatia. Amer J Phys Anthropol, 111, 193–209.
24. Sledzik P. S., Sandberg L. G. (2002) The effects of nineteenth-century military service on health. In: The backbone of history: health and nutrition in the Western hemisphere. Cambridge University Press. 185–207.

25. Smith B. H. (1984) Patterns of molar wear in hunter-gatherers and agriculturalists. Amer J Phys Anthropol, 63, 39–56.
26. Varrela T. M. (1991) Prevalence and distribution of dental caries in a late Medieval population in Finland. Archs Oral Biol, 36, 553–559.
27. Whittaker D. K., Molleson T. (1996) Caries prevalence in the dentition of a late eighteenth century population. Archs Oral Biol, 41, 55–61.
28. Wols H. D., Baker J. E. (2004) Dental health of elderly confederate veterans: evidence from the Texas State cemetery. Amer J Phys Anthropol, 124, 59–72.
29. Workshop of European anthropologists 1980. Recommendations for age and sex diagnoses of skeletons. J Human Evol, 9, 517–549.

Address for correspondence:
Žydrūnė Palubeckaitė-Miliauskienė
Department of Anatomy, Histology and Anthropology,
Faculty of Medicine, University of Vilnius,
M.K.Čiurlionio 21, 03101, Vilnius, Lithuania
Tel. (+370 5) 239 8709
Fax. (+370 5) 239 8705
e-mail: rimantas.jankauskas@mf.vu.lt

Papers on Anthropology XVI, 2007, pp. 237–243

CHARACTERISTICS OF PHYSICAL PREPAREDNESS AND PHYSICAL FITNESS OF THE MILITARY OFFICERS AND SOLDIERS

Liana Pļaviņa

National Defence Academy of Latvia

ABSTRACTS

Military officers and soldiers are responsible for various different tasks and obligations in the peace time and during military operations. They should be physically active, be ready to adapt to extreme situations and the new environment, they should be tolerant to psychological stress. Physical preparedness and fitness are controlled during the time of physical tests (standard exercises). The results of physical tests constitute the main criteria of the positive annual evaluation of the military. Beside the general physical fitness it is very important for the military to have some other features that characterise special military physical preparedness: speed, force, adroitness, flexibility, and the characteristics of psychological tolerance. We have provided a questionnaire and the evaluation of physical fitness in two examined groups. The questionnaire results have shown positive attitude to physical and sport activities of the officers and soldiers and stressed the problems in organizing and providing physical exercises. The results of standard physical tests (exercises) in the examined group of cadets are higher than in the group of the military officers of the Security Service.

Key words: physical activity, physical fitness, military officers and soldiers, cadets

INTRODUCTION

Nowadays military officers and soldiers carry out various tasks, there are different military specialists and numerous obligations. Military people should be physically active, be ready to adapt to extreme situations and the new environment, they should be tolerant to psychological stress. The physical preparedness and physical fitness of the military people are essential for the fulfilment of direct obligations [4,5,6]. The results of physical test exercises are the main characteristics and criteria of the positive annual evaluation of the military people. Beside the general physical fitness it is very important for the military people to have some other features that characterise special military physical preparedness: speed, force, adroitness, flexibility, and characteristics of psychological tolerance: belief in the own ability and force, self-confidence, boldness, and readiness to leadership. Special exercises are included: wrestling, getting over an obstacle zone, etc.

MATERIAL AND METHODS

The target of investigation is the evaluation of physical activity and physical fitness according physical test (exercises) results in two examined groups. The first group includes cadets of the National Defence Academy of Latvia (N=42) aged 18–28 years: 26% of the respondents of the NDA have a higher academic education level, 74% of the respondents in the NDA have secondary (middle) school education level. The second group includes military officers of the Security Service (N=36) aged 18–45. 10% of the respondents have a higher academic education level, 12% of the respondents continued their studies in a higher school, 78% of the respondents have the secondary (middle) school education level. We have provided a questionnaire that included some positions concerning the individual attitude to physical activities and the Sports test, the Sports exercises. The standard physical exercises include: the push up exercise, the pull up exercise, the country-cross race of 3000 m, the special military physical exercises include skill control procedures in wrestling , overcoming obstacles.

RESULTS AND DISCUSSION

One of the wide spread problems of modern society is hyperkinesias. Decreasing the motion is closely connected with technical progress, the amount of physical work diminished and the amount of mental activity increased. Less physical activity caused increasing of body mass. The problem of overweight is connected not only with decreasing physical activity, but also it is connected with the influence of various external and inner factors upon the individual [1,2,3].

Sufficient physical activity is the basis for healthy behaviour [7,8].

According to the questionnaire we receive information concerning the attitude to physical activities and sport of the military people. In the NDA 66% of the respondents have regular sports activities 10% of the respondents are active sportsmen with an intensive physical load, but at the same time 18% of the respondents have rare sports activities and 6% of the respondents have not any physical activity (Figure 1).

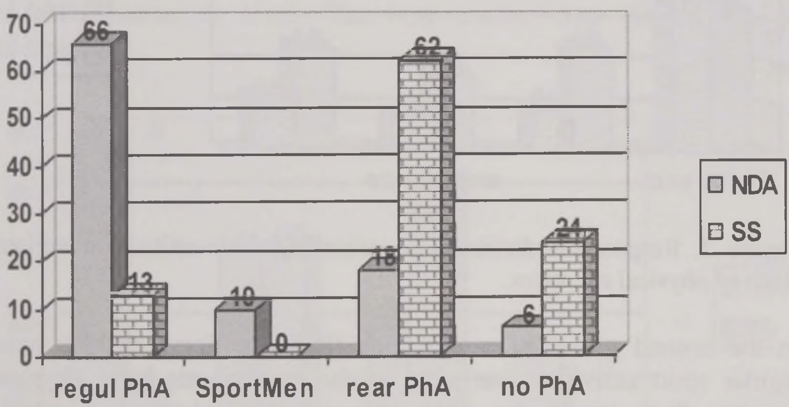


Figure 1. Respondent division (%) according to physical activities levels.

The cadets' self evaluation of physical state and activity has shown that 45% of the cadets characterised their physical preparedness as satisfactory; 17% of the respondents consider that their physical activity and physical preparedness is low (unsatisfactory), 38% cannot make objective evaluations of their physical state.

60% of the respondents in the NDA have the opinion that physical activities help improve the physical fitness level and 15% of respondents think that physical activities, sports exercises have a positive influence and consolidate the health state, 70% of the respondents did not accept the schedule of physical exercises in gymnasium, 94 % of the respondents – the cadets of NDA have sports activities outside service time. We are interested to know what kind of physical exercises cadets prefer, 34% of the respondents like force exercises, 24% of the respondents prefer force exercises and 18% undergo physical endurance exercises, 24% accept all kinds of physical exercises (Figure 2).

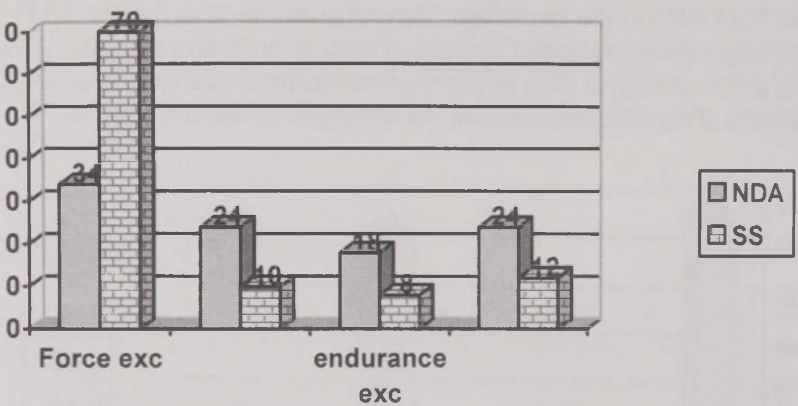


Figure 2. Respondent division (%) according their attitude to various kinds of physical exercises.

In the second group of respondents (Security Service) 13% have regular sport activities, but 62% of the respondents have physical activities form time, to time. 24% have not physical activities outside service (Figure.1). The questionnaire includes the position of the self-evaluation of the physical preparedness of respondent, 8% of officers are satisfied with their physical preparedness, 53% of the respondents are discontented with their physical preparedness level and decide to improve it, 14% of the respondents consider that physical activity is necessary for increasing physical preparedness and physical fitness, 33% of the respondents get a positive emotional effect form sports activities, and 19% consider that physical activity is essential for keeping their health in a good state. But the respondents pointed out the lack of equipment and unacceptable planning of physical exercises. There are 70% of respondents WHO prefer force exercises, 10% accept speed exercises and only 8% like endurance exercises, 12% accept all kinds of physical exercises (Figure 2).

The questionnaire results reflected positive attitude to physical activities in both examined groups. The main problem in both examined groups is the time and the place for physical exercises. The military people with a higher academic education level have more physical activities. The military people in the age up to 28 years have more physical activities and spend more time for sports exercises.

The results of standard physical tests (exercises) in the examined group of cadets are higher than in the group of the military people of the Security Service (Figure 3). In the cadets group 48% of the examined persons get excellent results in standard physical tests, 31% of cadets examined have a good evaluation mark, and 21% of the persons in the examined group have shown the results that correspond to the satisfactory level. The best results were shown in force exercises.

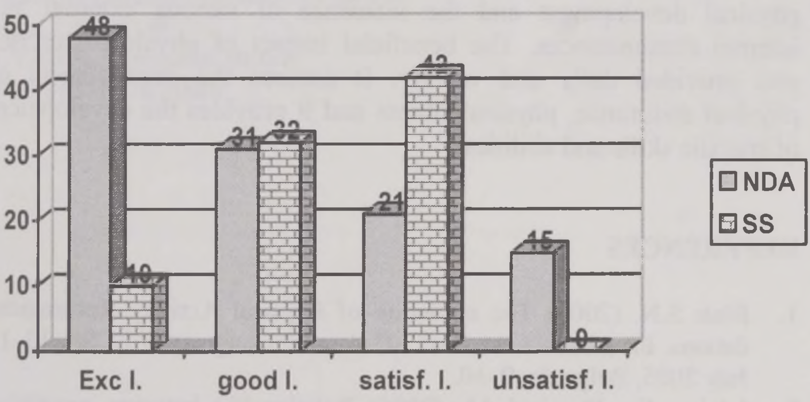


Figure 3. Respondent division (%) according to the level of physical test results.

64.9% of the military people were evaluated positively in the examined group of the Security Service according physical test results. 10% of the military people get the evaluation mark – excellent, 32% of the military people in the examined group were at a good level. 42% have the evaluation level – satisfactory – middle and 15% of the military people received unsatisfactory results in the physical test.

CONCLUSION

The questionnaire results have shown positive attitude to physical activities and sport activities of the military people and stressed the problems in organizing and providing physical exercises. The results of standard physical tests (exercises) in the examined group of the cadets are higher than in the group of the military people of the Security Service. The distinction of the results in the examined group is due to the age of the military people. The younger persons are more active (physically) and show better results.

Physical preparedness of the military people is based upon the physical development and the influence of various external and internal circumstances. The beneficial impact of physical exercises was provided daily and weekly. It ensures the improvement of physical endurance, physical fitness and it provides the development of specific skills and abilities.

REFERENCES

1. Blair S.N. (2005) The evolution of Physical Activity Recommendations. In: Abstract Book of 10th Annual Congress of ECSS, 13–16 July 2005, Belgrade, 9–10.
2. Jalakas E., Järvelaid M. (2005) Relationship between practicing sports and performing physical tests at the Estonian public service academy. Papers on Anthropology XIV, 112–116.
3. Michielon G., Scurati R., Roione G.C., Longo S., Invernizzi P.L. (2006) Tests of physical evaluation and performance level: Comparison between national and regional boxes. In Book of Abstracts of 11th Congress of ECSS,Lausanne, 2006, 112–113.

4. Plavina L.(2004) The description of Students`physical development. In Proceedings of the International Scientific conference Riga teacher Training and Educational management Academy, 05–06 April 2004. Riga, 2004, 399–406.
5. Plavina L. Characteristics of cadets physical activities ahead of studues in NDA. In RTU Scient. Proceedings. Humanitarian and Social science, 8, 10, Rīga, 2006, 133–145.
6. Umbraško A. Peculiarities and tendences of physical training in different armies. RTU Scient. Proceedings. Humanitarian and Social science, 8, 6, Rīga, 2004. 232–236.
7. Wyss T., Marti B., Mäder U. Physical Fitness of draftees compared with their habitual Physical activity. In Book of Absracts of 11th Congress of ECSS,Lausanne, 2006, 215.
8. Prskalo I. Physiological workload and additional exercising in physical education lessons. Proceedings book: Kinesiology New perspectives. 3rd International Scientific Conference. Opatija, Croatia, Sept. 25.– 29. 2002, 102–104.

Address for correspondence:
Liana Pļaviņa
National Defence Academy of Latvia
Riga, Latvia
LV-1014, Ezermalas str.6/8
Fax: (+371) 7076888

Papers on Anthropology XVI, 2007, pp. 244–256

UNDERSTANDING HUMAN GROWTH (PRAGUE LONGITUDINAL STUDY 1956–1981)

Miroslav Prokopec

National Institute of Public Health, Prague, Czech Republic

ABSTRACT

Out of 300 Prague children followed-up longitudinally, 178 (half boys and half girls) remained after 20 years of study. Individual growth curves were analysed according to a Swiss model (Stutzle et al., 1976). After the individual curves were smoothed out, 15 parametres which put each curve well under control, were ascertained in each of them. These parametres were further treated statistically for the whole sample, separately for boys and separately for girls.

The results will contribute to a better knowledge of the course of development of contemporary children and youths and will serve the paediatricians, paedagogues, and anthropologists in assessing growth in individual on the background of a wide variation of growth and maturation of healthy children of both sexes.

Key words: distance and velocity growth curves, adolescent spurt, parametrization, longitudinal growth study

INTRODUCTION

The growth curves which we know from cross-sectional growth surveys are not real growth curves. They are based on the presumption that an average 6-year-old child will take the place of the 7-year-old one in a year's time.

The cross-sectional survey is quick, may be accomplished to one date, can be representative for greater population units but it cannot involve more dimensions and, mainly, it cannot answer the question what the variability of yearly increments is.

A longitudinal study, on the contrary, lasts a long time, cannot be representative for a vaster region, can include more dimensions and give evidence of the variability of yearly increments, important in clinical practice. In investigating the laws of growth and development of children, both the above methods complement each other.

Is it at all possible to grasp such a complicated process as that of human growth? It is possible, but it is demanding for time and patience as well as the good will not only of the investigator but also of the investigated individuals. The aim of the paper is to demonstrate an analysis of the growth curve and to present the means and the variability of individual growth curves of 178 Prague children.

MATERIAL AND METHODS

The team of V. Kapalín from the National Institute of Public Health in Prague started to investigate children from one of the Prague qarters – Zizkov of around 100,000 inhabitants, born on Wednesday (the implemented way of random sampling) in 1956. It took five years to assemble close to 300 children and it lasted until 1981 before the children who did not drop out reached the age of 20 years. The children were investigated at the age of one, three, six, nine and 12 months and at half a year intervals thereafter. The survey was coordinated by the International Childrens´Centre in Paris. The Prague team was an unofficial member attending regural conferences of the member teams in various European capital cities.

Eighty-nine individual growth curves of healthy boys and the same number of healthy girls of the age from 1 month to 20 years were analysed. No wonder that the number of boys and girls was the same. This is the effect of the random sample which is independent of human will. Similarly the location of homes of the children were scattered regularly over the whole territory of Zizkov and the professions of the parents corresponded to those registered in the City population.

Before starting to analyse each distance individual growth curve with the aim of deriving from it characteristic parametres and yearly increments, we must even out the curve. Any slight inaccuracy in individual measurements, which may happen despite the utmost care, could cause, for example, one increment to be too big and the following too small.

The curve may be smoothed out either by hand, by the method of smallest squares or by mathematical methods (Preece-Baines, 1978; Cline, 1974, et al.) [5,1]. The author used the method Preece Baines I which may be used starting from the first or second year of life (it does not show the prepubertal growth spurt which occurrs in some boys around the age of 6 and that of Cline, using 7 points. When analysing individual growth curves, we followed the lines used by Stutzle et al. (1976) [9]. We have taken over their terminology in the original version. From the smoothed out curves we have derived the velocity (increment) curves which were again smoothed out when necessary. The average (x) and standard deviation (s) were calculated for each parametre, sex and age group separately. Standard deviation enables to calculate the so-called standardised deviation (the difference between individual measurement and the average, divided by standard deviation). The result is the relative deviation of the individual value from the average (Z-score). The minimum and maximum values in Table 1 give the physiological span of individual characteristrics for boys and girls.

Table 1. Average parameters of individual grouth curves of boys and girls.

Number	Symbol	Parametres	Boys (n = 89) x / s	Boys (n = 89) min. / max.	Girls (n = 89) x / s	Girls (n = 89) min. / max.
1	AMHV	Age at minimal height velocity (yr) Věk při nejmenší růstové rychlosti (roky)	**10,6** 1,0	7,6 14,2	**8,9** 1,1	6,4 12,1
2	APHV	Age at peak height velocity (yr) Věk při největší růstové rychlosti (roky)	**13,5** 1,0	11,3 17,0	**11,4** 1,1	9,1 13,6
3	AMHVR	Age at minimal prepubertal height velocity return (yr) Věk při návratu k nejmenší růstové rychlosti (roky)	**15,1** 1,0	13,1 18,7	**12,8** 1,1	10,4 15,3
4	H4	Height at age 4 (cm) Výška ve 4 letech (cm)	**105,0** 4,0	97,1 126,2	**103,9** 3,3	97,6 111,9
5	HMHV	Height at minimal prepubertal height velocity (cm) Výška při nejmenší růstové rychlosti (cm)	**143,6** 7,4	126,2 162,3	**134,2** 7,3	119,3 159,7
6	TAG	Total adolescent gain (cm) Celkový přírůstek za období dospívání (cm)	**30,7** 4,8	15,9 42,1	**25,6** 5,0	11,9 38,3
7	HPHV	Height at peak height velocity (cm) Výška při největší růstové rychlosti	**162,2** 6,5	145,0 177,2	**150,0** 6,4	135,1 170,2
8	HMHVR	Height at minimal prepubertal height velocity return (cm) Výška při návratu k nejmenší růstové rychlosti (cm)	**174,2** 6,0	160,3 187,8	**159,7** 6,1	143,1 178,5
9	HA	Adult height (cm) Výška v dospělosti (cm)	**178,9** 6,1	164,9 192,1	**167,1** 5,8	155,3 186,6
10	V5	Height velocity at age 5 (cm/year) Růstová rychlost ve věku 5 let (cm/rok)	**6,7** 0,8	4,8 8,3	**6,8** 0,9	3,5 8,9
11	MHV	Minimal prepubertal height velocity (cm/year) Nejmenší růstová rychlost (cm/rok)	**4,6** 0,7	3,2 6,6	**5,2** 0,7	3,1 7,2
12	PHV	Peak height velocity (cm/yr) Největší růstová rychlost (cm/rok)	**8,6** 1,1	6,1 11,8	**7,5** 0,9	5,5 9,6
13	PH	Peak height (cm/yr) Výška vlastního vrcholu (cm/rok)	**4,0** 1,2	0,9 8,5	**2,3** 1,0	0,5 5,5
14	PB	Peak basis (yr) Základna vlastního vrcholu (roky)	**4,6** 0,7	2,5 6,2	**4,0** 0,7	2,2 5,9
15	PAR	Peak area = PH × PB Plocha vlastního vrcholu = výška × základna	**18,5** 6,7	2,2 45,2	**9,3** 4,9	1,1 26,7

RESULTS

Figure 1 shows an example of the individual distance growth curves of 24 boys by their numbers. The dots represent the actual measured height, the lines show the final smoothed out curve giving the corrected values at each age. The smoothed out curves are free of artificial deviations, although these deviations, as may be seen from the figures, are not great. In each case when the child missed the date of investigation and the respective height was missing, the method of evening out the curves provides its substitute.

Figure 2 shows all the growth curves of the boys drawn over each other. The Figure depicts individual variation and its borderlines. It shows the growth curves which follow the most frequent trend of growth as well as such which change their course when compared with the general trend. A tall boy, in comparison with the others at an early age, may finish as a medium one or as a small one and vice versa, a small boy at the start can take over many of his contemporaries and finish as a medium or even as one of the tallest at the age of 20.

Figure 2 also shows that several boys reach their final stature before the age of 18 years (their height curve does not change its curse any more after the age of 16 or 17).

Certain numbers of curves keep their position in the bunch (collective) throughout the whole growth period. The pubertal spurt lasts about three years on individual curves whereas in growth curves constructed on the basis of cross-sectional data it lasts five years. Simultaneously, it is possible to observe that the onset of the pubertal spurt starts in some boys earlier, and in others later in life.

Figure 3 shows the smoothed out growth curves in the surveyed girls. Contrary to boys, the girls reach their fnal height earlier and their pubertal spurt starts and ends about two years earlier than in boys.

Figure 4. shows the height increment (velocity) curves in boys derived from the smoothed out individual growth curves. A sudden fall down into a ”valley”, climbing up to the top and a further downward fall to the zero value which represents the attainment of the final height.in adulthood.

The great variability in the age and in the body height at the attainment of the smallest yearly increment (MHV) and of the highest increment at adolescence (PHV – the peak height velocity) can be observed in this Figure. The PHV is a new and important biological value in the study of growth in the second decade of life.

Figure 5 shows the smoothed out increment curves in girls. The minimal yearly increment in height is attained earlier in girls than in boys, similarly as the peak height velocity which is attained by the majority of girls also at a lower age than in boys.

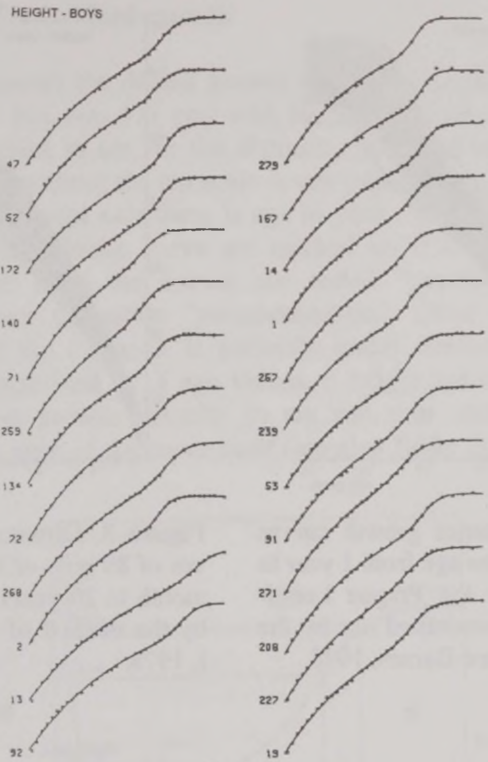


Figure 1. An example of a set of individual distance growth curves of boys from the Prague Longitudinal Study marked with their numbers. The dots represent actual measurements, the line is a smoothed curve according to Preece Baines I, 1978.

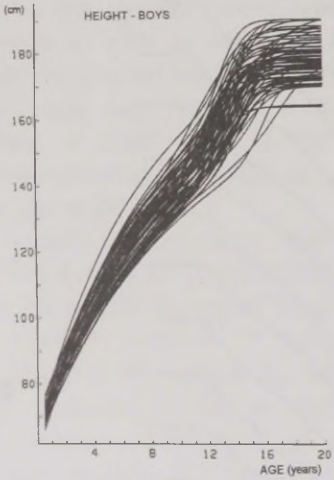


Figure 2. Distance growth curves of 89 boys of the age from 1 year to 20 years from the Prague Longitudinal Study smoothed out by the method of Preece-Baines, 1978.

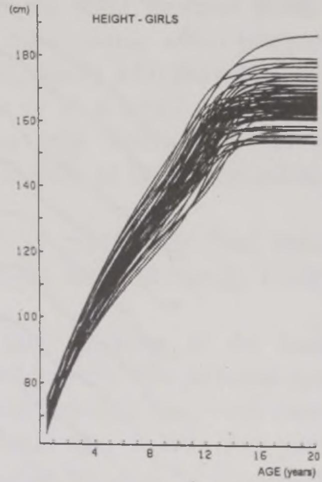


Figure 3. Distance growth curves of 89 girls of the age from 1 month to 20 years smoothed out by the method of Preece-Baines I, 1978.

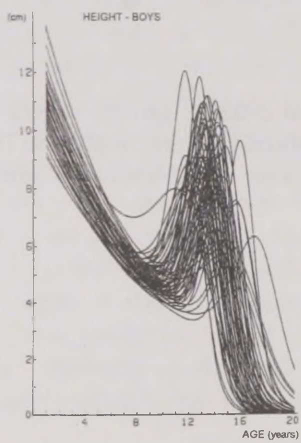


Figure 4. Velocity growth curves of boys derived from the smoothed distance growth curves shown in Figure 2.

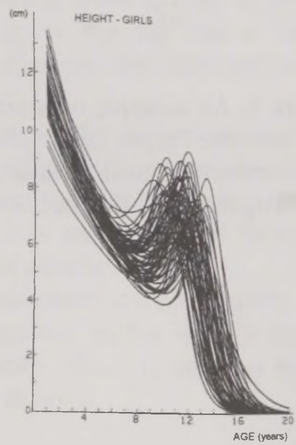


Figure 5. Velocity growth curves of girls derived from the smoothed distance growth curves shown in Figure 3.

Evaluation of individual growth

Figure 6 represents the distant growth curve of a certain boy (whose adult height – HA was 171 cm) with his velocity curve. The vertical axis shows height in cm for the distance curve and cm/year for the velocity curve (without the cm scale or cm/year scale being marked on it). On the horizontal axis there is age in years. Important points and sections on the velocity curve are marked on it in the graph. The values derived from the curves are called "parametres" and the process of their formation "parametrization". Once we know the parametres of the curve, it is perfectly under control. The growth curve is characterized by 3 age values, 6 height values, 3 pieces of information on growth velocity in cm per year and by 2 values describing the peak of the curve itself (see also Table 1).

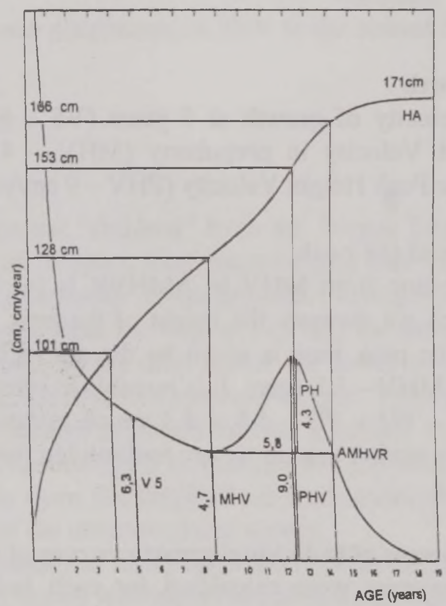


Figure 6. Distance and velocity curves of a boy from the Prague Longitudinal Study whose final (adult) height was 171 cm. Selected parametres are shown on the curves according to the method used in the study.

Age

First of all we are interested in the age at which the smallest yearly increment (AMHV – Age Minimal Height Velocity) occurs – 8.5 years, then in the age at the peak height velocity (PHV) – 12.4 years and further we would like to know the age at which the growth velocity returns to the level of the smallest yearly increnent (AMHVR) – 14.3 years.

Height

From the heights we take the evidence of the height at the age of 4 years which is compulsory (H4 – 101 cm), the height at the age of the minimal height velocity (HMHV – 128 cm), the total height increment for the age of puberty (TAG, Total age gain – 38 cm), the height at the Peak Height Velocty (HPHV – 153 cm), the height at the return to the minimal height velocity (HMHVR –166 cm) and the adult height (HA – 171 cm).

Velocity of growth

We note the velocity of growth at 5 years (V5 – 6.3 cm/year, the Minimal Height Velocity in prepuberty (MHV – 4.7 cm/year and maximal, i.e. the Peak Height Velocity (PHV – 9 cm/year).

Characterictics of the peak

The connecting line from MHV to AMHVR is the base of growth peak from which we measure the height of the peak (PH – 4.3 cm). The length of the peak base is given by the age difference between AMHVR and AMHV – 5.8 years. It is possible to calculate the area of the peak (PAR – PH x PB – 5.8 x 4.3 which makes 24.9. Here we follow the Swiss model, though we are multiplying two different units (years and cm/y).

Average parametres of individual growth curves of boys and girls

The above parameters were calculated for each individual growth curve. Then arithmetical means and standard deviations were calculated for 89 boys and 89 girls The results are given in Table 1. Each parametre has its number, the abbreviated name, its definition in English and Czech, the arithmetical mean (x), standard deviation (s) and the minimum and maximum value for each given parametre and sex.

Similar values in both sexes were found in height at 4 years (105 cm in boys and 103.9 cm in girls), in height velocity at the age of 5 years (6.7 cm/year in boys and 6.8 cm/year in girls), and to a certain extent also in the average peak base (4.6 cm in boys and 4.0 cm in girls). Differences between the sexes were found in all other parametres. The difference between the height at the maximum peak velocity in boys and girls makes 12 cm – which is a usual difference in the average height of adult males and females.

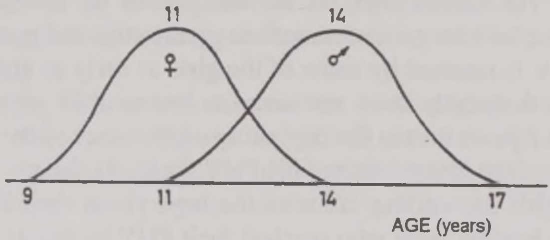


Figure 7. Schematic distribution of PHV in the second decade of life in boys and girls.

DISCUSSION

At the time when the "children" from the Prague longitudinal study reached the age of 18 years, their mean heights and weights exceeded those of the nation-wide cross-sectional survey.The reason was twofold: They were from the Capital city and the sample might have been also improved by the drop out of the lower social background children which made from it a selected sample. Throughout the years the nation-wide means of height and to a certain extent of weight increased by the secular trend so that in 1991 the means of the height of boys and girls from the longitudinal study more or less coincided with the means of the cross-sectional survey.

We see the biological meaning of the PHV in the fact that it marks the period of life bound with higher health risks as well as with greater sensitivity to environmental impacts.

The age span in which he PHV is attained lasts in boys about 6 and in girls about 5 years.

The knowledge about the width of variability of the onset and the course of adolescence of normal youths may be used as an argument for a paediatrician who needs to calm a boy in whom the PHV did not occur yet and who is affraid that he will be of small stature all his life, or to calm a girl who passed the PHV already and is affraid that she will be too tall.

A paedagogue can read out of the above results that he has in his class of teenagers between 12 and 14 years of age as yet biologically undeveloped (infantile) individuals as well as those in whom the metamorphosis into fully developed males and females was practically completed. He knows that on all the youths of this age without exception are laid the same demands in gymnastics and mathematics.

The PHV is reached by some of the girls as early as at the age of 9 years, most frequently at 11 and some as late as at 14 years. For boys the age of 11 years means the beginning of the onset of the PHV (only one boy from the group reached his PHV then). At the age of 14 years when the girls are ending, most of the boys reach their PHV. There were a few healthy boys who reached their PHV as late as 17 years of age.

CONCLUSIONS

1. Individual growth from 1 month to 19 years of age was followed up in 89 healthy boys and 89 healthy girls who enrolled in the Prague growth study in 1956–1961.
2. At the time when most of the investgated children reached 19 years of age, the mean height was higher than it was shown by the nation-wide cross-sectional survey. Nevertheless, in 1981 the average height in both longitudinal and cross-sectional surveys coincided (with the exception of 17 and 18 year old boys) well with each other (impact of the secular trend).
3. Fifteen parametres were investigated in the growth curve of each of the followed up children. (without the cm scale being marked on it)
4. The Swiss method (after Stutzle et al, 1976) [9]of parametrization was described in the article.
5. Both, the distance and the increment (velocity) smoothed out growth curves of all the 178 followed up children were presented in the article.

6. Attention was devoted to the variability of PHV, expressing the age of the maximal individual increment (the highest growth velocity in the second decade of life. A difference of 5 years in girls and 6 years in boys was found between the individual who reached the PHV as the first and the last from the group.
7. The PHV is higher in early and lower in late maturing individuals.
8. Late maturing individuals reach on average a taller final stature than the early maturing ones.
9. Averages of all 15 parametres of the growth curves, standard deviations, minimum and maximum values was given for each sex separately.
10. The results will serve paediatricians, paedagogues and anthropologists when assessing the individual development of children mainly in the second decade of life with respect to the wide variation in the onset of puberty and the PHV in healthy individuals.

BIBLIOGRAPHY

1. Cline A.K. (1947) Scalar- and plantar- valued curve fitting using spline under tension – Comn. ACM, 17, 218–223.
2. Hauspie R. (1980) Adolescence growth. In: Edit. Johnston, FE., Roche, AF and Susanne, C. Human Physical Growth and Maturation. New York. London; Plenum Press.
3. Kapalín V., Kotásková J., and Prokopec M. (1969) Physical and Mental Development of the Present Generation of Our Children (In Czech). Praha. Academia.
4. Lhotská, L., Bláha, P., Roth, Z. and Prokopec, M. V. (1993) Nationwide Survey of Child and Youth Growth 1991 (Czech Republic). In Czech. Praha. National Institute of Public Health.
5. Preece, M.A., Baines, M.J. A new family of mathematical models describing the human growth curve. Annals of Human Biology, 5, 1–24.
6. Prokopec M. (1982) Early and Late Maturers. Antrop. Keozl., 26, 13–24.
7. Prokopec, M. et al. (1986) Height and Weight of Czech Children According to the nation-wide Anthropological Survey in 1981 (Czech Districts). Czechoslovak Paediatr., 41, 1, 20–26.

8. Prokopec, M. Lhotská, L. (1989/90) Growth analysis of marginal cases of normal variation. Antrop.Koezl., 32, 65–79.
9. Stutzle, W.,Gasser, T. and Largo, R. (1976) Analysis of the adolescent growth spurt smoothing spline functions Compte-rendu de la XIIIe Reunion des Equipes Chargées des Études sur la Croissance á le Developement de l´Enfant Normal. Paris. Centre Internationale de l´Enfance, 109–212.
10. Tanner J.M. (1962) Growth at Adolescence. 2nd edn. Oxford. Blackwell Scientific Publications.

ACKNOWLEDGEMENT

The author thanks to Miss Marcela Havlínová for Figures 6 and 7 and to Mr. Pavel Chýle, MD, PhD for revision of the English text.

Supported by Grant Agency of the Czech Republic 2007 No.:406/04/0027

Address for correspondence:
Miroslav Prokopec
Narisovó 2850, 10600
Praha 10. Czech Republik.
E-mail: m.prokopec@yahoo.com

Papers on Anthropology XVI, 2007, pp. 257–265

APPLICATION OF A VIBRAPLATE TO SHAPE BODY MASS COMPONENTS IN REGULAR EXERCISES

Ewa Szczepanowska[1], *Katarzyna Jarska*[1], *Monika Chudecka*[2], *Elżbieta Sieńko*[1]

[1] Institute of Physical Culture, Department of Human Functional Anatomy and Biometrics, Szczecin University, Piastów 40b, 71-065 Szczecin, Poland
[2] Faculty of Natural Sciences, Chair of Anthropology, Szczecin University, Piastów 40b, 71-065 Szczecin, Poland

ABSTRACT

The aim of the work is to evaluate changes of morphological parameters, the BMI index and body mass components as a result of a battery of static exercises on a vibrating platform.

Female students (N=30), aged 21, were examined. They performed static exercise in a battery of exercises on a vibrating platform (48 Hz, 2 mm, VIBRAPLATE®). The whole study was performed in two weeks. The total time of the exposure on a vibrating platform was 20 min., it means 2 min. during 10 days. The basic measurements of anthropometrical features were done, and also body circumferences and skinfold thickness. The BMI (Body Mass Index) was calculated. Body mass components were measured by the bioimpedance method (Bodystat 1500 analyzer) with the calculation of FAT, LBM, H_2O and the basic metabolic rate.

The statistically essential decrease of body mass and the BMI index, and also diminishing of thickness of the abdomen skinfold ($p=0.01724$), and thigh circumference ($p=0.01147$) were observed. The tendency to a decrease of fat percentage and an increase of LBM and H_2O contents were also noticed.

Key words: whole body vibration, WBV, body mass components, skinfold thickness

INTRODUCTION

Monitoring of morphological features, the body mass composition and their changes under the influence of different forms of physical activity have been and still constitute the subject of the study of many authors. Looking for the possibilities to influence shape and body mass components is an especial interest of women. Some of the most popular objectives to start an exercise program are the reduction of body fat and the increase of muscle mass and muscle strength [7].

Simultaneously, searches of a safe method as a compensation of traditional training, or a substitute form in the case of a minor injury or break in training, have continued. Therefore, an intensive research for an influence on the mechanic vibration on particular body mass components of humans and their general physical efficiency has started. Vibration has been studied extensively for its dangerous efects on humans at specific amplitudes and frequencies. Another research has suggested that the low amplitude, low frequencies of mechanical stimulation on the human body have constituted a safe and effective way to exercise musculoskeletal structures [3].

The "Whole body vibration" training (WBV) has recently been introduced in health and fitness centres as an alternative method to traditional ways of body mass reduction and may therefore be considered as a measure of reducing body fat and increasing muscle mass and muscle strength. Vibration platforms generate vertical sinusoidal vibration across a range of frequencies (15–60 Hz) and displacements from <1 mm to 10 mm. During the WBV training the subject performs unloaded static and/or dynamic exercises on a platform. These mechanical stimuli are transmitted to the body where they stimulate sensory receptors in turn, most likely muscle spindles. This leads to the activation of the alpha-motoneurons and initiates muscle contractions comparable to the "tonic vibration reflex" [2,9].

The possibilities of the application of vibrating training and its meaning are widely studied. The WBV training has shown to cause clear metabolic responses, similar to other form of exercise. The studies of Rittweger et al. [6] seem to indicate that the WBVT may represent a mild form of exercise for the cardiovascular system. The changes of testosterone, the growth hormone or cortisol under vibration [4,1] and also the effect of vibration on bone density, muscle performance, body balance and posture control [10,11] are also studied.

There is a lack of scientific information concerning the impact of the WBV on the body composition. Though numerous researchers have shown that oxygen consumption, heart rate, blood lactate and thus muscular metabolic power increase during the WBV training.

The aim of our pilot study has been to analyze the influence of the static exercise on body fat, fat free mass (FFM) and skinfold thickness. The aim of the work has been to evaluate the changes of morphological parameters, the BMI index and body mass components as a result of a battery of static exercises on a vibrating platform.

MATERIAL AND METHODS

Female students (N=30), aged 21, recruited from the second course of the same faculty of the local university. All of them have described themselves as medium active persons.

The reasons for exclusion have been considered. It has been established: any cardiovascular, respiratory, abdominal, urinary, gynecological, neurological, musculoskeletal or other chronic diseases, pregnancy, menstrual irregularities, the history of diabetes or epilepsy.

The vibration protocol consisted of two weeks of the Whole Body Vibration Training (WBVT). Programs have included 2 min. per each of 10 days session. The total exposure time has lasted 20 min. The subjects were standing on a VIBRA PLATE® platform with knees semiflexed and they have been asked not to change their position.

The peak-to-peak amplitude of the vertical vibration has been 2 mm and the frequency – 48 Hz.

Before and after the battery of static exercises on a platform the following measurements of morphological features have been done: body mass, the circumferences of abdomen, waist, hip, arm and thigh, and also skinfold thickness of abdomen, arm, thigh, back and iliac area. Additionally, the measurements of the body composition by the bioimpedance method (electric conductivity) with using Bodystat 1500 analyzer have been carried out. Water contents, the percentage of fat and the lean body mass (LBM), and the BMI index have been noticed.

Differences between pre- and post-exercise test values have been analyzed by one-way ANOVA for repeated measures. All the analyses were executed using the statistical package Statistica, version 7.0 (Statsoft, Inc.). Significance level has been set at p<0.0500.

RESULTS

The vibration intervention has succeeded well in the changes of body mass and the BMI values through a significant decrease (p<0.0500) (Figure 1, 2).

The contrast "time" (before and after) analyses have revealed neither significant differences for the percentage of body fat, fat free mass and water, nor the in skinfold thickness and particular circumferences (p>0.0500). A significant decrease has been observed for thigh circumferences (p=0.01147) and the skinfold thickness of abdomen (p=0.01724) (Figures 3, 4).

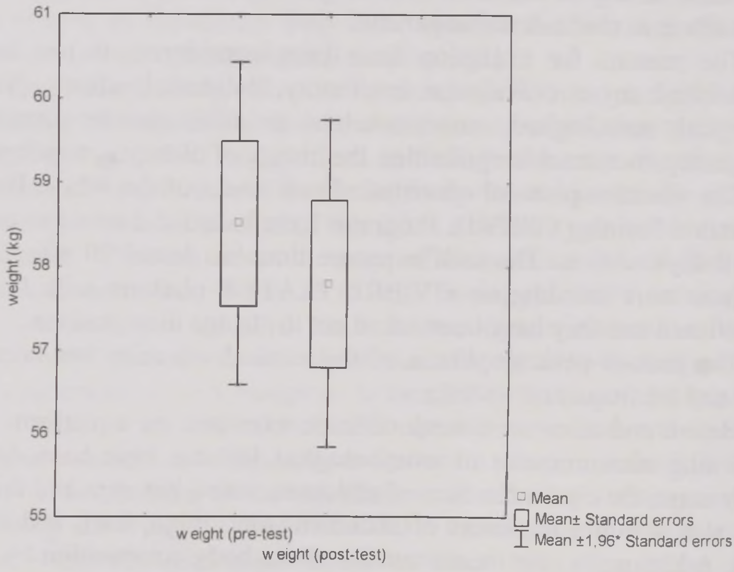


Figure 1. Changes in weight after the whole body.

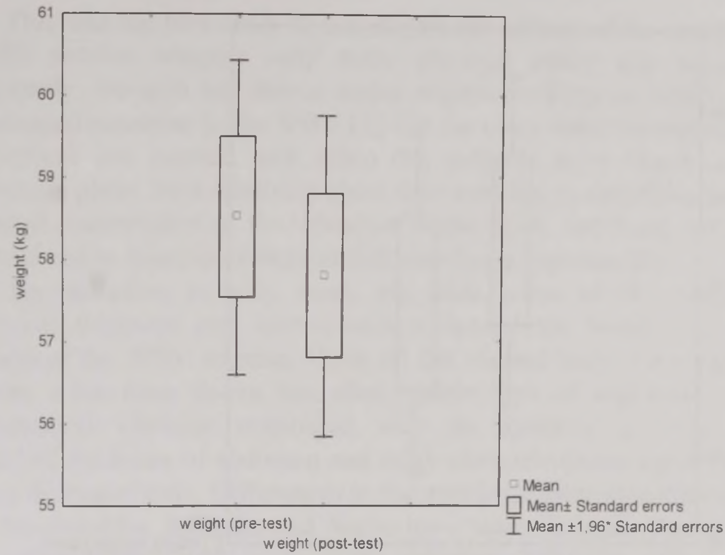


Figure 2. Difference in the BMI index values vibration training after the whole body vibration training.

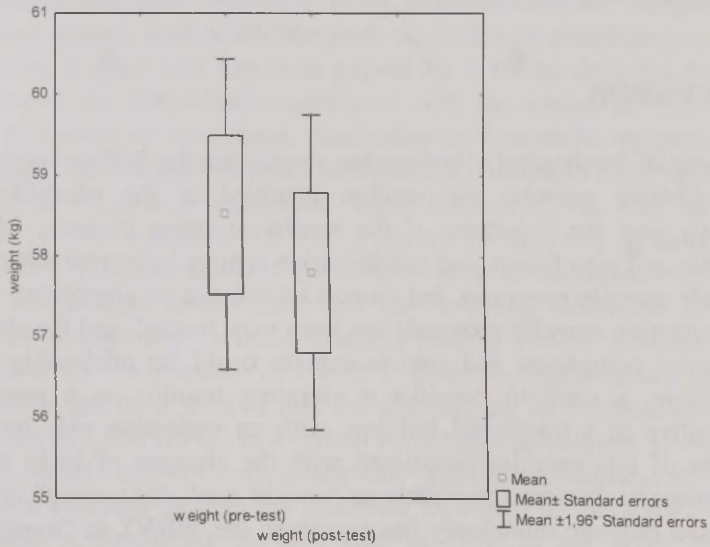


Figure 3. Thighs circumferences after the whole body.

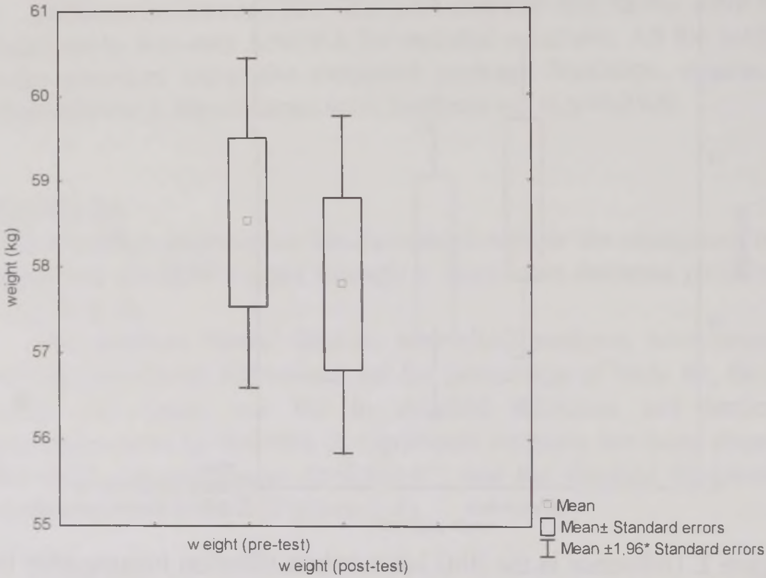


Figure 4. Skinfold thickness of abdomen vibration training after the whole body vibration training.

DISCUSSION

The use of mechanical vibration has shown that the WBVT might be an effective exercise intervention involved in the rehabilitation therapy and the reduction of the results of many diseases. Many athletes and also fitness and rehabilitation centres have used vibration in their exercise programs, but current knowledge on appropriate safe and effective exercise protocols has been very limited, and the claims made by companies and pseudo-experts could be misleading [3]. Therefore, a need to consider a vibrating training as a possible alternative to a traditional training, with an indication only on the effects of this exercise associated with the changes of body mass components, discerned popularly as "weight loss", "slimming". Since civilised pressure mistakenly has perceived the WBVT as "a quicker and more effective" method of weight loss, diminishing the significance of traditional training.

This was the first study to investigate the effects of the short-term WBV session whereas only static physical effort was involved. Currently, research has shown major negative effects on health after prolonged exposure to the WBV [3]. On the other hand the technology procedure has seemed safe when the subjects have stood on the vibration plates for a relatively short time with knees semifiexed to the limited transmission of the vibration to the head, and have not been considered to experience motion sickness-like symptoms [8].

The reduction in body mass, the BMI, some of the measured skinfold thickness and circumferences have been found after two weeks of the WBV training. From all the studied body mass components, it has been shown that after a short time of exposure to the mechanical vibration combined with no dynamic exercise, the skinfold thickness of abdomen and thigh circumferences significantly have decreased only. Differences in the metabolic characteristics of fat at the abdomen, buttocks and thighs have been noticed. The weight loss during slimming is easier at the abdomen. Adiposity cells in this region of body have shown great sensibility to lipolitic catecholamins. A significant increase of concentration of these hormones has been connected with static exercises. In the stimulation of the sympathetic nervous system, particularly the parts controlling a circulating system function, a great role has been played by a reflex, initiated by the teasing of the determinants connected with the anaerobic metabolic rate of sensory nerve endings, functioning as "metabolic receptors" in muscles. These receptors could be irritated by lactate, a local decrease of pH, an increase of intracellular liquid osmolarity, etc. This mechanism of the activation of the sympathetic nervous system has explained a relation between the concentration of noradrenaline (NA) and the intensity of exercise, and also a strong activation of this system during static exercises characterized by a local ischemia as a result of the compression of tensed muscles on blood vessels [5]. A tendency has been noticed that the decrease of fat contents and the increase of LBM (FFM) to a certain percentage takes place. However, these values have not been statistically significant. Roelants et al. in contrast analyses through the following 24 weeks of the WBVT have revealed a significant increase only in FFM in the WBV group, whereas no significant change occurred in FIT (Fitness Group, trained at the university fitness centre) or in the CO (Control Group, not participating in the training program) group [7]. There have been no changes in body fat, body mass and 12 skinfolds either. However, it has been shown that the WBV training has been an efficient alternative method as compared to the conventional exercise programs to improve the strength of knee-extensors [7].

The study mentioned above [7] and the forms of exercises tested in our laboratory have shown that it has been probably too short an exposure to vibrations to induce more significant changes in the body components.

Although, the vibration training as compared to the strength or explosive training could offer a shorter period of stimulation of the biological system, it should be propagated as a valid complement in the training protocol with all the traditional methodologies.

REFERENCES

1. Bosco C., Iacovelli M., Tsarpela O et al. (2000) Hormonal responses to whole-body vibration in men. Eur J Appl Physiol 81, 449–54.
2. Cardinale M., Bosco C. (2003) The effects of vibration as an exercise intervention. Exerc Sport Sci Rev, 31, 3–7.
3. Cardinale M. i Wakeling J. (2005) Whole body vibration exercise: are vibrations good for you?, Br J Sports Med, 39, 585–589.
4. Di Loreto C., Ranchelli A., Lucidi P. et al. (2004) Effects of whole-body vibration exercise on the endocrine system of healthy men. J Endocrinol Invest, 27, 323–327.
5. Nazar K., Kozłowski S., Kaciuba-Uściłko H. (1999) Przemiana materii. Fizjologia wysiłków fizycznych. [In:] Wprowadzenie do fizjologii klinicznej. Kozłowski S., Nazar K. pp.147–150, 278–283.
6. Rittweger J., Beller G., Fełsenberg D. (2000) Acute physiological effects of exhaustive whole-body vibration exercise in man. Clin Physiol, 20, 134–142.
7. Roelants M., Delecluse C., Goris M., Verschueren S. (2004) Effects of 24 Weeks of Whole Body Vibration Training on Body Composition and Muscle Strength in Untrained Female. Int J Sports Med, 25, 1–5.
8. Rubin C., Pope M., Fritton J.C., et al. (2003) Transmissibility of 15-hertz to 35-hertz vibrations to the human hip and lumber spine: determining the physiologic feasibility of delivering low-level anabolic

mechanical stimuli to skeletal regions at greatest risk of fracture because of osteoporosis. Spine, 28, 2621–2627.

9. Seidel H. (1988) Myoelectric reactions to ultra-low frequency and low-frequency whole body vibration. Eur J Apply Physiol, 57, 5, 558–562.
10. Torvinen S., Kannus P., Sievänen H. et al. (2003) Effect of 8-month vertical whole body vibration on bone, muscle performance, and body balance: A randomized controlled study. J Bone Miner Res, 18, 876–884.
11. Verschueren S., Roelants M., Delecluse C., Swinnen S., Vanderschueren D. i Boonen S. (2004) Effect of 6-Month Whole Body Vibration Training on Hip Density, Muscle Strength, and Postural Control in Postmenopausal Women: A Randomized pilot Study. J Bone Miner Res, 3,19, 352–359.

Address for correspondence:
Katarzyna Jarska
Institute of Physical Culture
Department of Human Functional Anatomy and Biometrics
Szczecin University, Piastów 40b, 71–065 Szczecin.
E-mail: katarzynajarska@tlen.pl

Papers on Anthropology XVI, 2007, pp. 266–272

CONTRIBUTIONS OF AGE, BODY HEIGHT AND BODY MASS TO THE TOTAL VARIANCE OF AN EXAMPLE PHYSICAL FITNESS VARIABLE

Romuald Stupnicki [1], *Paweł Tomaszewski* [2], *Katarzyna Milde* [2]

[1] Department of Physical Education, University of Rzeszów;
[2] Academy of Physical Education, Warsaw, Poland

ABSTRACT

Study aim: To present a method of computing individual contributions of a set of independent variables to the total variability of the dependent variable.

Material and methods: A group of 345 boys and 311 girls, aged 10–19 years, from Lithuanian schools were subjected to body height and mass measurements and to EUROFIT tests. From these, the results of the standing broad jump (SBJ) were analysed. Contributions of age, body height and mass to the total variance of the SBJ were computed from multiple regression coefficients and covariances.

Results: Boys and girls differed markedly with respect to the multiple correlation coefficients (R^2 = 0.635 and 0.179, respectively) and to contributions of independent variables. Age had the highest impact on SBJ variance in boys (32%) and none in girls (3%). Body mass had a negative effect in both genders. However, the SBJ was used only as an example of the computational procedure.

Conclusions: The procedure of determining contributions of independent variables is relatively simple computationally and may be applied to a wide range of issues.

Key words: Multiple correlations – Contributing variables – Total variance partition.

INTRODUCTION

When assessing the effects of basic somatic variables (body height and mass) and age on e.g. motor fitness variables, simple correlation coefficients are used most frequently but, inasmuch simple correlations reflect direct, statistical relationships, no causal conclusions can be drawn from them. Therefore, the advanced the statistical procedures which enabled a better insight into causal relations were developed by e.g. estimating the quantitative effects of various factors regarded as independent variables on the (dependent) variable in question. Among those procedures there are partial correlations/ regressions, multiple correlations/regressions, various forms of factor analysis [4], path analysis [5], etc.

The aim of the study was to design a computational procedure that would enable determining the individual contributions of a set of independent variables to the total variability of the dependent variable.

MATERIAL AND METHODS

Subjects: A group of schoolboys (n = 345) and schoolgirls (n = 311) aged 10–19 years from 3 schools in Kaunas (Lithuania) were studied.

Methods: The following variables were recorded: age (decimal, determined from birth dates), body height determined with a stadiometer with an accuracy of 0.1 cm and body mass determined with the use of medical balance with an accuracy of 0.1 kg. All the subjects underwent standard EUROFIT tests [3]. For the purpose of this study only the results of the standing broad jump (SBJ; cm) were used.

The results of body height and of the SBJ proved to be normally distributed along age and the corresponding distribution of body mass was sufficiently close to normal for the purpose of multiple correlation/regression calculus, age, body height and body mass being considered independent variables. Specially designed software written in Basic was used.

The multiple correlation coefficient (squared) may be obtained from the formula:

$$R^2 = \frac{\sum b_i S_{iy}}{S_{yy}},$$

where b_i stands for the multiple regression coefficients of independent variables i (age, body height and body mass), S_{iy} for residual sums of products of independent variables i and the dependent variable y, and S_{yy} is the residual sum of squares of the dependent variable y (SBJ in this case). The individual components $\frac{b_i S_{iy}}{S_{yy}}$ were thus expressed in the percentages of R^2 and called the contributions of independent variables. By assigning them the signs of the respective b_i, the positive or negative effects of independent variables on the dependent one are revealed. The sum of absolute values of percent age contributions is thus equal to the R^2 expressed as the percentage of the total variance of the dependent variable. The significances of individual contributions are identical with those of the respective coefficients of multiple regression.

Multiple regression coefficients (b_i) may be obtained from many statistical packages, e.g. Statistica®, and in case the S_{iy} values are not directly available, they may be obtained by the formula: $S_{iy} = (n-1)r_{iy} s_i s_y$, where r stands for the simple correlation coefficient and s for standard deviations.

RESULTS

The results of the SBJ in relation to age, body height or body mass are presented in Figures. 1 and 2 and the corresponding simple correlation coefficients in Table 1. The coefficients of multiple correlation (R^2) explained 63.5 and 17.9% of the total the SBJ variance for boys and girls, respectively (Table 1). Those percentages were partitioned into contributions of individual independent variables by applying the procedure outlined above.

Simple correlation coefficients were much higher in boys than in girls and this was also reflected in the coefficients of multiple correlation. Age, body height and body mass explained about 63% of the total variance of the standing broad jump results in boys and only about 18% in girls. Age contributed most to the SBJ variance (32%) in boys, much more than body height (24%), the effect of body mass being negative (–7%). In girls, the only significant contribution was that of body height (13%).

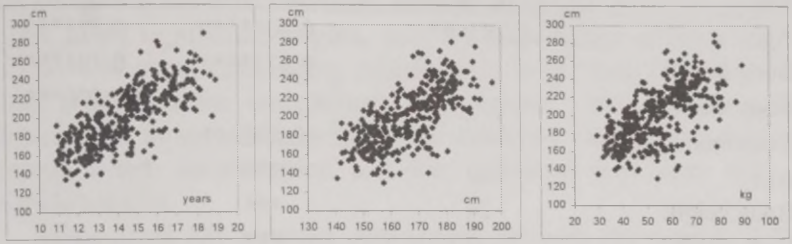


Figure 1. Relationships between the results of the standing broad jump (SBJ) and age (years), body height (cm) and body mass (kg) in schoolboys (n = 345).

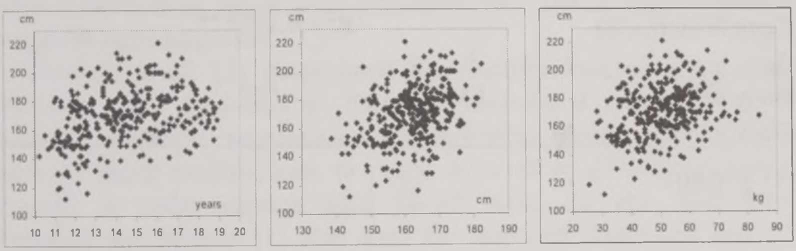


Figure 2. Relationships between the results of the standing broad jump (SBJ) and age (years), body height (cm) and body mass (kg) in schoolgirls (n = 311).

Table 1. Simple correlation coefficients, multiple correlations (R^2) and percentage contributions of independent variables (age, body height, body mass) to the total variance of the standing broad jump (SBJ) results in boys (n = 345) and girls (n = 311) aged 10 – 19 years

Boys	Body height	Body mass	SBJ
Age	0.783***	0.704***	0.771***
Body height		0.875***	0.721***
Body mass			0.606***
Contributions (%)		R^2 = 0.635***	
Age	32	***	
Body height	24	***	
Body mass	–7	***	
Girls			
Age	0.561***	0.573***	0.303***
Body height		0.772***	0.410***
Body mass			0.297***
Contributions (%)		R^2 = 0.179***	
Age	3		
Body height	13	***	
Body mass	–2		

*** $p<0.001$

DISCUSSION

The presented method of determining the contributions of independent variables to the variance of the dependent variable may give insight into the factors controlling various traits or abilities provided. The general conditions regarding distributions of variables have been met. That method was used previously [6,7] but no details had been presented then.

As follows from the data presented in Figures. 1 and 2, the relationships are linear with the exception of the SBJ/age in girls. However, the correlation ratio, R (or coefficient of multiple determination) computed for quadratic relationship, did not differ significantly from the linear correlation coefficient. It was thus inferred that the reliability of contributions was acceptable.

The partition of R^2 into the contributions of individual independent variables revealed that age, body height and body mass explained 63.5% of the total variance of the SBJ results in boys and only 17.9% in girls, both R^2 values being highly significant. Age contributed most to the SBJ variance in boys (32%), significantly more than did body height (24%), the effect of body mass being negative and negligible (7%), albeit significant; in girls, only the contribution of body height (13%) was significant, being significantly lower than in boys. The high portion of the unexplained SBJ variance, especially in girls, leaves field to speculations as to the unknown contributing factors, among which co-ordination and the volitional ones may play a significant role.

Szopa *et al.* [8] reported correlations between the results of the standing broad jump and body mass or height in 3 age categories of boys and girls. Those correlation coefficients ranged from 0.23 to 0.41 for body height and from –0.06 to 0.08 for body mass in boys, and from 0.20 to 0.29 and from –0.02 to 0.05 in girls, respectively. These were considerably lower than presented here due to much narrower ranges of age categories.

Beunen *et al.* [2] determined the contributions of independent (somatic, etc.) variables to those fitness-related by applying the stepwise multiple regression and the discriminant analysis and reported those contributions to range from 19 to 27% for explosive strength in male subjects aged 18–30 years. On the other hand, Benefice and Malina [1] also used the stepwise regression analysis and reported body mass to account for 25 and 12% of the variance of the standing broad jump in Senegalese boys and girls, respectively, over 10 years of age.

In conclusion, the presented method of determining percentage contributions of independent variables to the total variance of the dependent one is relatively simple computationally and may be applied to a wide range of issues.

REFERENCES

1. Benefice E, R.Malina (1996) Body size, body composition and motor performances of mild-to-moderately undernourished Senegalese children. Ann.Hum.Biol.,23,307–321.

2. Beunen G., J.Lefevre, A.L.Claessens, R.Lysens, H.Maes, R.Renson, J.Simons, B.Vanden Eynde, B.Vanreusel, C.Van Den Bossche (1992) Age-specific correlation analysis of longitudinal physical fitness levels in men. Eur.J.Appl.Physiol., 64,538–545.
3. Council of Europe (1993) EUROFIT. 2nd ed., Strassbourg.
4. Darlington R.B. (1997) Factor analysis. www.psych.cornell.edu/ Darlington/factor.htm
5. Garson G.D. (2007) Path analysis. www2.chass.ncsu.edu/garson/ pa765/path.htm
6. Milde K. (2004) Sprawność fizyczna dziewcząt z zespołem Turnera. Thesis, Academy of Physical Education, Warsaw.
7. Raczyński G., Czeczelewski J., Skład M., Stupnicki R., (1998) Interrelationships among food intake, somatic traits, and physical fitness in 10.5- to 15.5-year-old children from Eastern Poland. *Int.J. Sport Nut.*, 8:388–400.
8. Szopa J., Mleczko E., Żak S., (1996) Podstawy Antropomotoryki. PWN. Warsaw. p. 146.

The study was supported by grant No. AWF-DS70 of the Polish Ministry of Science

ACKNOWLEDGEMENT

Thanks are due to Professor Vida Volbekiene from the Lithuanian Academy of Physical Education in Kaunas for her assistance in conducting the study in schools

Address for correspondence:
Romuald Stupnicki
Stryjeńskich 10–199, 02–791 Warsaw, Poland
E-mail: rstupnicki@awf.edu.pl

Papers on Anthropology XVI, 2007, pp. 273–277

STUDY ON THE PHYSIQUE OF 60-80-YEAR-OLD HUNGARIAN WOMEN AT THE BEGINNING OF THE 21st CENTURY

Gábor A. Tóth and Botond L. Buda

Laboratories of Human Biology, Berzsenyi Daniel College, Szombathely, Hungary Private Practice for Neurologic Consultations, Szombathely, Hungary

ABSTRACT

The knowledge of the appearance and the body composition subject to age related physiological changes has a great importance from the point of view of clinical morphology. We described the physique of the 60-80-year-old Hungarian women at the beginning of the 21st century. As it is known, by physique one may understand the morphological constitution of the adult person, developing as a result of genetic inheritance and adaptation to environmental effects.

The results of the present study were obtained from the examination of 16 body measurements performed in 52 females. The somatotypes of the females represent a mesomorph-endomorph and meso-endomorph predominance. The average somatotype is 6.91 – 5.53 – 0.96. As compared to fertile women, a noticeable rise of endomorph and mesomorph components and, at the same time, a decline in linearity component can be observed.

Key words: somatotype, ageing, Hungarian women

INTRODUCTION

Gerontology, in a wider sense, involves the basic biological and sociological studies related to the elderly, and the research into geriatric diseases as well. When performing human biological researches, the selective influence of deceases has always to be taken into account. Besides cross-sectional studies, also complex longitudinal studies initiated both worldwide and in Hungary (Lengyel 1984) [10] are of great importance. One of the most prominent studies is the Baltimore Longitudinal Study of Ageing. Age related alterations of height, weight, chest circumference and arm length, physique and body composition have been determined (Hayflick 1995) [9].

As a part of gerontological studies (Dezsö 1965) [3], human biological research, aiming to define the parameters of selective survival (Dezsö et al. 1969) [4], was first made in Hungary in the 1960s under the control of Ottó Eiben. New results based on an overall sampling among Hungarian „centenarians" was published by Eiben (1990) [7] and Eiben and Bodzsár (1990) [8], respectively.

The knowledge of the age-related changes of the appearance and body composition has a great importance from a medical point of view. In line with ageing, more pronouncedly in women, body weight tends to decrease. In a close correlation to this, chest circumference diminishes as well (Beregi 1981) [1].

With this end in view, defining the physique of 60-80-year-old women at the beginning of the 21st century is an important task in our judgement, considering especially the fact that ageing is rather a physiological than a pathological process. It is an understood thing that by the phrase physique one means the morphological constitution of the adult person, developing as a result of genetic inheritance and adaptation to environmental effects (Eiben 1972) [5].

MATERIAL AND METHODS

The results of the present study have been obtained from the data revealed from 16 body measurements performed in 52 females residing in Western Hungary. Their mean age: 66.69 years (SD: 4.41).

Somatometric examinations were performed by the Martin's technique (MARTIN and SALLER 1957), considering the recommendations of IBP/HA (TANNER et al. 1969). Somatotype was assessed by the anthropometric somatotyping method of Carter and Heath (1990).

RESULTS AND DISCUSSION

The results of the anthropometric examination are shown in Table 1. Examining postmenopausal women older than 60, we stated that body height – 163.06 cm – significantly falls short of that observed in women still menstruating (TÓTH and Buda 2007) [13]. In the present study we found body height to be 155.85 cm. Further decrease in body height is characteristic. Body weight was found 76.67 kg among postmenopausal women older than 60 (TÓTH and BUDA 2007) [13] and 67.76 kg by the present study. Decrease in body height and body weight was found significant, while the fall of BMI values from 28.78 to 27.89 was not. Significant difference was, however, found between the BMI values of premenopausal and postmenopausal women aged between 40–60 (TÓTH and BUDA 2007) [13].

The somatotypes of the females (Figure 1.) show a mesomorph-endomorph and meso-endomorph predominance. The average somatotype is 6.91 – 5.53 – 0.96. In fertile women the somatotype 5.12 – 3.91 – 1.97 was found to be characteristic by EIBEN et al. (1985). Thus, as compared to fertile women, a noticeable rise of endomorph and mesomorph components and, at the same time, a decline in linearity component can be observed. The alterations in the somatotype are characteristically related to ageing in women. Putting these changes on the file is of great importance so much the more the somatotype is defined on the basis of 10 body measures. Thus, comparing somatotypes is more informative than that of body height, body mass, the body fat percentage or BMI values.

Table 1. Means and standard deviations of the body measurements in 60-80-year old Hungarian women

Body measurements investigated	Mean	SD
Weight (kg)	67.76	14.03
Sitting height (cm)	81.53	3.14
Height (cm)	155.85	5.48
Height of acromion (cm)	129.10	5.41
Height of daktylion (cm)	61.78	6.59
Height of iliospinale (cm)	89.61	4.84
Chest circumference (cm)	93.30	8.50
Upper arm circ. (relaxed) (cm)	27.63	3.79
Upper arm circ. (bended) (cm)	28.28	3.75
Calf circumference (cm)	34.52	3.80
Bicondylar humerus (mm)	66.52	5.78
Bicondylar femur (mm)	96.33	9.32
Skinfold triceps (mm)	22.40	7.74
Skinfold subscapular (mm)	21.04	8.33
Skinfold suprailiaca (mm)	28.27	9.30
Skinfold calf (mm)	22.52	9.43

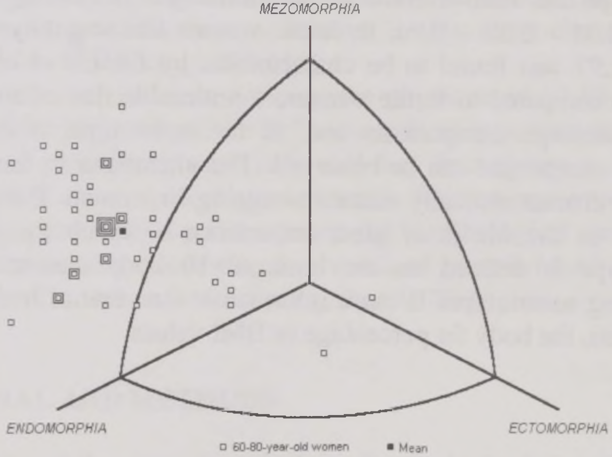


Figure 1. Somatotypes of 60–80-year-old Hungarian women. Mean somatotype: 6.91 – 5.53 – 0.96.

REFERENCES

1. Beregi, E. (1981) Az öregedés orvosi problémái. Aesculap, Medicina, Budapest. pp. 148.
2. Carter, J. E. L., Heath, B. H. (1990) Somatotyping. Cambridge Univ. Press. Cambridge. pp. 448.
3. Dezső, Gy. (1965) Anthropological examination. In: Haranghy, L. (Ed.) Gerontological Studies in Hungarian Centenarians. Akadémiai Kiadó, Budapest, 33–45.
4. Dezső, Gy., Eiben, O., Thoma, A. (1969) Metrikus testalkati jellegek eloszlása egy időskori mintában. Anthrop. Közl., 13, 31–37.
5. Eiben, O. G. (1972) The physique of woman athletes. The Hungarian Sci. Counc. for Phys. Educ., Budapest. 15–18.
6. Eiben, O. G., Bősze, P., László, J., Buday, J., Gaál, M. (1985) Somatotype of patients with Streak Gonad Syndrome. Humanbiol. Budapest, 16, 53–64.
7. Eiben, O. G. (1990) An Anthropological Sketch on the Hungarian Centenarians. Coll. Antropol., 14, 219–225.
8. Eiben, O. G., Bodzsár, É. B. (1990) Measurable Constitutional Characters and Selective Survival in Hungarian Centenarians. In: Beregi, E. (Ed.) Centenarians in Hungary. 31–39. Karger, Basel.
9. Hayflick, L. (1995) Az öregedés titkai. Magyar Könyvklub. Budapest. pp. 414.
10. Lengyel, É. (1984) Az öregségkutatás klinikai módszerei. In: Beregi, E. (Ed.) Az öregedés. 76–88. Akadémiai Kiadó. Budapest.
11. Martin, R., Saller, K. (1957) Lehrbuch der Anthropologie I. G. Fischer Verl. Stuttgart. 661.
12. Tanner, J. M., Hiernaux, J., Jarman, S. (1969) Growth and Physique Studies. In: Weiner, J. S., Lourie, J. A. (Eds.) Human Biology. A Guide to Field Methods. IBP Handbook No. 9. 176. Blackwell Sci. Publ. Oxford. Edinbourgh.
13. Tóth, G. A., Buda. B. L. (2007) Differences in BMI and body fat values of pre- and postmenopausal Hungarian women. Glasnik, 42, 411–418.

Address for correspondence:
Gábor A. Tóth
Laboratories of Human Biology, Berzsenyi Daniel College,
Szombathely, Hungary
E-mail: tgabor@bdtf.hu

Papers on Anthropology XVI, 2007, pp. 278–282

110 YEARS SINCE THE INTRODUCTION OF BOILED RUBBER GLOVES INTO SURGICAL PRACTICE

Maie Toomsalu

Institute of Anatomy, University of Tartu

INTRODUCTION

Surgery has three enemies – haemorrhage, pain, and wound infection. Haemorrhage was defeated, although not completely, by Ambroise Paré, pain by Horace Wells, William Thomas Green Morton and Charles Jackson, but wound abscesses continued to affect patients even in the 19th century. Mortality from blood poisoning after hand or leg amputation was sometimes as high as 90 per cent (Raudsepp, 1968: 130). In 1847 Ignaz Philipp Semmelweis introduced washing of hands with chlorinated lime solution when coming from the dissection room, which led to the decrease of deaths from puerperal fever. In 1860–1861 L. Pasteur conducted his famous experiments that showed the possibility of infection of sterile nutrient culture broth with microorganisms from the external environment and disproved the theory of spontaneous generation of life. In 1867, having read the papers of Semmelweis and Pasteur, Joseph Lister published his epoch-making article “On the Antiseptic Principles of the Practice of Surgery” (antisepsis – destruction of microbes by chemical means). To kill microbes, he used carbolic acid, the disinfective properties of which were discovered by the French pharmacist Lemaire in 1860–1863. Carbolic acid, however, had a poisonous side-effect on the organisms of both doctors and their patients. In 1886 Ernst von Bergmann (worked as professor of surgery at the University of Tartu from 1871–1878), in cooperation with C. Schimmelbusch and Schlange introduced boiling and steaming of surgical instruments and dressing material before the operation (asepsis – destruction of microbes by physical methods, e.g. high temperature). In 1893 the

French surgeons Octave Terrilon and Henri Chaput published their paper "Surgical asepsis and antisepsis". Surgeons had also learned to wash their hands before operations, but something was still missing.

RUBBER GLOVES INTRODUCED

In 1889 a charming and punctual nurse, Caroline Hampton, arrived from New York to work at Baltimore John Hopkins Hospital with the surgeon William Halsted (1852–1922). She was appointed head nurse of the surgical division. In the winter of 1889/1890 the tender skin of Miss Hampton's hands did not tolerate cleansing with sublimate any more and she developed eczema (Raudsepp, 1968: 137). The threat of losing his nurse inspired Halsted, and one day in 1890, he gave Miss Hampton thin rubber gloves that had been made to special order by Goodyear Rubber Company. The gloves that could be sterilized in hot steam freed the nurse from the need to wash her hands with sublimate. Soon these gloves began to be called "the gloves of love" and Caroline Hampton became Caroline Halsted (Raudsepp, 1968:137). Halsted did not publish any article on it.

In 1894 Halsted's colleague Hunter Robb strongly recommended that surgeons wear rubber gloves at operations. In 1895 his paper "Aseptic Surgical Technique" was also reviewed by the German surgical journal *Zentralblatt für Chirurgie*, but it did not attract sufficient attention in Europe. In J. Randers-Pehrson's book *The Surgeon's Glove* (1960), however, one can read that rubber gloves were taken into regular use at Halsted's hospital as late as 1897. J. J. Bloodgood, Halsted's assistant from 1892, published a report in 1897 on abdominal operations conducted at Baltimore John Hopkins Hospital. About the use of rubber gloves, he wrote that assistants used them without exception from 1897, but surgeons wore them very rarely (Bloodgood, 1899: 223–562). In 1931, however, the same author (Bloodgood, 1931) wrote that in those times Halsted did not fully understand the significance of rubber gloves yet. The same monograph also mentions that the first article on using rubber gloves to avoid sepsis was published in 1898 by the American Ch. McBurney. At that time, however, rubber gloves were already in use at operations in Europe. From 1890 onwards, bacteriological research proved that earlier methods for disinfecting surgeons' hands were insufficient. In 1897 A. Wölfer in Prague, J. von Mikulicz in Breslau (Wroclaw) and G. Perthes in Leipzig came to the idea of making surgeons' hands infection-free by using sterilized gloves. Mikulicz tried to apply gloves woven of cotton thread, Perthes silken gloves and Wölfer rubberized silken gloves at operations. These means, however, did not prove effective.

In 1897 the journal *Zentralblatt für Chirurgie* published Professor Werner Zoege von Manteuffel's article "Gummihandschuhe in der chirurgischen Praxis" (Zoege von Manteuffel, 1897: 553–556), where the author suggested that the surgeon should wear sterilized rubber gloves during the operation. Although this would prolong the operation by 5–10 minutes if the gloves did not fit perfectly, operating with "boiled hands" would guarantee absolute safety. As indications for wearing them, he mentioned operations on septic wounds, extraordinary operations, if the surgeon had earlier treated infected wounds, if he had small wounds or furuncles on his hands, unexpected injuries. For rural doctors, W. Zoege von Manteuffel recommended to include in their equipment rubber gloves in a sterile package, so that hands would be sterile even if they could not be washed properly. The article generated a lively discussion, and during the First World War Zoege von Manteuffel wrote, "I am sincerely happy and proud that all surgeons use gloves now. Not everyone can see his idea spread all over the world, and even if the author of the idea is sometimes forgotten, it is better than if the useful idea had fallen into total oblivion" (Reyher, 1931: 109). Actually, the application of boiled rubber gloves by W. Zoege von Manteuffel was accidental. One day his assistant Woldemar Fick had a furuncle on his hand and therefore could not assist at the operation and had to wait idle. The assistant was a student with no operation experience. Soon it became clear that another assistant was needed, and W. Zoege von Manteuffel shouted to Fick, "Boil the operation gloves and come to help!" So, Fick became the first to assist in boiled rubber gloves, although he himself remained quite passive towards one of the most significant innovations in practical surgery (Fick, 1931: 142). In 1898 the congress of the German Association of Surgeons discussed the topic of boiled rubber gloves, and they still had opponents, particularly active among them A. Döderlein, a gynaecologist from Tübingen. In his response, W. Zoege von Manteuffel emphasized that impenetrable rubber gloves will retain their place in surgery. The reports and speeches by W. Zoege von Manteuffel, Mikulicz and Perthes attracted attention not only in Europe but also in the United States and elsewhere (Käbin, 1986; Randers-Pehrson, 1960). A. von Eiselsberg, a Viennese surgeon, wrote about the introduction of rubber gloves, "To hit on this idea, one has to be a man of genius like Zoege was" (Kügelgen, von, 1931: 109). When, however, Paul Leopold Friedrich demonstrated thin seamless rubber gloves at a conference of surgeons in 1898, W. Zoege von Manteuffel's role fell into oblivion. W. Zoege von Manteuffel was not disturbed by this; for him it was important that rubber gloves were used (Wainer, 1980: 1389–1391).

CONCLUSION

On 13 July 2007 (1 July Old Style) 150 years passed from the birth of Maximilian Friedrich Werner Zoege von Manteuffel, an excellent surgeon from Tartu, honorary surgeon in ordinary to the Russian Emperor Nicholas II. Today all surgical teams operate in rubber gloves; meticulous operations are made and human lives saved. Although W. Zoege von Manteuffel and his operations are seldom remembered, W. Zoege W. Manteuffel would still be happy as operations are performed in germ-free rubber gloves, and by now, this has been done for 110 years.

REFERENCES

Bloodgood, J.C. Halsted thirty-six years ago. Matas Birthday Volume. Hoeber. New York, 1931.

Bloodgood, J.C. Operations on 459 cases of gernia in the John Hopkins Hospital from June 1889 to January 1899. John Hopkins Hospital Report 7, pp. 223–562, 1899.

Fick, W. Erinnerungen aus meiner Assistentenzeit bei Professor W. Zoege von Manteuffel. In: Kügelgen, von, A., Werner Zoege von Manteuffel Professor der Chirurgie in Dorpat. 1857–1926. Ein Lebensbild in Briefen, Erinnerungen und Worten seiner Freunde und Schüler. Reval, Estländische Verlagsgesellschft Wold. Kentmann&CO, 1931, S.142.

Käbin, I. Die Medizinische Forsclung und Lehre an der Universität Dorpat/Tartu 1802–1940: Evgebnisse U. Bedeutung für der Entwicklung der Medizin. 1986 Nordostdeutsches Kulturwerk, Lüneburg.

Kügelegen, von, A., Werner Zoege von Manteuffel Professor der Chirurgie in Dorpat. 1857–1926. Ein Lebensbild in Briefen, Erinnerungen und Worten seiner Freunde und Schüler. Reval, Estländische Verlagsgesellschft Wold. Kentmann&CO, 1931, S. 108.

Randers-Pehrson, J. The Surgeon's Glove. Thomas. Springfield, 1960.

Raudsepp, J. Kirurgia läbi sajandite [Surgery Throughout Centuries]. Tallinn, Kirjastus „Valgus", 1968.

Reyher, von, W. Werner Zoege von Manteuffel, weiland Professor der Chirurgie in Dorpat, als Gelehrter, Lehrer und Arzt. In: Kügelgen, von, A. Werner Zoege von Manteuffel Professor der Chirurgie in Dorpat. 1857–1926. Ein Lebensbild in Briefen, Erinnerungen und Worten seiner Freunde und Schüler. Reval, Estländische Verlagsgesellschft Wold. Kentmann&CO, 1931, S. 109.

Zoege von Manteuffel, W. Gummihandschuhe in der chirurgischen Praxis. Centralblatt für Chirurgie. 1897, Nr. 24, 553–556.

Wainer, L. Das chirurgische Erbe. Werner Zoege von Manteuffel. Zentralblatt für Chirurgie, 1980, 105 (20), 1389–1391.

Address for correspondence:
Maie Toomsalu
Institut of Anatomy
Medical Collections
Lossi 38, 51003 Tartu
E-mail: toomsalu@ut.ee

Papers on Anthropology XVI, 2007, pp. 283–292

SPECIFICITIES OF FOOT GROWTH AMONG SCHOOLCHILDREN OF RIGA AND LATVIAN REGIONS

S. Umbraško, J. Vētra, I. Dulevska, S. Boka, L. Gavricenkova, R. Zagare

Institute of Anatomy and Anthropology, Riga Stradins University, Riga, Kronvalda 9, LV-1010, Latvia

SUMMARY

The average maximum of the annual increase of foot length in boys and girls is parallel to increase of longitudinal parameters. The length of foot in boys and girls is equal until the age of 12, but from 13 years the boy's foot is longer. Boy's feet stop growing at 16–17 years, but girls – at 17–18 years. Asymmetries of feet parameters are marked in growing period. The flat feet are found among schoolchildren of Riga and Latvia regions equally. The deformities of transversal foot arch increase with schoolchildren age. The reason of deformities of transversal foot arch is different – low life quality, inadequate footwear, insufficient mobility etc. Schoolchildren of Latvia regions more commonly have hollow feet and their number lately is increased.

INTRODUCTION

The backbone and the foot are the most important parts of the locomotor apparatus of the body. Foot is the biological system with great self-regulating abilities, which maintains sufficient reserves for the balance and the distribution of optimal load in various foot parts. In a take-off movement it provides the acceleration for the total body centre of gravity. Foot arch catches and spreads the body mass pressure along the whole foot, making the gait springy, steady and flowing, adapting the foot to the uneven support field. Inside foot edge

has a force- reducing function, which attributes to the foot elasticity, preventing the brain and internal organs from concussion.
Due to sedentary life-style, insufficient mobility, inadequate food (too little proteins), as well as other factors, there develop asymmetries in the active and passive locomotor apparatus. Initially, these changes are functional and are easier to be controlled and improved, but with time they become irreversible and result in deformities and foot support load changes.

Aim
To define separate foot parameters, to assess the foot growth specificities among schoolchildren of Riga and some Latvian regional schools.

Objectives
1. To state foot parameters by means of plantogram with a graphic calculation method.
2. To assess the foot longitudinal and transversal arch, form of toes.
3. To analyze the incidence of asymmetry of foot parameters and the degree of prevalence.

MATERIAL AND METHOD

1700 schoolchildren of 7 to 19 years of various Riga city district schools and 467 schoolchildren of 7 to 11 years of various Latvian regional schools underwent screening. The screening at Riga schools was carried out from 1998 till 2003, in regional schools in October and November, 2006. Measurements were done at the school's medical office in the morning till 1 p.m. Foot plantogram was done by the plantograph of the company APEX „TOTAL CONTACT FOOT IMPRINTER SYSTEM".

Plantograms were analyzed by graphic calculation method, suggested by G. Potihanova, S.Godunova, V.Cernina (1967) [8].

Plantogram was graphically processed and estimated considering the state of longitudinal arch and transversal arch.

1. The state of the middle part of longitudinal foot arch is characterized by a coefficient K. $K = \frac{x}{y}$, where

x – width of marked imprint part along the line vv',
y – width of outward part of longitudinal arch.

Table 1. Evaluation of middle part of longitudinal foot arch

Coefficient K value	Evaluation of arch
0–0.50	Increased
0.51–1.10	Normal
1.11–1.20	Lowered
1.21–1.30	1st degree flat foot
1.31–1.50	2nd degree flat foot
> 1.51	3rd degree flat foot

Thus, if longitudinal foot arch is greatly lowered, we see the widening of middle foot in plantogram, diminishing of the heel angle, the anterior and posterior arch is elongated (Table 1.).

2. The size of heel angle Hc"K determines the posterior state of longitudinal foot arch. If the angle is 5° or higher, the foot is normal, if the angle is less than 5°, the foot is flat.
3. The length of anterior and posterior part of the arch is marked off by line segments ww' and uu'. The extension of these parts is the evidence of the flat foot even if the middle part of the arch is normal. The transversal foot arch is characterized by the following indices:
   - The angle NAP is at the 1st toe. The foot is normal if the angle is less than 18°, in the opposite case the transversal arch is flattened;
   - The angle OBR is at the 5th toe. The foot is normal if the angle is less than 12°, if the angle is equal or higher than 12°, the transversal foot arch is lowered (Потиханова Г. Г., Годунов С. Ф., Чернина Н. П., 1967 [8]; Мартиросов Э. Г. 1982; Auliks I. 1985 [1])

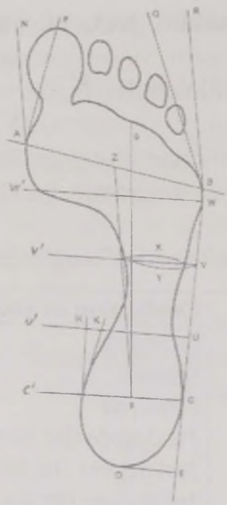


Figure 1. Graphical calculation method of plantogram (Auliks I. 1985[1]).

Longitudinal foot arch is evaluated by coefficient K value size, which characterizes the state of middle part of longitudinal arch by the angle Hc'K value size, which points to the position of posterior part of longitudinal foot arch and at the same time to the pronation of calcaneus and talus bones. Transversal foot arch is characterized by the angle NAP at the 1st toe and the angle OBR at the 5th toe. The angle NAP points to the *valgus* position of the 1st toe and the foot, the angle OBR – to the *varus* position of the foot. Single foot anthropometric parameters were determined. The height of the medial foot arch was measured by means of a rectangular ruler from the support field till the inferior surface of the boat-shaped bone (Fig. 1.).

The shape of the foot toes is determined by P.Galmiche (1967)[7] method – if the 1st toe is longer than the rest, it is the Egyptian foot, if the 2nd toe is longer, its is the Greek foot, and if I=II=III toes are equal, then it is a quandrangular or Chinese foot.

Podiatry is the branch of science which is studying all that deals with the foot. The foot takes a special, important place in the locomotor system. The notion „foot" is interrelated with the notion „shoes". Appropriate shoes for the foot perform an important protection function of the feet and vice versa, cause various foot diseases or deformities.(2006). In Latvia only a slight percentage of children and teenagers wear adequate shoes for a growing foot. This was the reason to study the foot parameters of Latvian schoolchildren.

The mean foot length of seven year old boys is 189,64 ±10,40 mm, but at the age of 17 years the mean foot length is 260,01±11,63 mm. The most intensive foot growth takes place at the age of 12 to 13 years with the mean yearly increase by 11,52 mm, but the second most intensive foot growth period is at the age of 14 to 15 years, when the foot increases on average by 10,86 mm per year.

Table 1. Mean foot length increase per year in absolute figures (mm)

Age	Boys		Girls	
	Right foot	Left foot	Right foot	Left foot
7–8	7.24	7.04	5.97	6.67
8–9	6.93	8.09	7.14	6.56
9–10	6.30	6.16	6.28	7.23
10–11	9.89	9.37	9.89	8.81
11–12	5.81	6.84	9.73	9.37
12–13	11.30	11.52	1.12	2.18
13–14	6.59	6.03	0.81	0.79
14–15	10.31	10.86	2.89	2.00
15–16	4.48	4.60	0.10	0.72
16–17	0.62	0	1.35	1.28
17–18	0	0	0	0
Total	**69.47**	**70.37**	**45.28**	**45.59**

For girls at the age of 7 years, the mean foot length is 189.10 ±7.93 mm, but at 17 years – 234.69±11.35 mm on average.

By means of t test, checking statistic hypothesis on the equality of mean values of boys' and girls' left foot length, we stated, that by 12 years the foot length, both in boys and girls, is equal but starting with 13 years, the boys' foot is longer which is statistically confident. Foot width in 7 year-old boys on average is 71.96±5.85 mm, but starting with 18 years it is 95.88±5.97 mm. The most intensive increase of this sign is in boys at the age of to 15 years when the foot on average grows by 4.71 mm.

For girls at the age of 7 years the foot is on average 70.35±3.06 mm wide, but at the age of 19 years, it is on average 88.17±4.1 mm.

The most intensive average annual increase of this sign in girls is from 11 to 12 years, when the left foot grows by 3.79 mm, but the right one by 4.48 mm per year. Both in boys, and in girls, the maximum yearly growth of the foot length coincides with the increase of other maximum longitudinal parameters (body height, length of the back-bone, length of the leg), i.e. in boys from 12 to 13 years, in girls from 11 to 12 years. Comparing it to results of other authors' studies at the beginning of the 20th century (Fedders G., 1936 [2]; Millere R., 1963[4]), the accelerated growth period in our study was found to start about one year earlier.

Analyzing foot growth specificities, it was found that both in boys, and in girls, the asymmetry of length and width was found in all age groups. In this study, 14.9% of Riga city schoolchildren were found to have symmetrical foot length, but in Latvian regional schoolchildren symmetrical feet were found in 13.8% cases. Asymmetrical foot length, when the left foot prevalence is greater (1–5 mm) was found in 75,1% in Riga and 79,3% regional schoolchildren, but 10% Riga and 6.9% regional schoolchildren were found to have asymmetry from 6 to 10 mm, when much longer is the left foot.

Similar foot width' asymmetry was seen both in boys and girls in almost all age groups of Riga and regional schoolchildren, when the left foot was wider than the right one. In the literature other authors are also describing the asymmetries of foot parameters (Прокопенко В.И.,1975; Алексеев Б.А.,1977). These authors analyze foot asymmetry in sportsmen. The foot specificities mentioned are explained by the authors as progressive morphofunctional changes, which have developed as a result of purposeful exercises. Unfortunately, one can find little data in the literature on the asymmetry of foot parameters, since the authors most commonly are doing measurements only for one – the right foot.

The form of the toes is also important, when buying shoes for casual wear, as well as sports foot-wear. Fashion patterns also influence the choice of foot-wear.

The toe form of Latvian schoolchildren has not been studied so far. In the literature there are studies of several authors (P. Galmiche, 1967[7]; S. Braun et al., 1980[6]; P. Andersen, 1986[5]) on the form of toes. These authors comment that most common is the so-called Egyptian toe form, when the 1st toe is longer. In the Ukraine (Кухтенко И.Н., Фарниева О.В. 1980[11]) there was studied the toe form of sportsmen. Authors state that sportsmen develop morphological changes of foot parameters typical for the specific kind of sport.

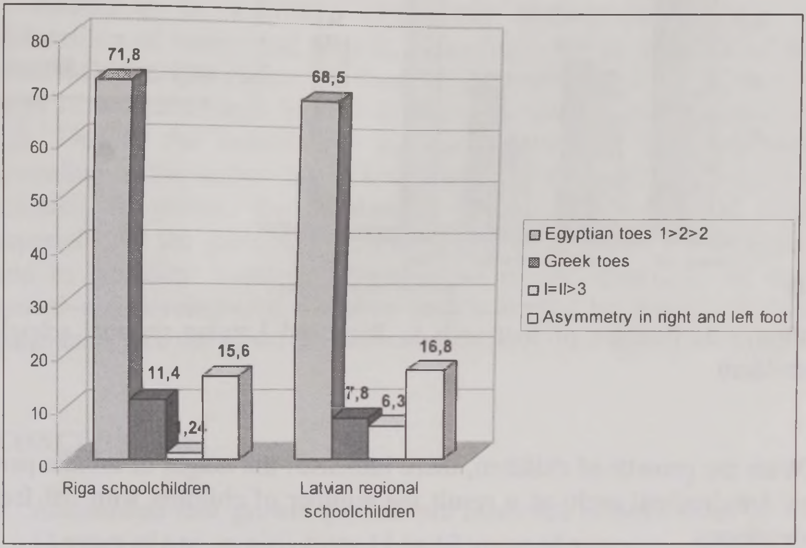


Figure 2. Variants of toe position in Riga and Latvian regional schoolchildren (by P.Galmiche. 1967[7]).

Both Riga and regional schoolchildren are more commonly found to have the variant of Egyptian toe position, whe the 1st toe is longer than the rest. One has to mention, that quite often (Fig.2.) are seen the asymmetries of toe positioning, which can essentially affect the foot, when buying shoes or going in for sport.

Children under survey were assessed the state of the foot by medial longitudinal and transversal arch. We assessed the coefficient K of the middle part of the medial longitudinal arch and the state of HC[1]K angle of the posterior part. Normal feet by coefficient K value are seen both in boys and girls and similarly for both feet in about 58% cases (Fig. 3.).

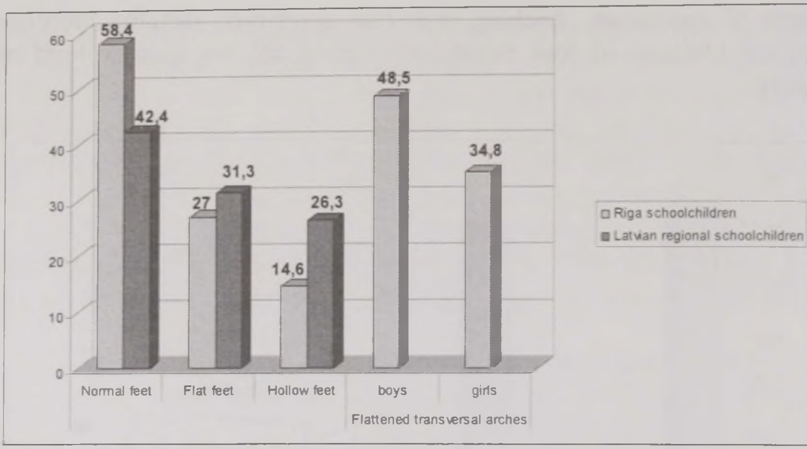


Figure 3. Position of foot arch in Riga and Latvian regional schoolchildren.

With the growth of children, there increases the height of middle part of longitudinal arch, as a result the number of children with flat feet decreases.

In the study of 1998–2003, 18-year –old adolescents, when the foot stops growing, were found to have 3rd degree flat foot only in 4.0% in the right foot and 4.6% in the left foot.The angle HC[1]K points to the state of the posterior part of longitudinal arch, it also determines the pronation of talus and calcaneus bones. In our study flat longitudinal posterior arch in boys was found in 7.8–8.4% cases, but in girls 8.9% cases. By this parameter, the flat longitudinal arch is more common in younger age children. Similar data can be found also in the literature. V.Krāna (1967) found the decrease of flat longitudinal arch from 27.2% in 8- year- old girls till 15.7% cases in 17-year –old adolescent girls in Latvia. In boys, at the age of 8 years, there were 46.3% cases till 25.9% cases in 17-year-old adolescent boys.

Lowered longitudinal arches are more commonly found in younger age children, while transversal flat foot is more common in older children. Deformities of transversal arch in Latvian regional schoolchildren were seen only in 5.4% cases, since the group included schoolchildren from 7–11 years of age, as a result, the number of this kind of deformities was not big. Similar tendencies in their studies on disorders due to support load in feet are presented by other authors too, among them A.Kraucis[3] in his study of 1998. The author found „*varus*" type deformities in 38% children.

According to V.Krana's (1967)[10] studies, the number of deformities of transversal arch is increasing with the increase of the children's age. The author had found deformities of transversal arch in boys 11.0–33.3% cases, in girls 15.4–31.4% cases from 7–18 years of age. One of the reasons for the development of foot deformity according to the author is the low quality, inadequate foot-wear for children. At present the problem of foot-wear is topical as well, especially for the growing feet. The degree of asymmetry prevalence and its typicality could be characterized as the specificity of foot growth and development. Children with a marked asymmetry of foot parameters face the problems to choose and wear the right foot-wear.

CONCLUSIONS

1. Accelerated foot growth periods are observed in boys from 12 to 13 years of age, in girls from 11 to 12 years of age.
2. Symmetrical foot parameters are seen only in 15% schoolchildren.
3. Both in Riga and Latvian regional schoolchildren the left foot in most cases is found to be longer and wider.
4. Two-thirds of schoolchildren are seen to have the Egyptian type of toe position, when the 1st toe is longer than the rest.
5. Slightly more than half of schoolchildren are seen to have normal longitudinal foot arches.
6. Flat feet are found to be in almost one-third, equally often both in Riga, and Latvian regional schoolchildren.
7. Children of rural regions are more commonly seen to have hollow feet, and their number lately is increasing.
8. Deformities of transversal arch, which characterize the anterior foot part, are more commonly of „*varus*" type.

Key words: feet, longitudinal arch, transversal arch.

REFERENCES

1. Auliks I. (1985.) Sporta medicīna. Rīga, Zvaigzne, 51–53.
2. Fedders G. (1936) Rīgas latviešu pamatskolas skolēnu garums un svars. IM mācību līdzekļu nodaļa, Rīga, 45.
3. Kraucis A. (1998) Balsta slodzes īpatnības dažāda vecuma bērniem. Jums, kolēģi. Medicīnas žurnāls. Nr.5, 49–52.
4. Millere R. (1963) Rīgas pilsētas skolēnu fiziskās attīstības standarti. Metodiski norādījumi, Rīga, 31.
5. Anderssen P. (1986) Fooder oj Foodtoj. Statens Husholdninngsrad, 1–23.
6. Braun S., Basquin L., Mery C. (1980) Considerationssur 10 asside du pied normal. Etude statistique. Revue de Rheumatisme, 47(12), 127–133.
7. Galmiche P. (1967) Le practicien devant un pied doulourex. La presse Medicale, Paris, 75(24), 1247–1259.
8. Годунов С. Ф., Потиханова Г.Г., Чернина Н. И. (1967) Инструкция по определению плоскостопия. Протезирование, протезостроение, 7, 145–171.
9. Каменев Ю.Ф. (2004) Боль в стопе при статических заболеваниях и деформациях. Петрозаводск, «Интел Тек», с. 94.
10. Кранс В.М. (1967) Закономерности роста стопы и ее сегментов у латышских детей и подростков. Автореф. канд. дисс., М., с. 15.
11. Кухтенко И.Н., Фарниева О.В. (1980.) Стопа и вопросы построения рациональной обуви. Изучение особенностей морфологии стоп спортсменов. Матер. 5-ого пленума межд. конф. Москва, с. 47–55.
12. Мицкевич В.А., Арсеньев А.О. (2006.) Подиатрия, Москва, БИНОМ, с. 134.

Address for correspondence:
Silvija Umbraško, PhD
Riga Stradiņš University
Institute of Anatomy and Anthropolagy
Kronvalda 9, Riga, LV-1010, Latvia
silvija_umbrasko@inbox.lv

ISSN 1406–0140