Papers on Anthropology

XI

PAPERS ON ANTHROPOLOGY
XI

UNIVERSITY OF TARTU
CENTRE FOR PHYSICAL ANTHROPOLOGY

PAPERS ON ANTHROPOLOGY

XI

TARTU 2002

The collection is indexed in BIOSIS, SPORTDiscus,
Anthropological Index Online,
EBSCO Publishing and
Sports Documentation Monthly Bulletin

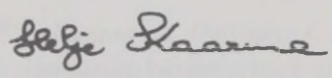
PREFACE

Together with the numerous authors of the present collection we are happy that the anthropological trend of research continues to receive a lot of attention in health care, medicine and physical education.

Establishing anthropological regularities enables us, together with geneticists, to move towards the final aim of theoretical medicine and biology — establishment of constitutional peculiarities of both sick and healthy persons.

We express our gratitude to all the authors, reviewers and Tartu University Press.

We wish you great success and look forward to further cooperation with all of you.



Prof. Helje Kaarma

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80 YEARS FROM THE BIRTH OF THE ESTONIAN ANTHROPOLOGIST KARIN MARK

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Karin Mark was a well-known anthropologist whose research papers and data collected by her are cited widely not only in Estonia and Russia. Her generation's lot in life was to survive the hard years of war and to manage without the equipment that present-day scientists have at their disposal.

The article presents a short overview of the life of Karin Mark — a modest person who became a renowned scientist. As a supplement we publish a list of her major publications.

K. Mark was born in Tartu on 24 March 1922 as the eldest daughter of the Finno-Ugric linguist Academician Julius Mark and sculptor and graphic artist Kristiine Mei. Her childhood and schoolyears passed in Tartu. When a student at the Faculty of Mathematics and Natural Sciences at Tartu University, K. Mark developed an interest in anthropology. She became a student of the well-known Estonian anthropologist Prof. Juhan Aul and his assistant. Thanks to J. Aul, namely the Estonian people is somatologically profoundly studied. He mapped the distribution of Estonians' external morphological features and the anthropological types of people distinguished on the basis of these. In post-war time J. Aul was actually the only anthropologist in Estonia. However, having a great teaching load at the Chair of Zoology at University, it was impossible for him to devote himself completely to anthropological studies. So K. Mark began to arrange and systematise the palaeoanthropological material collected by the archaeologists of the Institute of History. On the basis

of that material she also wrote her diploma thesis, where attention was focused on the problems of ethnic anthropology — how the modern anthropological types of Estonians could have been historically established.

As a postgraduate student at the Institute of History (her supervisor was the famous Russian anthropologist Dr. Georgi F. Debetz), K. Mark studied thoroughly all the palaeoanthropological (craniological) material collected by that time and defended her thesis *Palaeoanthropology of the Estonian SSR* for Candidate's degree in biological sciences (Moscow, 1953) [1].

In the 1950s much attention was paid at the Department of Archaeology and Ethnography of the Institute of History to the problems of ethnogenesis. The Baltic states are situated in a contact zone between Baltic Finns and Balts, or, in a broader sense, between Finno-Ugrians and Indo-Europeans. For solving the problems of ethnogenesis, the Head of the Department of Archaeology Prof. Harry Moora, the most distinguished Estonian archaeologist and an outstanding humanitarian, also recruited experts in other specialities. So K. Mark worked at the Institute of History as an anthropologist from 1952 until retirement in 1986. Already in her Candidate's dissertation she developed her own conception about the formation of the anthropological types of Estonians [2, 3]. For getting additional palaeoanthropological material K. Mark arranged archaeological excavations of medieval village cemeteries (at Varbola, Kõrgepalu, Iisaku, Maardu, etc.). The results of her studies are presented in many extensive articles, published both in the former Soviet Union and abroad [4–9, 11, 13, 18, 35].

At the same time, being still a postgraduate student, K. Mark began her somatological studies. In 1952–1954 she participated in the joint Baltic anthropological expedition in Estonia, Latvia and Lithuania. The results of these studies have been published in the book *Ethnic anthropology of the Eastern Baltic Sea Region* [9]. In the second half of 1950s, inspired by the well-known Russian anthropologist G. F. Debetz, K. Mark started extensive ethnic anthropological studies of all the Finno-Ugric peoples. On annual expeditions during a period of twenty-two years (1955–1976) K. Mark collected anthropological data among the peoples of the Middle Volga and the Ural foothill area — among Komis, Mordovians, Maris and Udmurtians. In the North she studied Finns and Sami, also Karelians, Vepsians, Izhorians, in the South — Transcarpathian Hungarians. The longest

journeys took her to West Siberia, to the areas of the Khanti and the Mansi. For comparison the neighbouring peoples of Finno-Ugrians were studied — Swedes, Bashkirs, Chuvashes, Tartars and Russians. In Estonia, the collection of material continued until 1980. All the anthropological measurements were carried out and descriptions written by K. Mark personally, which makes the material entirely unique.

Associating her large anthropological material with archaeological and linguistic data, K. Mark wrote the book *Zur Herkunft der finnisch-ugrischen Völker vom Standpunkt der Anthropologie* [33]. It was published by the time of the 3rd International Finno-Ugric Congress, which was held in Tallinn in 1970. K. Mark also presented the main results of her work at the plenary session of the congress [36].

K. Mark participated several times in joint Soviet-Finnish anthropological expeditions in Finland and in Komi. The results of these research trips were published in an extensive publication of the Finnish Academy of Sciences [37]. In 1975 K. Mark published a monograph on the anthropology of the Baltic-Finnic peoples [41]. She has written a number of important studies on the anthropology of several Finno-Ugric peoples [10, 13, 19, 21, 34, 37, 39, 40, 41, 44, 45, 51, 55, 56, 57, 58]. In Budapest, a study by K. Mark about the origin of Finno-Ugric peoples was translated into Hungarian [42].

K. Mark paid special attention to the study of ethnic history of Estonians. The foundation to anthropological investigations and collection of materials at the Institute of History as well as to systematic palaeoanthropological studies in Estonia was laid by K. Mark 50 years ago. In the 1970s the Institute of History began, at K. Mark's initiative, population-genetic odontological studies from the aspect of ethnic anthropology. The data have been published in the monograph *Anthropology of Estonians in Connection with the Problems of Ethnogenesis* [57], in which K. Mark examines Estonians' somatology comparing it with that of the ethnic minorities of Estonia in the 1930s as well as with other peoples, and also discusses the problems of ethnic formation of Estonians.

K. Mark complemented, specified and improved her life's work about the genesis of Finno-Ugric peoples on the basis of anthropological data until the end of her life. The analyses of data are extensive, embracing the context of Eurasia. The material consists of data of somatological studies of about 13,000 people belonging to 130 ethnic and territorial groups. They represent mostly Finno-Ugric peop-

les; in addition, over twenty groups of Indo-European and Turkic-Tartar peoples were studied for comparison. She presented her conception about the formation of the anthropological types of Estonians on the basis of anthropological, archaeological and other adjacent sciences as early as around 1955 and of Finno-Ugric peoples — in the 1960s and 1970s. For interpretation of her results, in addition to anthropological material, K. Mark worked through respective new archaeological and linguistic data. However, her work was unexpectedly interrupted on 4 December 1999.

The data collected by K. Mark on Finno-Ugric peoples are invaluable as they form a foundation for morphological studies and studies of the material and spiritual culture of Estonians as well as of other Finno-Ugric and neighbouring peoples.

K. Mark was a widely acknowledged scientist both in her homeland and abroad. In 1959 she received the Soviet Estonia Award. In 1965 she was elected a foreign member of the Finno-Ugric Society, in 1970 — a member of the International Committee of Finno-Ugrists. She was also a member of the Naturalists Society of Estonia and of the European Anthropological Association.

K. Mark was cheerful, with great sense of humour, a friendly but exacting leader, who shared her knowledge with her younger colleagues and students during expeditions as well as in everyday work. The extensive research data collected by her and substantial studies on Finno-Ugric peoples will serve as an eternal memorial to Karin Mark.

K. MARK'S MAJOR PUBLICATIONS

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3. Марк К. Ю. Новые данные по палеоантропологии Эстонской ССР.// Труды Института этнографии АН СССР. Т. 23. Москва 1954, с. 126–137.
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OBESITY AS A RISK FACTOR FOR EARLY MYOCARDIAL INFARCTION IN MEN

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ABSTRACT

Overall obesity and high body weight have been related to increased risk of clinical events of atherosclerotic diseases in prospective population-based studies, but abdominal obesity has supposed to be even a stronger predictor of coronary heart disease (CHD). In a case-control study 71 males who had experienced myocardial infarction (MI) at the age of 55 years or earlier and 68 controls were studied for cardiovascular risk factors. Body mass index (BMI) characterizing overall obesity and waist circumference and waist to hip circumference ratio (WHR) indicating abdominal obesity were registered. The prevalence of overall and abdominal obesity was more frequent among survivors of MI. The mean values of all the anthropological indicators mentioned were also higher in MI subjects. BMI showed only one association with obesity indicators: positive correlation with serum TG level in survivors of MI. Several correlations were found between lipid data and WHR; the associations were more often significant in the survivors of MI. Blood pressure data revealed significant correlations with all body mass parameters in the control group; the associations were weaker in MI survivors. About 75% of MI subjects used antihypertensive drugs. Multiple regression analysis showed that the strongest independent and positive correlate of the anthropometric indices in the control group as well in MI survivors was diastolic blood pressure.

Key words: obesity; myocardial infarction; lipids; blood pressure

INTRODUCTION

Estonia belongs to the countries with an exceptionally high CHD mortality among middle-aged population [1]. An epidemiological study of population of Estonia has indicated that elevated total cholesterol concentration and hypertension are important determinants of cardiovascular mortality in male population of Tallinn [17]. It is well-known that blood lipid parameters and blood pressure are associated with body mass. Overall obesity and high body weight have been related to increased risk of clinical events of atherosclerotic diseases in prospective population-based studies [8, 11]. However, there is some evidence that abdominal obesity, as indicated by high WHR or high waist circumference, is even a stronger predictor of atherosclerotic diseases than overall obesity, as indicated by high BMI. A recent study has demonstrated that abdominal obesity, especially when combined with increased serum low density lipoprotein cholesterol (LDL-C) level, is associated with accelerated progression of carotid atherosclerosis in men [12].

The aim of this study was to compare common cardiovascular risk factors in men who survived early myocardial infarction and controls of the same age, and to determine associations of obesity with blood lipid profile and blood pressure.

MATERIAL AND METHODS

Subjects

In the case-control study a cohort of Tallinn men (n=71) who had experienced myocardial infarction (MI) at the age of 55 years or earlier were studied for cardiovascular risk factors. The male control group of the same age (n=68) was chosen from Estonian Population Register.

Methods

Personal data, ethnic origin and life style risk factors were registered by a self-administered questionnaire. Physical activity was estimated

by the scale of Grimby [7]. The lowest grade: 1— no physical activity and the highest grade: 6 — hard exercise regularly several times a week). In the classification system for smoking habits the gradient was as follows: 1 — never smoked; 4 — day-to-day regular smoker.

Body weight and height were measured; as a measure of overall obesity BMI was calculated as weight (kg) divided by square of the height (m^2). Waist and hip circumference were determined and the ratio of these values (WHR) was calculated. Waist circumference and WHR were used as measures of abdominal (central) obesity. Systolic and diastolic blood pressures (Korotkoff phase I and V) were measured twice, the mean of the readings was used in the study.

Fasting blood samples were drawn and total serum cholesterol (TC), high density lipoprotein cholesterol (HDL-C) and triglycerides (TG) were determined enzymatically in Tallinn Diagnostic Centre. LDL cholesterol level was calculated by the Friedewald formula [4].

Statistical methods

All statistical analyses were performed using programs of MedCalc packet [14] and Excel. Mean values and standard deviations were calculated. Spearman's rank correlation coefficients were used to evaluate associations of nonparametrical values, and linear regression analysis by Pearson was used in the other cases. Multiple linear regression analysis was used to clear out independent correlates of the indices of obesity. All registered indices were used in the models.

RESULTS

The frequency of overall and abdominal obesity in the study groups is presented in Table 1. Among survivors of early MI there were significantly more subjects with overweight as compared to controls; the difference was most considerable in the BMI class 25–29.9. For assessment of abdominal obesity different cutpoints of waist circumference are used [5, 6, 9]. If waist circumference = 96 cm was used as the cutpoint, increased abdominal obesity was found to be 28.6% more frequent among the survivors of early MI (Table 1). Manuals [6, 9, 16] do not present general cutpoints for WHR. Using the level

>0.96 as indicator of increased WHR [12], we did not reveal significant differences in the prevalence of increased WHR between MI survivors and controls.

Table 1. Frequency (%) of overall and abdominal obesity among controls and survivors of early myocardial infarction (EMI)

	Controls	EMI
BMI, kg/m^2		
Normal weight 18.5–24.9	34.9	12.5**
Overweight ≥25.0	65.1	87.5**
Pre-obese 25.0–29.9	39.1	58.3*
Obese class I 30.0–34.9	17.4	23.6
Obese class II 35.0–39.9	7.2	4.2
Obese class III ≥ 40	1.4	1.4
Waist circumference, cm		
Increased ≥94 (9,16)	56.5	61.1
>95 (5)	49.2	61.0
≥96	47.8	76.4**
Substantially increased =102 (6, 9, 16)	27.5	36.0

Numbers in parentheses indicate the reference
* P< 0.05
** P<0.01

Table 2. Indices of cardiovascular risk factors (Mean ± SD) in control group and in survivors of early myocardial infarction (EMI)

	Controls n=68	EMI survivors n=71	P-value
Age	49.3 ± 5.6	50.2 ± 7.2	0.39
BMI (kg/m^2)	27.2 ± 4.7	28.6 ± 3.5	0.05
WHR	0.95 ± 0.07	0.97 ± 0.05	0.05
Waist circumference, cm	95.7 ± 12.0	99.0 ± 9.6	0.07
Systolic BP, mmHg	129.5 ± 16.1	131.7 ± 17.8	0.44
Diastolic BP, mmHg	85.8 ± 12.0	86.4 ± 11.8	0.77
TC, mmol/l	5.25 ± 1.27	6.04 ± 1.12	<0.001
TG, mmol/l	1.12 ± 0.75	1.72 ± 1.06	<0.001
HDLC-C, mmol/l	1.08 ± 0.36	1.01 ± 0.36	0.25
LDL-C, mmol/l	3.62 ± 1.11	4.27 ± 1.03	<0.001
TC/HDL-C	5.39 ± 2.28	6.74 ± 2.42	<0.001

The mean values of cardiovascular risk factors in study groups are presented in Table 2. BMI, waist circumference and WHR were higher in patients with early MI, but blood pressure (BP) indices did not differ between the groups. All lipid parameters except HDL-C, were significantly higher in survivors of MI. subjects 77% of MI subjects received antihypertensive treatment and 12% lipid lowering drugs.

There was only one significant linear correlation between BMI value and lipid parameters: BMI correlated positively with serum TG level in survivors of early MI (Table 3). A number of correlations were found between lipid data and WHR; the associations were more often significant in MI survivors. Another measure of abdominal obesity, waist circumference, correlated with lipid data in the control group in a similar way as WHR. In cases the waist circumference values showed considerably fewer correlations with lipid parameters than WHR. The measures of abdominal obesity correlated positively and significantly with age in the control group, but not in survivors of MI. Blood pressure data revealed significant correlations with all body mass parameters in the control group; in MI survivors the correlations were weaker and not so frequent.

Multiple linear regression analysis showed that in the control group BMI correlated independently and positively with age and TG value and negatively with smoking habits' grade (coefficient of determination 0.19; $P<0.001$). WHR correlated in this group independently and positively with age and TC/HDL-C ratio (coefficient of determination 0.10; $P=0.034$). Independent correlates of waist circumference were age (positive), HDL cholesterol level and smoking habits (negative associations; coefficient of determination 0.22; $P=0.001$). In MI survivors BMI correlated independently and positively with TC/HDL-C ratio (coefficient of determination 0.093; $P=0.011$)

When blood pressure data were added to multiple regression models, diastolic blood pressure proved to be the strongest positive independent correlate of BMI, WHR and waist circumference in the control group as well in the survivors of MI.

Table 3. Correlation coefficients of indicators of overall and abdominal obesity with lipid parameters in control group and survivors of early myocardial infarction (EMI).

	BMI		WHR		Waist circumference	
	r	P	r	P	r	P
I Control group						
Age	0.22	0.07	0.24*	0.05	0.29*	0.02
TC	0.06	0.62	0.17	0.17	0.10	0.40
TG	0.19	0.12	0.21	0.09	0.23	0.06
HDL-C	–0.21	0.08	–0.26*	0.04	–0.32*	0.01
LDL-C	0.07	0.57	0.24	0.06	0.16	0.20
TC/HDL-C	0.19	0.12	0.29*	0.02	0.26*	0.03
BP systol	0.44*	<0.001	0.42*	<0.001	0.50*	<0.001
BP diastol	0.57*	<0.001	0.52*	<0.001	0.60*	<0.001
II Survivors of EMI						
Age	–0.20	0.09	0.06	0.64	–0.09	0.44
TC	0.11	0.36	0.24*	0.05	0.16	0.19
TG	0.29*	0.02	0.29*	0.02	0.30*	0.01
HDL-C	–0.15	0.21	–0.21	0.08	–0.16	0.19
LDL-C	0.16	0.21	0.26*	0.03	0.18	0.14
TC/HDL-C	0.21	0.09	0.31*	0.01	0.22	0.07
BP systol	0.23*	0.05	0.19	0.11	0.22	0.06
BP diastol	0.34*	0.003	0.21	0.07	0.29*	0.01

* statistically significant correlations

DISCUSSION

As anticipated, the mean values of body mass and abdominal obesity indices were higher in survivors of MI. The prevalence of subjects with overweight (BMI=25) and abdominal obesity (waist circumference >96 cm) were also higher among MI survivors. Obesity is known to be related to an increased risk profile for atherogenesis with an increased incidence of hyperlipidemia and hypertension. Central adiposity, with an increased intra-abdominal fat mass, is associated with a particularly adverse lipid profile [15]. This is in accordance with our finding that WHR and waist circumference were stronger correlates to lipid profile than BMI values.

Blood pressure data revealed significant correlations with all body mass parameters in the control group; the correlations were weaker and not so frequent in MI subjects. The fact that mean blood pressure values did not differ between cases and controls seems unexpected at first sight. These results may become comprehensible if we take into account that about 75% of the MI patients received antihypertensive drugs (lipid-lowering drugs were used by 12% of cases).

Prospective epidemiological studies have shown that abdominal adiposity, assessed by WHR, is more strongly associated with the risk of coronary heart disease than overall adiposity, assessed by BMI [13]. Abdominal obesity has an important role in pathogenesis of insulin resistance, hypertriglyceridemia and type II diabetes [15, 2, 18]. Coronary heart disease is the main cause of mortality among patients of type II diabetes [3]. In our study this disease was diagnosed in 6.9% of survivors of early MI. However, among older MI patients the prevalence of type II diabetes is usually higher; also, a lot of different disorders of glucose metabolism are known to precede manifestation of diabetes. The prevalence of these disorders in survivors of MI is considered to be greatly underestimated [10]. The matter forms the basis for further studies in our population.

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Papers on Anthropology XI, 2002, pp. 27–39

BODY BUILD AND BODY FAT IN MALE PATIENTS AT THE DEPARTMENT OF CARDIOLOGY AT TARTU UNIVERSITY HOSPITAL

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ABSTRACT

The purpose of the investigation was to study body build and body fat content and their correlations with diagnostic categories in male patients at the Department of Cardiology at Tartu University Hospital.

The sample included 150 male patients. The measurements taken were height, weight and body fat (assessed with Omron®BF 300 Body Fat Monitor — Omron®/Matsusaka Co. Ltd., Made in Japan). All diagnoses were taken from case histories.

According to the recommendations of Kaarma [7, 8] the sample was studied in three age groups and in five SD classes of height and weight. With advancement in age, the sum of diagnoses per individual increased in all the categories of physique. In classes of concordance between height and weight (small, medium and big), height, weight and percentage of body fat tissue increased accordingly. Using mathematical formalisation, it was possible to show that individual sum of diagnoses was connected with age and body fat content. Both the classification of physique into five categories and the body fat monitor Omron® BF 300 can be recommended for application in routine clinical practice.

Key words: height-weight mean and SD classification, male, CHD, body fat monitor

INTRODUCTION

In the fifth century BC Hippocrates described people with short thick bodies, calling them *habitus apoplecticus*, and observed that they were susceptible to vascular diseases and apoplexy. Kretschmer [21] used the term *pycnic* for this body type, and Greil [4, 5] named them *pycnomorphs*. In Anglo-American literature mostly the term *endomorph* has been used. Nowadays this body type is considered to be a risk factor for coronary heart disease (CHD), type II diabetes, podagra, hypertension and adiposity. Not only body build but also commonly used anthropometric variables as height and weight and body mass index calculated from them have a prognostic significance for morbidity and mortality [1, 2, 18, 25, 31, 33, 34]. Population studies have revealed a strong negative association between body height and mortality [34]. The mortality associated with body mass index is characterised by typical low-weight causes (tuberculosis, obstructive lung disease and stomach cancer) and typical high-weight causes (cerebrovascular diseases, diabetes and colon cancer) [34]. There is a marked U-shaped association between body mass index and mortality [34].

Malina et al. [24] have shown in adults that CHD risk factors, such as elevated systolic and diastolic blood pressure, hyperglycaemia, elevated level of triglycerides, cholesterol, HDL-C fraction and HDL-C/cholesterol, are correlated to the endo- and mesomorphic component of Heath-Carter somatotype classification and inversely correlated to the ectomorphic component.

Katzmarzyk et al. [17] have shown that even in 9–18-year-old youths there is a strong correlation between the high endo- and mesomorphy component of Heath-Carter somatotype and elevated levels of triglycerides, LDL-C fraction and hyperglycaemia and lower levels of HDL-C fraction.

The studies by Koleva et al. [19, 20] in Bulgaria have found that the most common somatotype for men was endomorphic mesomorph. Men with the highest endomorphy and mesomorphy were those who most frequently suffered from arterial hypertension.

Williams et al. [35] suggest that adiposity and muscularity are important features of increased CAD risk, linearity is beneficial.

Segal et al. [30] conclude that body fat fraction rather than body weight *per se* is associated with increased cardiovascular risk factors, and sex steroid alterations are also related to body fat. In the study of

Segal et al. [30] body composition was assessed by hydrostatic weighing.

In Estonia body build studies and body composition assessment have been rarely used in clinical practice until now.

In Western countries body composition assessment has been widely used because of epidemic spread of adiposity. There are many laboratory techniques of body composition assessment — underwater weighing, DEXA, MRI and deuterium. However, they are very expensive and need skilled personal service. Therefore in health, fitness and ambulatory practice field methods [6] have been recommended — skinfold thickness measurement and prediction equation application.

In recent years bioimpedance methods have increasingly been recommended. In Estonia hand-hand bioimpedance Omron®BF 300 body fat monitor (Omron®/Matsusaka Co. Ltd., Made in Japan) has been used from the end of 1998.

MATERIAL AND METHODS

For this study 150 male patients were recruited from the Department of Cardiology at Tartu University Hospital. Their height was measured with Martin anthropometer to the nearest 0.1 cm, and weight was measured with medical balanced-beam wages to the nearest 0.05 kg. Body fat percentage and body fat in kilograms were assessed by Omron®BF 300 body fat monitor [26] (Omron®/ Matsusaka Co. Ltd., Made in Japan). In order to take a measurement it is necessary to enter height, weight, age and gender into the unit database. The resistance value was recorded for each person as he comfortably gripped the handles of the BIA unit. Feet were placed shoulder width apart and the unit was held out in front of the body. The BIA unit has electrodes planted in the handles and the electrodes measure impedance to the current as it travels between the right and left hand.

Measuring of height, weight and body fat content was done by the first author, Dr. Liivika Born. Diagnoses were obtained from the case records of the Department of Cardiology.

RESULTS

We start presenting the results with primary statistical analysis of the male patients' body build and age data.

Table 1. Data of primary statistical analysis of male patients' age and body build

No.	Variable	N	Mini-mum	Maxi-mum	Mean	SD	CV
1.	Age	150	20.00	78.00	53.42	12.13	22.71
2.	Height (m)	150	1.64	1.93	1.77	0.06	3.40
3.	Weight (kg)	150	51.30	132.80	88.72	15.54	17.51
4.	Body mass index (BMI)	150	17.34	43.00	28.13	4.59	16.30
5.	Fat %	150	8.10	42.50	26.71	6.92	25.90
6.	Fat (kg)	150	4.10	51.60	24.05	9.48	39.42

The patients were characterised by great variability in age and anthropometric data. Their age varied from 20 to 78 years, weight from 51.30 to 132.80 kg, BMI from 17.34 to 43.00, body fat percentage from 8.10 to 42.50 and body fat in kilograms from 4.10 to 51.60. Great diversity was also characteristic of diagnoses. For statistical analysis we selected only the diagnoses which occurred at least in eight case records as a single case or in combination with others. There were seventeen of such frequent diagnoses; they are presented in Table 2.

However, many patients (especially elderly ones) are represented by several diagnoses, and therefore we devised a new index — sum of individual diagnoses (SID), which was calculated by adding all the diagnoses of a patient. Its minimum point score value was 1 and maximum point score value 6 points. The mean value of SID was 2.43±1.44.

Table 2. Incidence of diagnoses in male patients

No.	Diagnoses	Cases	Percent
1.	Morbus ischaemicus cordis	66	43.71
2.	Morbus hypertensivus I	7	4.64
3.	Morbus hypertensivus II	39	25.83
4.	Morbus hypertensivus III	10	6.62
5.	Tachycardia paroxysmalis supraventricularis	6	4.00
6.	Fibrillatio atriorum paroxysmalis	57	37.75
7.	Extrasystolia	17	11.26
8.	Infarctus myocardii	7	4.64
9.	Insufficientia valvulae mitralis	8	5.30
10.	Stenocardia	49	32.45
11.	Cardiosclerosis post infarctum	12	7.95
12.	Insufficientia cordis I	12	7.95
13.	Insufficientia cordis II	44	29.14
14.	Insufficientia cordis III	33	21.85
15.	Endomyocarditis	12	7.90
16.	Cardiomyopathia	18	11.90
17.	Cardiosclerosis	20	13.20

Table 3. Male patients' linear correlations matrix between age, anthropometric data and per case diagnoses sum (n=150)

No.	Variable	IDS	Age	Height	Weight	BMI	Fat %	Fat kg
1.	IDS	1.000						
2.	Age	0.554*	1.000					
3.	Height	–0.120	–0.282*	1.000				
4.	Weight	0.095	0.054	0.380*	1.000			
5.	BMI	0.150	0.169*	–0.009	0.932*	1.000		
6.	Fat %	0.368*	0.557*	–0.182*	0.576*	0.697*	1.000	
7.	Fat kg	0.251*	0.359*	0.048	0.861*	0.904*	0.897*	1.000.001

Table 3 presents age, SID and anthropometric variables. There was strong evidence that SID was significantly correlated with age ($r=0.554$, $p<0.05$) and with body fat percentage; BMI was more important than body weight, and the correlation of height with SID was even negative. Age was also a very significant factor, having strong correlations with body fat percentage ($r=0.557$, $p<0.05$) and also with SID ($r=0.554$, $p<0.05$). Height was negatively correlated

with SID (r= –0.12) and even more with age (r= –0.281). So, taller individuals had fewer diagnoses and older patients were shorter.

Table 4. Relationships between diagnoses and anthropometrical variables (* p<0.05)

No.	Diagnosis	Age	Height	Weight	BMI	Fat %	Fat kg
1.	Morbus ischaemicus cordis	0.551*	–0.207*	0.051	0.035	0.309*	0.153
2.	Morbus hypertensivus I	–0.047	0.091	0.047	–0.027	–0.109	–0,059
3.	Morbus hypertensivus II	0.037	0.101	0.319*	0.295*	0.190	0.266*
4.	Morbus hypertensivus III	0.187*	–0.039	0.204*	0.241*	0.259*	0.277*
5.	Tachycardia paroxysmalis supraventricularis	–0.122	0.038	–0.045	–0.055	–0.138	-0.100
6.	Fibrillatio atriorum paroxysmalis	0.134	0.103	0.120	0.088	0.147	0.136
7.	Extrasystolia	0.124	–0.078	–0.058	–0.027	0.078	0.013
8.	Insufficientia valvulae mitralis	–0.006	–0.040	–0.129	–0.121	–0.136	–0.142
9.	Stenocardia	0.407*	–0.152	–0.121	0,064	0.157	0,017
10.	Infarctus myocardii	0.102	–0.040	0.052	0.069	0.085	0.080
11.	Cardiosclerosis post infarctum	0.267*	–0.129	–0.061	–0.007	0.140	0.018
12.	Insufficientia cordis I	–0.110	0.043	0.017	0.004	0.016	0.029
13.	Insufficientia cordis II	0.116	–0.026	0.123	0.138	0.075	0.081
14.	Insufficientia cordis III	0.194*	–0.076	–0.094	–0.070	0.112	0.042
15.	Endomyocarditis	–0.284*	–0.031	–0.109	–0.104	–0.113	–0.099
16.	Cardiomyopathia	–0.138	0.164*	–0.048	–0.133	0.117	–0.115
17.	Cardiosclerosis	–0.245*	–0.015	–0.057	–0.053	–0.171	–0.144

p<0,05

Table 4 presents data of correlations between diagnoses and anthropometric variables. Here it is worth mentioning that CHD had a strong correlation not only with age but also with body fat percentage. On the other hand, it was in negative correlation with height and had a weak correlation with BMI. The correlation between hypertension (*Morbus hypertensivus*) and age, body weight, BMI and body fat increased with increase in hypertension severity grade. Stenocardia had a strong correlation with age ($r=0.401$, $p<0.05$), the correlation with body fat was weak ($r=0.157$). It is interesting to note that the correlation between inflammatory heart diseases and their convalescence with age was negative; their correlations with height, weight, BMI and body fat were also negative. In other words, these diseases were diagnosed in younger and taller individuals with lower fat content.

If it is necessary to draw a parallel between the incidence of seventeen diagnoses, pointscore of individual diagnoses (SID), age and five anthropometric variables, a simultaneous anthropometric and age graduating classification can be used (Table 5). Our data were characterised by great variability in age — from 20 to 78 years. We created three age classes on the basis of average and SD values as follows: the middle-age class (mean ±0.5 SD) from 47 to 59 years, the younger class below 47 years of age and the older class above 59 years of age. Each age class was divided into five body build classes. According to the previous studies of Kaarma [7, 8], Kaarma et al. [9–15] and other researchers from Tartu [23, 27, 29, 32] we used height and weight mean ±0.5 SD values and height-weight bivariate distribution. So we created fifteen classes for all cases. In each class we calculated the mean ± SD values for height, weight, BMI, body fat percentage and for body fat in kilograms. There were typical changes in body build in the classes small, medium, large — height, weight, BMI, body fat percentage and body fat in kilograms increased step by step. The differences between pycnomorphs and leptomorphs were also typical — the first mentioned class had lower height but higher weight, BMI and body fat content. This suggested that the five class system was also applicable for the cardiological population.

Table 5. Distribution of the male patients by age and body build classes (n=150)

No	Variab-les	Age classes														
		Young (n=46) <47 years of age					Middle-aged (n=47) =47–59 years of age					Elderly (n=58) >= 59 years of age				
		S n=8	M n=6	L n=8	P n=12	Le n=12	S n=8	M n=6	L n=10	P n=10	Le n=12	S n=13	M n=6	L n=9	P n=13	Le n=17
1.	Height (m)	1.73	1.78	1.85	1.76	1.84	1.71	1.76	1.83	1.72	1.80	1.67	1.76	1.84	1.72	1.80
2.	Weight (kg)	71.01	85.66	107.23	92.95	78.85	73.58	91.63	108.58	94.41	80.88	70.54	88.50	112.34	100.53	82.47
3.	BMI	23.61	26.79	31.47	30.12	23.35	25.13	29.55	32.605	31.66	24.83	24.55	28.74	33.21	34.08	25.36
4.	Fat %	17.73	18.71	26.48	26.38	18.59	24.75	28.68	31.21	30.82	21.79	28.32	32.05	32.57	34.67	26.56
5.	Fat kg	12.82	16.00	28.65	25.11	14.24	18.21	26.28	33.87	29.41	17.72	19.82	28.43	36.73	34.83	21.38
6.	Age	39.12	37.83	40.62	41.75	34.91	51.62	53.17	53.30	54.50	52.00	67.15	66.33	62.33	65.15	65.65

Table 6. Incidence of cardiologic diagnoses in different age groups

No.	Diagnoses	Total n/%	Young n/%	Middle-aged n/%	Elderly n/%	Significant difference between classes
1.	Morbus ischaemicus cordis	66/43.71	4/8.70	19/40.40	43/74.10	+
2.	Morbus hypertensivus I	7/4.64	3/6.50	3/6.40	1/1.70	–
3.	Morbus hypertensivus II	39/25.83	8/17.40	19/40.40	12/20.70	+
4.	Morbus hypertensivus III	10/6.62	1/ 2.20	2/4.30	7/12.10	–
5.	Tachycardia paroxysmalis supraventricularis	6/4.00	2/4.30	2/4.30	2/3.40	–
6.	Fibrillatio atriorum paroxysmalis	57/37.75	13/28.30	19/40.40	25/43.10	–
7.	Extrasystolia	17/11.26	4/8.70	4/8.50	9/15.50	–
8.	Stenocardia	49/32.45	4/8.70	14/29.80	31/53.40	+
9.	Insufficientia valvulae mitralis	8/5.30	4/8.70	–	4/6.90	–
10.	Infarctus myocardii	7/4.64	1/ 2.20	2/4.30	4/6.90	–
11.	Cardiosclerosis post infarctum	12/7.95	1/ 2.20	–	11/19.00	+
12.	Insufficientia cordis I	12/7.95	6/13.00	4/8.50	2/3.40	–
13.	Insufficientia cordis II	44/29.14	8/17.40	18/38.30	18.31	–
14.	Insufficientia cordis III	33/21.85	6/13.00	7/14.90	20/34.50	+
15.	Endomyo-pericarditis	12/7.90	9/19.60	2/4.30	1/1.70	+
16.	Cardiomyopathia	18/11.90	8/17.40	6/12.80	4/6.90	–
17.	Cardiosclerosis	20/13.20	11/23.00	9/19.10	–	+

In Table 6 we present the results of the incidence of the seventeen diagnoses according to three age classes. There were significant differences between age classes in the prevalence of diagnoses 1, 3, 8, 11, 14, 15 and 17.

In the next stage of the study we calculated for each class the number of patients (P), number of patients with seventeen diagnoses (D) and total prevalence of the diagnoses of these patients.

Applying the chi-square test, we managed to reveal a statistically significant difference in the prevalence of diagnoses between the three age classes.

Table 7. Distribution of male patients into age/ body build classes (PC — male patients' general number, one patients diagnoses sum IDS and ratio IDS/PC)

Age/Body build class	Young	Middle-aged	Elderly	Total
1 Small	PC= 8 and IDS = 8 **Ratio = 1**	PC = 8 and IDS = 17 **Ratio = 2.12**	PC = 13 and IDS = 37 **Ratio = 2.85**	PC = 29 and IDS =62
2 Medium	PC = 6 and IDS = 10 **Ratio = 1.67**	PC = 6 and IDS = 8 **Ratio = 1.33**	PC = 6 and IDS = 25 **Ratio = 4.167**	PC = 18 and IDS = 43
3 Large	PC = 8 and IDS = 10 **Ratio = 1.25**	PC = 10 and IDS = 30 **Ratio = 3.00**	PC = 9 and IDS = 26 **Ratio = 2.89**	PC = 27 and IDS = 66
4 Pycno-morphic	PC = 12 and IDS=23 **Ratio = 1.92**	PC =10 and IDS = 32 **Ratio =3.2**	PC =13 and IDS = 40 **Ratio = 3.08**	PC =35 and IDS =95
5 Lepto-morphic	PC =12 and IDS= 14 **Ratio = 1.167**	PC =12 and IDS =24 **Ratio = 2.0**	PC=17 and IDS =61 **Ratio = 3.59**	PC =41 and IDS = 99
Total	PC=46	PC=46	PC=41	PC=150

DISCUSSION

The age of the patients of the Department of Cardiology varied greatly from young to elderly. Therefore, there was also a very broad spectrum of diagnoses from inflammatory diseases to degenerative atherosclerotic heart disease(CHD). Anthropometric data also showed great variability — young subjects were taller, elderly ones shorter, but their weight, BMI and body fat content were bigger. Such characteristics of anthropometric variables have also been found in population studies in Germany, Canada and Tartu [4, 6, 28].

In their earlier studies Kaarma [7, 8] and Kaarma et al. [9–15] have shown that a height-weight mean and SD classification systematises well all the other anthropometric variables. This study we showed that by same principle we can systematise age category and also diagnostic categories.

Formalisation of diagnostic categories into point scores is an opportunity to analyse diagnostic load and to correlate it with anthropometric variables.

Body fat assessment with Omron®BF300 body fat monitor was also the first application of this method on a sample of in-patients. In males over 50 years of age Lintsi et al. [22] had found that their mean body fat percentage was 24.3±1.05, Kaasik et al. [17] found that border guard servicemen's body fat percentage was 25.31±4.81, in over 60-year-olds 27.75±2.96%. A study of male inhabitants of Tartu by Saluste et al. [28] had found that the body fat percentage in males older than 50 years was 24.1±6.7% and in those older than 60 years even 30.7±4.4%. In Scotland Durnin and Womersley [3] had assessed in males aged 50–72 years body fat percentage at 28%. In Canada Jetté [6] had found in STF male subjects percentage of body fat at the age of 50–59 years 23.5% and at the age of 60–65 years 24.0%.

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Papers on Anthropology XI, 2002, pp. 40–52

AGE AND SEX DEPENDENT NORMVALUES OF SUBCUTANEOUS ADIPOSE TISSUE LAYER THICKNESSES MEASURED BY MEANS OF THE OPTICAL DEVICE LIPOMETER

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ABSTRACT

Independently of the degree of obesity, body fat distribution plays an important role in the development of several metabolic and endocrine complications. This body fat distribution pattern is strongly influenced by gender and age. We employed the new optical device, LIPOMETER, to investigate possible sex and age related patterns of subcutaneous adipose tissue layers (SAT-layers) in mid-European adults to provide basic knowledge of the development of SAT-layers.

In a cross-sectional study 287 men and 303 women were investigated by the LIPOMETER to establish normvalues of SAT-layers. The thickness of SAT-layers was measured by the LIPOMETER at 15 well-defined positions on the right side of the body from neck to calf, describing precisely the SAT distribution pattern of a subject. The device enables the SAT-layer measurement in a large number of people in a safe and rapid manner.

The subjects were grouped into five age-groups according to age and sex. In women, we observed an increase in upper body related SAT-layers in all age-groups whereas the SAT-layers of the lower extremities showed no age dependency. The pattern of female SAT development suggests that there is a shift in the enlargement of SAT-layers from the whole trunk to the top of the

body with advancement in age, forming a more and more android SAT pattern with advancement in age. On the contrary, in men, nearly all body sites were significantly influenced by age. Changes in men are associated with significant growth from group 1 (20–30 yrs.) to group 2 (30–40 yrs.) primarily in trunk-related SAT-layers. Thereafter, the occurrence of significant changes, if any, is associated with a slight decrease in the leg-related SAT layers.

There is a clear sexual dimorphism of SAT-layer thicknesses in all subsequent age groups, especially of all body sites on the extremities. A discriminant analysis revealed that body site 2 (triceps) had the greatest discriminant power between the sexes. This SAT layer enabled a correct classification in 97.3% of all cases in the eldest age group.

In summary, this study describes the changes in SAT-layer thicknesses with age in both sexes, and thus, it renders normvalues for further investigations.

Key words: body fat distribution, body fat composition, subcutaneous adipose tissue, pattern, obesity

INTRODUCTION

Independently of the degree of obesity, body fat distribution plays an important role in the development of several metabolic and endocrine complications such as insulin resistance, lipid and lipoprotein abnormalities and associated cardiovascular disease [2, 5, 11, 12, 19, 20, 22]. This body fat distribution pattern is strongly influenced by gender and age. Sexual dimorphism of body fat distribution is revealed through the android type with fat stored primarily on the trunk versus the gynoid body fat distribution pattern with more peripheral body fat [18, 21].

However, little evidence is available if and to what extent sex and age dependent variation might be responsible for the increase or decrease in the subcutaneous adipose tissue (SAT) during life from adulthood to senescence [3]. Furthermore, the situation of measuring SAT distribution in a more sophisticated manner is unsatisfying. The application of the frequently used CALIPER enables only a rough estimation of SAT-layer thicknesses by measuring compressed skin-

folds and a double layer of skin. Imaging techniques like computer tomography (CT) and magnetic resonance imaging (MRI) are not applicable as field methods for measuring SAT because of the high initial costs and radiological burden. Furthermore, scans of only a few slices do not allow a representation of the whole body fat distribution pattern [1, 6, 14, 22]. To overcome these shortcomings, a new optical device, the LIPOMETER has been developed, which allows of non-invasive, quick, precise, and safe determination of SAT-layers (in absolute millimetres) at any site of the human body. The technical characteristics of the LIPOMETER have already been published [16, 17].

In the present paper we applied this new measurement tool to healthy male and female subjects in order to render normvalues of their subcutaneous body fat development through different subsequent age groups.

MATERIALS AND METHODS

Healthy subjects

SAT-patterns of 287 men and 303 women were investigated with the LIPOMETER in recent years. All the people were judged as healthy by a questionnaire and were within normal limits of laboratory data, such as, e.g. glucose, triglycerides, and cholesterol (data not shown). Anthropometric characteristics of all measured subjects are given in Table 1. To show the SAT-development according to age and sex, all men and woman were grouped as follows: Group 1 (G1) covers the age range 20-30 years, group 2 (G2) from 30-40 years, group 3 (G3) from 40–50 years, group 4 (G4) from 50-60 years and group 5 (G5) from 60–70 years of age.

Table 1. Anthropometric characteristics [mean ± standard deviation (minimum-maximum)] of 590 healthy subjects in whom the thicknesses of 15 subcutaneous fatty layers were recorded. 287 men and 303 women were assigned to five subsequent age groups (Group 1: 20–30 yrs., Group 2: 30–40 yrs., Group 3: 40–50 yrs., Group 4: 50–60 yrs., Group 5: 60–70 yrs.)

		n	Age	Height	Weight
Group 1	♀	54	25.4±2.8 (20.3–29.9)	165.8±5.2 (152–179.5)	58.7±7.3 (42–74)
	♂	48	26.1±2.8 (20–29.8)	179.6±6.2 (164.5–194)	80.1±11.9 (61.5–113)
Group 2	♀	73	35.2±3.0 (30.4–39.9)	164.3±6.6 (130–175)	63.8±11.6 (36–95)
	♂	57	35.3±2.6 (30.4–39.6)	180±6.0 (165.5–197.5)	84.1±11.3 (65–124)
Group 3	♀	79	44.8±2.5 (40.5–49.9)	163.9±5.8 (152.5–181)	67.6±11.4 (50.5–118)
	♂	71	45.4±2.7 (40–49.9)	176.6±5.3 (164–191)	86.5±13.4 (65–135)
Group 4	♀	69	54.9±2.5 (50.3–59.3)	162.4±5.6 (150–180)	71.6±11.3 (51–110)
	♂	65	55.1±2.6 (50–59.8)	174.1±6.3 (161–197)	81.7±9.8 (61–108)
Group 5	♀	28	65.0±2.8 (60.1–69.8)	161.4±6.1 (154–180)	74.1±12.7 (58–99)
	♂	46	64.6±3.0 (60.1–69.7)	173.2±6.3 (161–188)	81.7±10.9 (60–110)

SAT-layer measurement by LIPOMETER

The thickness (in millimetres) of SAT-layers was measured by the LIPOMETER at 15 well-defined positions on the right side of the body from neck to calf, describing precisely the SAT distribution pattern of a subject.

Statistics

Standard statistics were employed (SPSS for Windows). The data were tested for normal distribution by Kolmogorow-Smirnov-test. One-way ANOVA was employed to identify significance of differences between men and women throughout the age-groups. To com-

pare the differences in the thickness of every measured SAT-layer between the sexes in all age-groups a non-parametric test was used. Stepwise discriminant analysis was employed to investigate if single SAT-layers or the combination of certain SAT-layers can differentiate between the sexes in the age-groups. P-values less than 0.05 were considered significant.

RESULTS

The values of all measured body sites in women throughout the 5 age groups (G1-G5) were normally distributed. The same was observed in men except for the fact that the SAT-layer of body site 3 — biceps — in age group 1 ($p=0.024$) and age group 2 ($p=0.021$) of men were skewed to the left. Percentiles, e.g., the 3rd percentile, the 50th percentile and the 97th percentile of every measured SAT-layer and of every age group (G1–G5) are shown in Figures 1–3. Medians are presented in Table 2.

In women, the SAT-layer of body site 9 — lower back — and all SAT-layers from the lower extremities (11 — front thigh, 12 — lat. thigh, 13 — rear thigh, 14 — inner thigh and 15 — calf) showed no changes between the investigated age-groups (Kruskal-Wallis; $p>0.05$). All other SAT-layers, however, exhibited significantly different results. In men only three SAT-layers (3 — biceps, 9 — lower back and 10 — hip) showed stability, whereas the other SAT-layers tended to vary significantly in subsequent age groups.
Consequently, the age-dependent SAT pattern development is different for both sexes. Changes in men are associated with significant growth from G1 to G2 primarily in trunk-related SAT-layers (Fig. 1 and Fig. 2, Table 2). Thereafter, the occurrence of significant changes, if any, is associated with a slight decrease in leg related SAT layers. An opposite pattern occurs in women. The changes of upper body related SAT-layers in women are associated with an increase in all age-groups. The predominance of growth is found from G1 to G2 as shown by the 50th percentile of SAT-layers (Fig. 1 and Fig. 2, Table 2). Whereas at this age six body sites (1 — neck, 3 — biceps, 4 — up. back, 6 — lat. chest, 7 — up. abdomen and 10 — hip) tend to grow significantly (all $p<0.05$), with

Table 2. Human SAT-layer development. Medians are presented (in mm) for each investigated female (E) and male (Γ) age group

Specified body site		20–30y	30–40y	40–50y	50–60y	60–70y
1 neck	♀	6.7	7.8	9.9	11.6	14.5
	♂	5.6	8.2	9.9	10.1	9.3
2 triceps	♀	11.9	12.2	12.2	13.3	13.4
	♂	5.4	6.0	5.3	4.8	4.6
3 biceps	♀	5.3	5.8	7.0	8.8	9.7
	♂	3.3	3.8	4.0	3.5	3.8
4 upper back	♀	5.2	6.2	7.6	8.4	8.9
	♂	4.4	5.7	6.4	5.7	5.5
5 front chest	♀	8.0	8.4	9.6	11.2	13.3
	♂	5.5	8.3	8.4	6.9	7.0
6 lateral chest	♀	6.4	8.5	10.6	13.9	12.9
	♂	5.8	9.4	8.6	8.1	8.4
7 upper abdomen	♀	7.6	10.3	12.7	13.9	15.6
	♂	7.7	11.2	11.6	10.9	10.1
Specified body site		20–30y	30–40y	40–50y	50–60y	60–70y
8 lower abdomen	♀	10.2	9.9	11.7	13.1	13.6
	♂	8.3	10.2	10.7	9.7	8.7
9 lower back	♀	10.5	11.7	11.9	12.8	11.6
	♂	8.5	9.8	9.3	9.2	9.5
10 hip	♀	8.3	11.8	11.9	12.4	12.1
	♂	8.7	11.8	10.4	10.1	9.3
11 front thigh	♀	10.2	10.1	9.7	10.0	9.5
	♂	4.0	5.5	4.8	4.5	4.0
12 lateral thigh	♀	10.2	10.0	9.9	9.0	8.7
	♂	5.1	4.2	3.6	3.0	3.2
13 right thigh	♀	7.2	6.5	6.7	6.4	7.4
	♂	3.8	3.4	2.8	2.8	2.6
14 inner thigh	♀	11.4	11.3	11.9	11.8	12.8
	♂	7.0	8.2	7.4	6.9	5.9
15 calf	♀	5.6	5.5	5.2	4.9	4.6
	♂	3.1	2.8	2.9	2.5	2.4

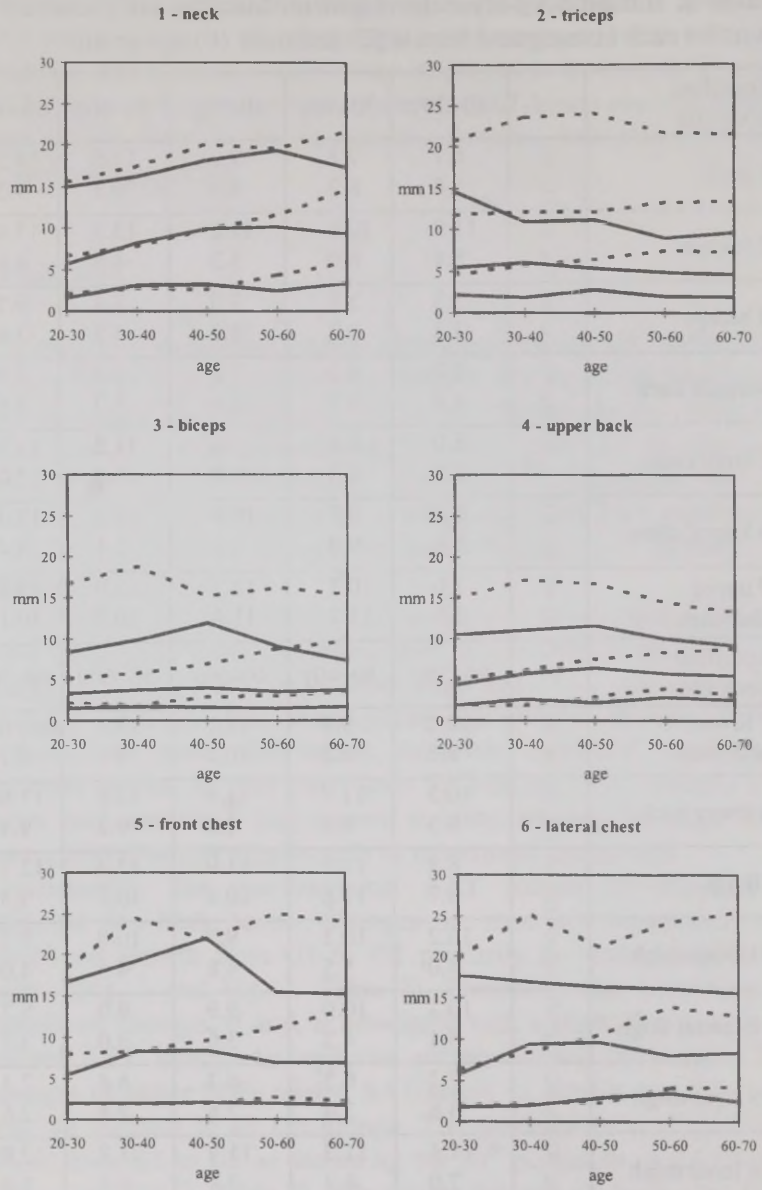

Figure 1. SAT-layers in men and women throughout the five age-decades studied (from 20 yrs. to 70 yrs. of age). The 3rd percentile, median and the 97th percentile of six SAT-layers (from 1 — neck to 6 — lat. chest) are shown. Values are expressed in mm. Solid line: men, dashed line: women

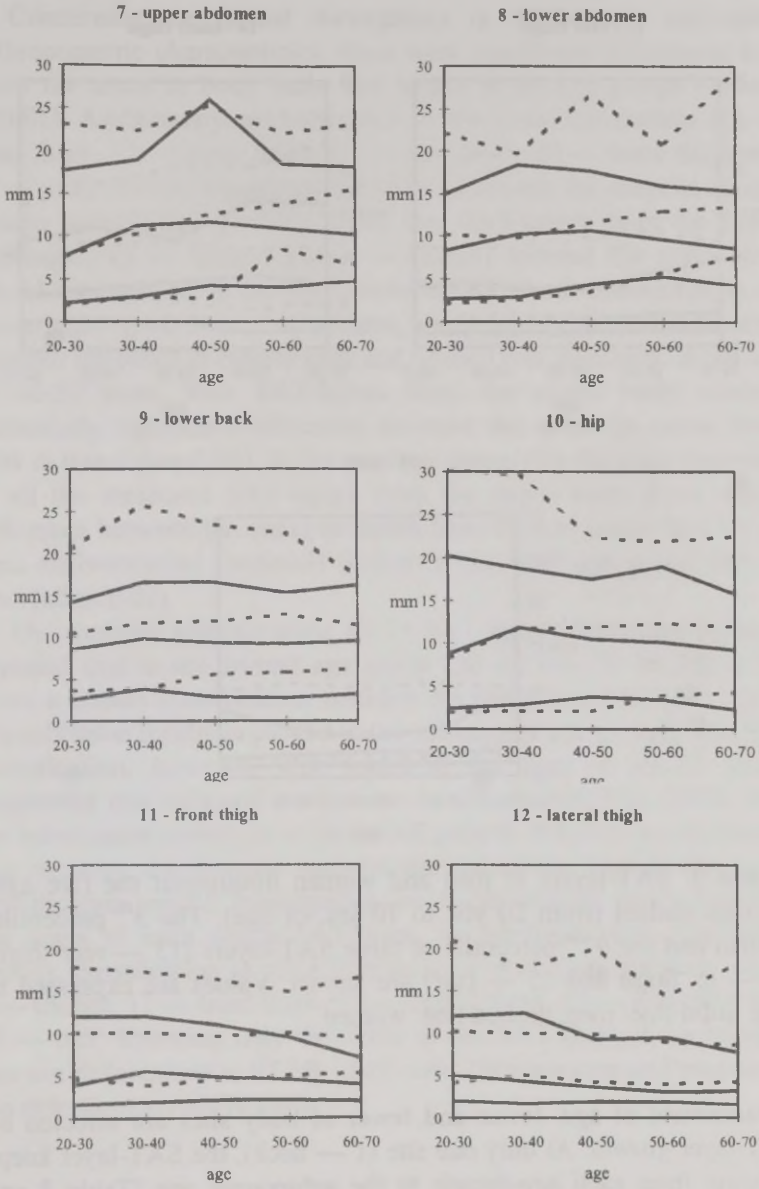

Figure 2. SAT-layers in men and women throughout the five age-decades studied (from 20 yrs. to 70 yrs. of age). The 3rd percentile, median and the 97th percentile of six SAT-layers (from 7 — up. abdomen to 12 — lat. thigh) are shown. Values are expressed in mm. Solid line: men, dashed line: women

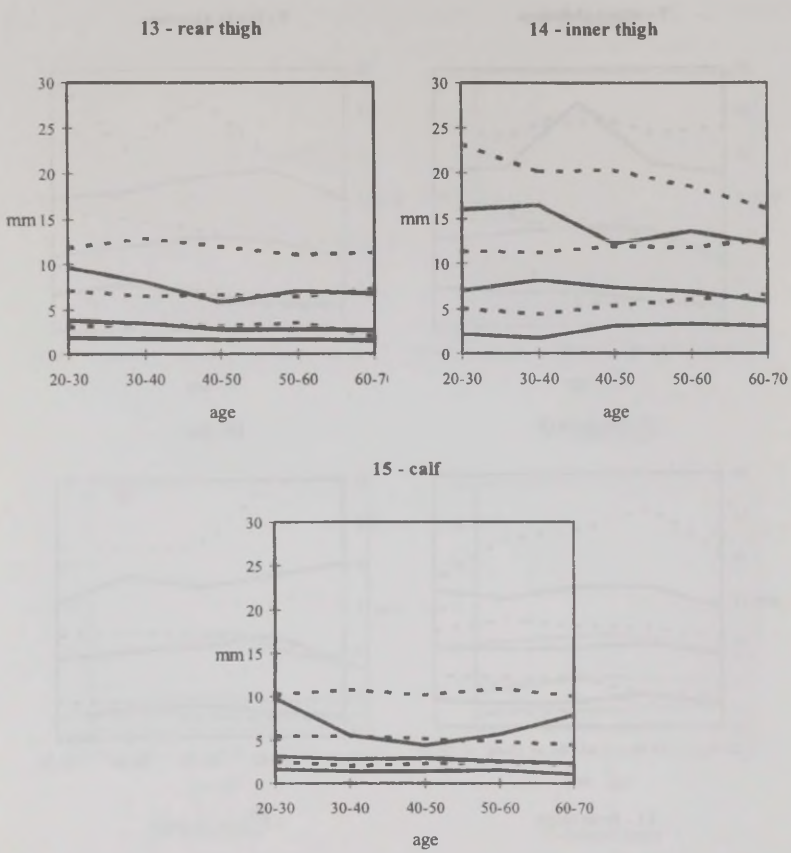

Figure 3. SAT-layers in men and women throughout the five age-decades studied (from 20 yrs. to 70 yrs. of age). The 3rd percentile, median and the 97th percentile of three SAT-layers (13 — rear thigh, 14 — in. thigh and 15 — calf) are shown. Values are expressed in mm. Solid line: men, dashed line: women

advancement of age, fewer and fewer of body sites are affected by SAT-layer growth. At only one site (1 — neck), the SAT-layer keeps growing from each age-decade to the subsequent one (Table 2 and Fig. 2). The pattern of female SAT development suggests that there is a shift in the enlargement of SAT-layers from the whole trunk to the top of the body with advancement in age. However, SAT-layers from the legs do not change significantly between all age groups investigated (Fig. 2 and Fig. 3, Table 2).

Concerning the sexual dimorphism in SAT-layers and other anthropometric characteristics, there were significant differences between the sexes in body mass and height in all age-groups (U-test; $p<0.01$). Additionally, all body sites on the lower extremities (11 — front thigh, 12 — outer thigh, 13 — rear thigh, 14 — inner thigh and 15 — calf) showed significant difference between the sexes in all age groups investigated ($p<0.01$). Only two SAT-layers from the upper extremities (2 — triceps and 3 — biceps) showed the same clear sexual dimorphism as the SAT-layers of the lower extremities in all age-groups ($p<0.01$). Furthermore, a progressive differentiation between the sexes in elderly men and women was indicated: at the age of 40-50 years, four SAT-layers from the upper body reached statistically significant difference between the sexes (p varies from 0.04 to lower than 0.01). In the next age group (50–60 yrs.), however, in all the measured SAT-layers from the upper body there was a difference between the sexes (p varies from 0.04 to lower than 0.01). This differentiation continued further in the final age group (60–70 yrs.) (all $p<0.01$).

Discriminant analysis using all 15 SAT-layer thicknesses as input revealed that in the second age group (20–30 yrs.) in 91,2% of all cases a correct classification between the sexes could be performed. Classification results improved in the subsequent age groups. The best classification, however, was found at the age of 60–70 years, suggesting that men and women can be discriminated by 100% with the information contained in their SAT pattern. It has to be mentioned that stepwise discriminant analysis showed almost exactly the same classification results. Investigating the discriminating power between the sexes of each single SAT-layer, we obtained more than 80% correct classification in all age groups for the following body sites: 2 — triceps, 11 — front thigh, 12 — lateral thigh, 13 — rear thigh and 15 — calf. Knowing only the value of the SAT-layer of the triceps, one can differentiate in 97.3% of all cases between men and women in the eldest group (60–70 yrs.).

DISCUSSION

We applied the newly developed optical device LIPOMETER on a large sample of people to provide representative normvalues of SAT-layers. Moreover, we focused on possible sex and age related patterns of SAT-layers in mid-European adults to provide basic knowledge of the development of SAT-layers.

In women, we noticed an increase in upper body SAT-layers in all age-groups while the SAT-layers of the lower extremities showed no changes. The higher a site is situated on the body, the longer a significant growth is observed in the subsequent age groups, forming a more and more android SAT pattern with advancement in age. Furthermore, these results were confirmed by a marked increase of the BMI in women in the subsequent age-groups from G1 (BMI 21.4 kg/m²) to G5 (28.4 kg/m²).

Our results showed some similarities with the studies of Fu and Fung [9], who used Lange callipers to measure skinfolds at 10 body sites in Chinese females of two different age groups (20–30 yrs. and 40–50 yrs.). They found significant differences between the two groups in skinfold measurements. From published data it can be concluded that the accelerated accumulation of body fat on the trunk is due to both the effects of ageing and the increase in androgenic activity in postmenopausal women [4, 7, 8, 10].

A somewhat different pattern of SAT-layers was obtained in men. From the youngest group G1 onwards, all SAT-layers start from lower levels than in women. The growth of the SAT-layers in men is, like in women, predominantly found between the age-groups G1 and G2. Thereafter almost no significant growth occurs in men. As observed in other studies, there is a redistribution of body fat from the subcutaneous compartments to visceral adipose tissue. Enzi et al. showed that males at any age tend to accumulate fat at the visceral fat depot, increasing with age. This observation is consistent with other studies which have indicated that in men abdominal subcutaneous adipose tissue decreases after the age of 50 years whereas in women it increases up to the age of 60–70 [4, 13].

The complex mechanisms regulating body fat distribution are still under investigation. Basing upon these results, future studies might investigate possible connections between SAT-layers and laboratory data, such as metabolism related factors and hormones in order to find

physiological explanations for the observed age-dependent variations of measured SAT-layers.

Finally, it should be mentioned that several metabolic and endocrine diseases such as type-2 diabetes mellitus or the polycystic ovary syndrome (PCO) tend to pronounce more or less typical SAT patterns [2, 12, 13, 15, 19, 22]. The LIPOMETER technique, which enables an exact and quick determination of the individual SAT development, might contribute to the still ongoing search for a diabetes and/or PCO predictor among anthropometric measures. The data presented in this paper could be applied as a basis for "healthy" normvalues for comparison with SAT patterns of diseased subjects.

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RELATIONSHIP BETWEEN BACK EXTENSOR MUSCLE STRENGTH, FATIGUABILITY AND ANTHROPOMETRIC CHARACTERISTICS IN MIDDLE-AGED WOMEN

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ABSTRACT

The aim of the study was to measure the relationship between back extensor muscle fatiguability, strength and anthropometric characteristics in middle-aged women. Twenty women participated in this study after giving their written informed consent. The subjects were distributed in two groups: patients with chronic low back pain (CLBP; mean age 50.3 yrs, n=10) and healthy controls (mean age 45.6 yrs, n=10). All patients completed questionnaires concerning their back pain history, current back pain and functional disability. They had no neurological deficit or orthopaedic restrictions. The isometric maximal voluntary contraction (MVC) force of the back extensor muscles was recorded by standard back dynamometer. Subjects performed Sørensen back endurance test until exhaustion while electromyogram (EMG) power spectrum and endurance time were recorded. Bipolar surface EMG recordings were made bilaterally over the erector spinae muscle at levels L3-L4. Spectral mean power frequency (MPF) was determined by using fast Fourier transform algorithms. The results indicated that MVC force of the back extensor muscle and MVC force relative to body weight was significantly lower ($p<0.05$) in CLBP patients than healthy controls. No significant differences ($p>0.05$) in endurance time and in MPF during Sørensen endurance test were observed between the two groups. In CLBP patients the MVC correlated significantly positively with upper body and whole body mass ($r=0.72$, $p<0.05$). In healthy controls the body-mass index

correlated significantly negatively ($r=-0.65$, $p<0.05$) with endurance time.

Key words: low back pain, back extensor muscle fatiguability, anthropometric characteristics

INTRODUCTION

Low back pain represents one of the leading causes of working disability in industrialised countries, being one of the most common musculoskeletal disorders. Low back pain is often caused by static holding tasks; it means increasing load to the spine, which leads to spinal muscle fatigue. In physically demanding occupations, back muscle fatigue is easily developed during repetitive lifting, bending and twisting manoeuvres, which have been shown to be occupational risk factors for low back pain [7]. A common finding in many chronic low back pain patients is that the back extensor muscles are both excessively fatiguable and weak [3, 8, 10, 11, 16, 18, 19]. Therefore, the evaluation of the back extensor muscle fatiguability has important applications in ergonomics as well as in assessment of patients with low back pain during rehabilitation. It has been observed that body weight [1, 3, 13] and body mass index [10] have a significant influence on lumbar back muscle fatiguability in Sørensen endurance test. Body mass index (BMI), which is the ratio of body weight in kilograms to height in meters squared ($kg \cdot m^{-2}$), gives a quantified answer to the question whether an individual is underweight, of normal weight, or overweight. Increased BMI is positively associated with chronic low back pain [5, 17]. The relationship between the changes in electromyogram (EMG) power spectrum during fatiguing sustained isometric contractions of the back extensor muscles and BMI in subjects with chronic low back pain is poorly understood. Assessment of fatiguability in the Sørensen back isometric endurance test is based on measuring endurance time, but this is hampered by subjective qualities, e.g. motivation and tolerance of discomfort or pain. Surface EMG power spectrum parameters and their shift toward lower frequencies have been employed to objectively assess the back extensor muscle fatiguability in sustained isometric contractions [2, 10, 13, 19, 21]. EMG power spectrum shifts to lower frequencies

caused by neural and metabolic factors in the muscle. The muscle fatigue-induced changes in EMG spectrum parameters have been related to the action potential conduction velocity propagation, which is believed to be a result of metabolic by-product accumulation (e.g. lactate, H^+ and extracellular K^+) [4, 22].

The aim of this study was to examine back extensor muscle fatiguability in submaximal isometric contraction and its relationship to strength and anthropological characteristics. Muscle fatigue during Sørensen back isometric endurance test was assessed using mean power frequency (MPF) slopes of the EMG power spectrum and endurance time.

MATERIAL AND METHODS

Two groups of middle-aged (35–55-year-old) female subjects participated in the study: patients with chronic low back pain (CLBP, n=10) and healthy controls (n=10). Patients were recruited through Tartu University Hospital, where they had frequently sought medical attention for low back pain. In the initial clinical examination at the hospital, the cause of the back pain was confirmed to be nonspecific, and patients with nerve root compression or disc prolapse, severe scoliosis, spondyloarthrosis, previous back surgery, and other serious and specific causes of back pain were excluded. The chronic back pain diagnosis included the criteria that patients had low back pain for longer than 3 months (on the average for 6.8±2.1 yrs) and that they did not have radicular symptoms. All patients completed questionnaires concerning their back pain history, current back pain and functional disability. None of the voluntary controls had a history of pain in lower back or had experienced lower-back pain during the previous year. The study carried the approval of the University Ethics Committee. Age and anthropometric characteristics of the subjects are presented in Table 1.

Isometric maximal voluntary contraction (MVC) force of the back extensor muscles was recorded by standard back dynamometer.

During Sørensen back isometric endurance test the subject lay in a prone position on a treatment couch with the lower half of the body below the level of the anterior superior iliac spines strapped to the couch at three positions: at the ankles as close to the malleoli as

possible, at the knee creases, and at the level of the greater trochanter of the femur. The seat belts were tightened as firmly as possible while considering the subject's level of comfort. The subject's hands were placed at the sides of the trunk, and the chest was supported at a 45° angle downward from the horizontal position. The subject was instructed at the beginning of the test to lift the upper trunk clear of the chair and maintain the horizontal position as long as possible. The horizontal position during the test was controlled by a small sack (hanging from the ceiling), which was placed between the scapulae. The subjects were verbally encouraged to maintain the horizontal position of upper trunk. The test was ended if the subject could no longer hold the test position or stopped because of maximal fatigue. The endurance time was recorded using a stopwatch. The subjects were verbally encouraged to continue throughout the endurance test.

While the Sørensen test was performed, surface EMG was recorded bilaterally from the erector spinae muscles at L3 level. It has been indicated that lumbar L3 region of erector spinae is a sensitive area for monitoring the EMG power spectrum changes during fatiguing isometric contraction [13]. After the skin was rubbed with alcohol, pairs of bipolar EMG electrodes (Beckman miniature skin electrodes) were attached over the thickest part of the erector spinae muscle (approximately 3 cm laterally to the spinous process) of the right and the left side. The electrodes were applied with interelectrode (centre-to-centre) distance of 20 mm, in the direction of the muscle fibres. As a reference electrode, a large carbon rubber plate (Nemectron, Germany, 7×12.5 cm) was placed on the iliac crest. The EMG signals were amplified and displayed with Medicor MG-440 (Hungary) preamplifiers with the frequency band ranging 1 Hz–1 kHz. The output signals from EMG preamplifiers were digitised on-line (sampling frequency 1 kHz) by analogue-to-digital converter installed in personal computer. The digitised signals were stored on a hard disk for further analysis. Spectral MPF was determined by using fast Fourier transform algorithms [12], in which a 1024-data-point window (1 s) slides over the whole recorded signal area with a 512-point shift (50% overlap). The MPF was defined as the weighted mean value of the data points forming the single spectrum. During Sørensen back endurance test the MPF was determined and averaged over each period of 5 s, and MPF slopes (% change/min) for right and left side were calculated.

Standard statistical methods were used for the calculation of means and standard errors of the means (±SE). A three-way repeated-measures ANOVA with two within factors (time and side) and one between factor (group) was used. Post hoc analysis was performed using Scheffe test. Pearson product-moment correlation was determined between BMI, endurance time and MPF slopes. Statistical significance was accepted at $p<0.05$.

RESULTS

No significant difference ($p>0.05$) in age, height, body mass and upper body mass was been observed between the two groups (Table 1). Body mass index was significantly ($p<0.05$) higher in CLBP patients compared to healthy women. Isometric MVC force of the back extensor muscles and MVC force relative to body weight was significantly higher ($p<0.05$) in healthy women compared to women with CLBP (Table 2). Endurance time did not differ significantly ($p>0.05$) between the groups. No significant differences ($p>0.05$) in MPF slopes of the erector spinae muscle for the right and left side during Sørensen endurance test were observed between the two groups. In CLBP patients the MVC correlated significantly positively ($p<0.05$) with upper body mass and whole body mass (Table 3). In healthy controls the body mass index correlated significantly negatively ($p<0.05$) with endurance time (Table 4).

Table 1. Age and anthropometric characteristics of the subjects (mean± SE)

Characteristics	Patients (n=10)	Controls (n=10)
Age (years)	50.3 ± 3.4	45.6 ± 1.3
Height (cm)	164.7 ± 2.2	163.2 ± 1.1
Body mass (kg)	71.9 ± 3.9	67.2 ± 3.1
BMI ($kg \cdot m^{-2}$)	26.9 ± 1.4 *	24.0 ± 1.4
Upper body mass (kg)	43.9 ± 2.4	40.9 ± 1.8

BMI- body mass index; * $p<0.05$ compared to controls

Table 2. Isometric strength and fatiguability characteristics of back extensor muscles during Sørensen endurance test in patients with CLBP and controls (mean ±SE).

Characteristics	Patients (n=10)	Controls (n=10)
MVC (N)	620.9±37.7 *	818.1±37.1
MVC/BW	0.89±0.04 *	1.26±0.08
T (s)	255.0±41.0	308.3±20.5
MPF_{slope}(r) (%/min)	19.2±4.1	14.0±2.1
MPF_{slope}(l) (%/min)	14.3±3.1	14.4±2.6

MVC — isometric maximal voluntary contraction force; MVC/BW — isometric maximal voluntary contraction force relative to weight; T — endurance time; MPF_{slope} — mean power frequency decrease over time; r — right side; l — left side.
* $p<0.05$

Table 3. Correlation coefficients between back extensor muscle strength and fatiguability and anthropometric parameters in CLBP patients (n=10)

Characteristics	MVC	MVC/BW	T	MPF_{slope}(r)	MPF_{slope} (l)
Height	0.22	0.09	–0.20	0.03	–0.07
Body mass	0.72 *	–0.29	–0.21	0.39	–0.01
BMI	0.51	–0.38	–0.12	0.40	0.15
Upper body mass	0.72 *	–0.29	–0.21	0.39	–0.02

* $p<0.05$; signs are the same as in table 2.

Table 4. Correlation coefficients between back extensor muscle strength and fatiguability, and anthropometric parameters in healthy controls (n=10)

Characteristics	MVC	MVC/BW	T	MPF_{slope}(r)	MPF_{slope} (l)
Height	–0.01	–0.07	0.08	–0.08	0.19
Body mass	–0.02	–0.73 *	–0.44	–0.01	0.39
BMI	–0.32	–0.85 *	–0.65*	0.13	0.42
Upper body mass	0.02	–0.72 *	–0.45	0.01	0.41

* $p<0.05$; signs are the same as in table 2.

DISCUSSION

The study showed that back extensor muscle isometric strength was significantly lower in middle-aged women with CLBP as compared to healthy middle-aged women. Subjects with low back pain often avoid

using their back in everyday situations, because of fear of pain and its consequences [23]. A decrease in physical activity can result in reduced lumbar mobility and loss of back extensor muscle strength because of muscle atrophy [15]. It has been shown that lumbar back muscle fatigue leads to abnormal spinal movements due to loss of precise muscle co-ordination which increase mechanical loading of passive elements, such as ligaments and intervertebral discs, and may cause back injury and pain [24]. Poor back muscle endurance may predict future occurrence of low back pain [3, 14]. In this study the MPF of the erector spinae muscle at the beginning of the Sørensen back endurance test did not differ significantly between the groups, which indicates the similar back extensor muscle loading in all measured subject groups in pre-fatigue condition. No right-left side differences were found for initial MPF and MPF slope. Thus, the muscle loading and rate of decrease of muscle activation during fatiguing contraction was similar for both sides.

The lumbar erector spinae muscle MPF decreases observed in the present study during Sørensen back isometric endurance test are in agreement with the results of previous studies. This EMG spectrum shift has been attributed to changed muscle metabolism during fatiguing contractions: intracellular pH decrease due to lactate accumulation and H^+ concentration or extracellular K^+ accumulation [20]. In moderate contractions investigated, lactate production was expected to be minimal, especially in view of the high percentage of type I (slow twitch) muscle fibres shown to be present in erector spinae muscle [9]. Extracellular K^+ accumulation might, therefore, be the important factor limiting erector spinae muscle endurance at moderate contraction levels. The exact physiological mechanisms behind the EMG spectral changes are believed to be multifactorial, where a number of factors have been suggested to influence the rate of EMG spectral shifts toward lower frequencies during fatiguing contractions. These factors include: slowing of action potential velocity, synchronisation of motor units, slowing of firing frequency, recruitment of new motor units during the fatiguing contraction [6].

The present data suggest that BMI has a significant influence on back extensor muscle fatiguability in the Sørensen isometric endurance test. This suggests that subjects with high BMI fatigued faster during Sørensen test than subjects with low BMI. In literature there are some suggestions that subject's body mass (weight) may influence the Sørensen isometric endurance test result [1, 3, 13]. Kankaanpää et

al. [10] investigated the influence of BMI on paraspinal muscle fatiguability (endurance time, EMG spectral indices) by using Sørensen test and found a strong influence of this factor. BMI showed a strong negative correlation, and endurance time a strong positive correlation with paraspinal muscle fatiguability (MF slope). Multiple regression analysis indicated that MF slope (fatigue) during the test was dependent on BMI in both sexes, but the effect of BMI was more pronounced in women than men.

ACKNOWLEDMENTS

This work was supported by the Estonian Science Foundation, grant No. 5279

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SEASONAL RHYTHMS OF MENARCHE IN ESTONIA

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ABSTRACT

The study follows a secular trend of pronounced seasonal rhythms of menarche among Estonian females. The results demonstrated that while two females out of five had their menarche in summer months, more than one out of four had the month of menarche close the month of birth. The study also explored the impact of such biopsychosocial factors as body structure, interconnections inside the family and school distress on the seasonal rhythms of menarche of Estonian females. Thereby it is possible to hypothesise that among the imprinting biopsychosocial factors dislodging the seasonal rhythms of menarche beside ontogenetic ones, social independence and social distress have their impact.

Key words: menarche, seasonality, body mass index, adolescence, Estonia

INTRODUCTION

The first menstrual period is a major milestone for females. The cluster of biopsychosocial factors such as genetic influences, socio-economic conditions, general health and well-being, nutritional status and certain types of exercise are well-known to determine the age of women at menarche, but the predictive factors for seasonality in menarche have not been so well researched. Cases of coincidence between the month of menarche and the month of birth have been

reported in several studies [1–3], being explained by an impact of ontogenetic factors [4]. The connection of menarche with periods of school vacation has also been described.

In Estonia, as early as in 1926, a study was carried out on the students of Tartu Girls' Gymnasium (n=517) [5]. Seasonal distribution by the month of menarche was described, as seen in Figure 1, as follows: in June, July or August in 32.6 % (summer); in September, October or November in 19.8% (autumn); December, January or February in 23.9% (winter) and March, April or May in 23.7% (spring) of the cases [5].

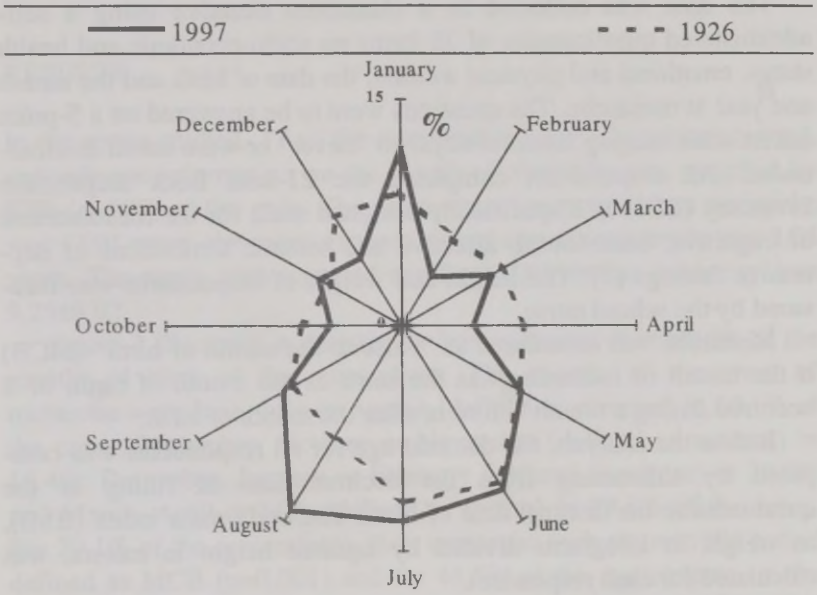

Figure 1. The annual rhythm of menarche in 1926 and in 1997 in Estonians, described in percentage prevalence by months.

The present study was aimed, firstly, to survey the month of menarche of Estonian schoolgirls on the sample of schoolgirls from the city of Tartu and, secondly, to detect the impact of some biopsychosocial aspects on the month of menarche.

For studying the date of the onset of menarche, the data collected in an early postmenarcheal period are of higher credibility than data

collected later [6]. For that reason, secondary school students from grades 9 to 12 were chosen as the sample of the study.

METHODS

Five hundred and eighty schoolgirls from grades 9 to 12 in four secondary schools in Tartu participated in the study. In their ethnic origin, 99.1% of the respondents were Estonians with the mean age of 15.7 years (13- to 18-year-olds).

The data was collected in a classroom situation using a self-administered questionnaire of 72 items on socio-economic and health status, emotional and physical welfare, the date of birth and the month and year at menarche. The questions were to be answered on a 5-point Likert scale ranging from "always" to "never" or were asked as close-ended. All respondents completed the 21-item Beck Depression Inventory (BDI) as a specifically designed scale for the measurement of cognitive, behavioural, affective and somatic dimensions of depressive feelings [7]. The height and weight of respondents was measured by the school nurse.

Menarche was considered as "close to the month of birth" (MCB) if the month of menarche was the same as the month of birth, or it occurred during a month before or after the month of birth.

Before the analysis, the decimal age for all respondents was computed by subtracting from the decimal date of filling in the questionnaire the decimal date of birth. The body mass index (BMI), as weight in kilograms divided by squared height in meters, was calculated for each respondent.

Differences in proportions between various groups were tested using Pearson chi-squared test, in which a two-tailed $p<0.05$ was considered statistically significant. To determine the important variables of the probability of MCB occurrence, the binominal logistic regression was performed. The dependent variable was MCB (1=month of menarche coincides with the month of birth or +/– one month; 0=others), and independent variables were the biopsychosocial aspects explored in the questionnaire.

Gynaecological age, month of birth, and body mass index (kg/m^2) were considered as biological aspects. Social aspects were parents' education level, economic status, the number of siblings, and living

together with parents or not. Psycho-emotional aspects were satisfaction with one's own life, interconnection with one's parents, enjoying going to school, getting good marks at school. In addition, self-assessed health status and existence of some chronic disorder, all 21 single items and the total sum score of Beck Depression Inventory, as well parents' smoking behaviour and eating behaviour of the respondents were considered as independent variables. 95% confidence interval (95% CI) for the logistic regression coefficient was computed. Data were analysed using the Statistical Package for the Social Sciences (SPSS), version 8.0 for Windows.

RESULTS

In the group studied, 17 of the respondents were still premenarcheal, and relevant information on the month of menarche was supplied by 87% (n=505) of the girls. The mean age of respondents at menarche was 13.01 years, the mean gynaecological age of the sample was 3.08 years. The mean sum score of the Beck Depression Inventory was 9.25±6.92.

Figure 2 illustrates a statistically homogeneous distribution of the months of birth of the respondents. The months of the onset of menarche were June, July or August (defined as summer) in 40.1% of the cases; September, October or November (defined as autumn) in 19.4%; December, January or February (defined as winter) in 20.8% and March, April or May (defined as spring) in 19.8% of the cases. For 29.1% of the respondents, their menarche took place in the period defined as MCB (p=0.001) and for 43.5% of the respondents, in the period of two months before or after their birthday (p=0.005). This closeness of the birthday and the onset of menarche differed according to months of birth (Figure 3).

It was seen most often, in 65.5% of the cases, in the subjects born in July (OR 4.12; 95% CI 1.532–11.105, p=0.005), next in June — in 58.1% (OR 3.27; CI 1.227–8.694, p=0.018). The least frequent MCB was seen in respondents born in April (30.6 %), January (31.7 %) and October (32.6 %).

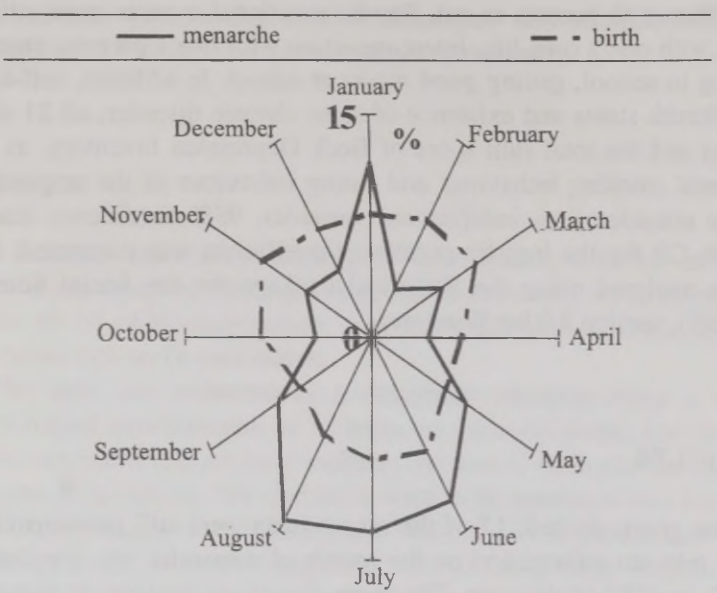

Figure 2. The annual rhythm of the month of birth and the month of menarche of Estonians, described in percentage prevalence by months

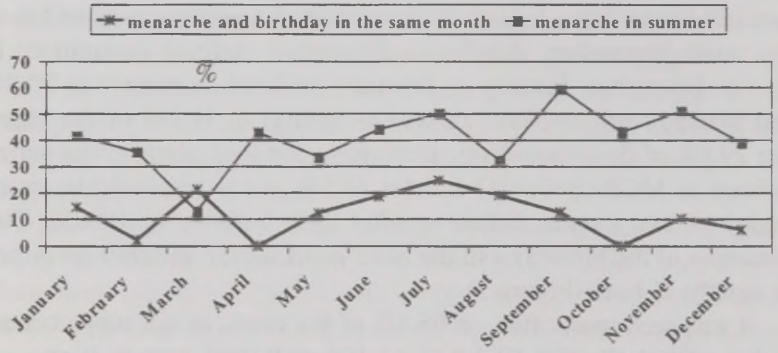

Figure 3. The percentage of the respondents with the onset of menarche in the same month with the month of the birth and in the summer months (in June, July or August), by the month of the birth

The mean BMI of the sample was 20.2 kg/m^2, with the median at 19.9 kg/m^2. Among the respondents with BMI from 19 to 24 kg/m^2 MCB was observed significantly more often (35.0% of cases; p=0.008) than among the respondents whose BMI was lower than 19 kg/m^2 (21.0 %) or higher than 24 kg/m^2 (17.7 %).

No statistically significant difference was found between the prevalence of MCB and the level of parents education, economic status of the family, having or not having a chronic disorder, self-assessed health status, the total sum score of BDI or any single item of BDI.

Living or not living together with one's parents and number of siblings showed the following tendencies of influence on MCB. From the total sample, 6.8% of the respondents did not live together with their own mothers, and they showed a 33.3% prevalence of MCB *versus* 28.6% showed by others. If in the total sample about one tenth of respondents were the only children in their families, and their prevalence of MCB was 22.4%, then those, who had 1 to 4 siblings, showed 31.0% prevalence of MCB; but among the 2.7% of the respondents who had more than 4 siblings, none had MCB.

In the total sample, 10.4% of respondents usually skipped their breakfast. The extent of MCB among them was greater (43.4% *versus* 28.4%; p=0.01) than among breakfast eaters (OR=0.2; 95% CI 0.065–0.656). A similar connection between MCB and eating lunch at school or not, was not observed. But the tendency to MCB was higher among the respondents who preferred to eat alone contrary to those who never did it, with prevalence of 32.8% *versus* 25.0% (OR 1.1; 95% CI 0.254–4.859). The respondents who could always share happiness with their mothers showed a 26.0% prevalence of MCB *versus* 39.2% of those who never did it (p=0.034). When the respondents were divided into three groups according to sharing of happiness and sadness with their parents as follows: 1) always or mostly, 2) sometimes, 3) seldom or never; a 22.2%; 28.5% and 41.2% (p=0.007) prevalence of MCB was found in the groups, respectively. In other words, the prevalence of MCB was highest among the girls who reported the lowest level of interconnection with their parents.

The respondents who always considered going to school to be enjoyable had their menarche close to their birthdays in 44.8% of cases *versus* 11.1% for those who never considered going to school to be enjoyable. However, the respondents who reported that they always received good marks at school, had the lowest, 18.2% prevalence of

MCB *versus* 28.9% and 33.0% of MCB of respondents who got good marks mostly or just sometimes.

DISCUSSION

The different annual rhythms of menarche that are reported in the literature on different cohorts of women, show the importance of the impact of socio-cultural and environmental aspects on the seasonality of menarche [9–13]. Comparing the current data with a study carried out in 1926 by H. Madisson, the current study showed, as it is seen on Figure 1, that menarche happened in summer months on an even more clear-cut pattern than 70 years ago. The 40% prevalence of MCB outcome in the current study is about the same (38.2%) as in a similar study carried out in Poland [14].

The fluctuation in the seasonal prevalence of menarche is congruent with school vacations in Estonia: traditionally summer holidays are the longest, lasting up to three months, until the first of September; in the beginning of November there is traditionally a week free from school, winter holidays last three weeks starting at Christmas and spring holidays in March are the shortest, lasting about a week. A significant connection between school vacation periods and peaks of menarche has also been reported previously [1]. Finding higher prevalence of MCB among the respondents whose birthday was during the period of school vacation could therefore be expected. As Figure 2 shows, all the peaks of menarche are in the months that include a vacation.

The most common environment of psycho-emotional impact on teenage girls, next to their family, is school. The current study showed that psychosocial distress is one of the factors influencing MCB. The respondents who assessed going to school as enjoyable had their MCB more frequently than their schoolmates who never did so. Always receiving good marks at school seemed to be a source of distress for respondents with an effect on MCB.

It is well known that nutritional status, more precisely sufficient adipose tissue is a factor associated with menarche. In the current study, the BMI of respondents at the time of onset of menarche is not known; however, a connection between the current BMI and MCB was seen. This leads to a hypothesis that underweight and overweight

makes the females' maturating process more sensitive to the influence of psychosocial factors.

The findings that those respondents, who skip their breakfast, who prefer to eat alone and/or who have a poor interconnection with their parents, have MCB more frequently than others, can just be an expression of greater social independence of these respondents from their mothers and families. The social independence explanation is supported by Shaw and Barker et al. who assert that skipping breakfast is a matter of individual choice [15, 16]. Naturally, the impact that a mother has on her daughter is multi-factorial. The primary goal of an adolescent in achieving adulthood is to establish independence from her parents. The need for privacy is also among the nearly universal characteristics of adolescence. Seeing that this independence-dependence struggle begins in early adolescence, these previously mentioned outcomes such as skipping breakfast and poor interconnection with one's mother characterise the achieved social and emotional independence.

In the studied sample more than one out of four had their month of menarche close their month of birth. So, it is possible to hypothesise that among the respondents with more prevalent MCB, there was less environmental distress or they were less sensitive to the distress to achieve the goal of social and emotional independence.

The study was limited in design, but hopefully it opened some new aspects that influence the maturation process of females. One of the limitations of the study was the lack of parental interviews, but these were not a part of the original study design.

CONCLUSION

The aim of the study was to follow the annual rhythms of menarche in Estonia, and it revealed much more pronounced seasonal rhythms of menarche among females born in early 1980s compared with their compatriots born at the beginning of 20th century. A significant impact of such biopsychosocial factors as body structure, interconnections inside family and school distress on the seasonal rhythms of menarche of Estonian females was observed. The respondents with under- and overweight showed higher sensitivity to psychosocial affective factors.

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Papers on Anthropology XI, 2002, pp. 71–80

DIFFERENCES IN ANTHROPOMETRIC AND PHYSICAL PERFORMANCE CHARACTERISTICS BETWEEN LIGHTWEIGHT AND OPEN CLASS ROWERS

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ABSTRACT

The purposes of this study were to: 1) compare the possible differences in anthropometric and metabolic variables between lightweight and open class rowers; and 2) find out how specifically anthropometric and metabolic characteristics are related to the performance parameters in the lightweight and open class rowers. Nine lightweight (20.4±4.7 yrs; 182.3±3.0 cm; 71.4±2.0 kg; % body fat: 10.0±1.3%) and eleven open class (21.6±3.0 yrs; 191.1±4.7 cm; 87.1±6.2 kg; %body fat: 10.5±2.6%) Estonian national level rowers were subjected to two exercise sessions on a rowing ergometer. An incremental exercise test to determine the anaerobic threshold (AT_4), maximal oxygen uptake (VO_{2max}) and maximal aerobic power (Pa_{max}), and a 2000 metre "all-out" test to evaluate the performance indices were performed. In addition, a sum of six skinfolds (Sum 6SF), muscle mass, skeletal mass and cross-sectional area of thigh as the anthropometric variables were determined. The anthropometric and metabolic characteristics of lightweight rowers were significantly lower than those in open class rowers. The results of a 2000 metre "all-out" test were significantly worse in lightweight rowers when compared with open class rowers. Lack of significant differences between the examined groups was observed in the measures of leannes (%body fat, Sum 6SF), relative VO_{2max} and heart rate at AT_4.

Key words: anthropometry, physical performance, rowing.

INTRODUCTION

The quantification of the physique of elite athletes is a relevant reference point in relating body structure and sports performance. The anthropometric profile of rowers has been reported to be closely related to the level of sports performance [1,12,19]. During the 2000 metre competition race, a rower has to make more than 200 times a stroke with a peak force of 800 to more than 1000 Newtons [21]. Rowing demands a high level of strength and endurance [7]. Except in competitions in the lightweight category (maximum body mass 72.5 kg), there is an advantage of rowers with a massive body build [7,12,19]. A high correlation has been reported between the competition results and specific anthropometric characteristics (e.g., body mass, muscle mass) in open class rowers [12,17].

Aerobic metabolism has been reported to supply 70–86% of the competition energy expenditure whereas the remaining energy is supplied by anaerobic sources [17]. It has been demonstrated that the maximal oxygen uptake (VO_{2max}) is well correlated with rowing performance [12,22,23]. When measured in absolute terms, the VO_{2max} value in open class rowers is high (6.0–6.6 $l.min^{-1}$) [19,21], but this is mainly due to their large body size [19]. The maximal oxygen uptake calculated per kg of body mass ($VO_{2max/kg}$) in rowers is not particularly high except in the lightweight rowers, whose $VO_{2max/kg}$ values may reach even 75 $ml.min.^{-1}kg^{-1}$ [19,21].

There has been a number of studies investigating the influence of anthropometric [12,17] and metabolic [12,23] variables to the performance characteristics in open class rowers. To our knowledge, there are not any studies which have investigated the effect of these variables to the performance characteristics in lightweight rowers. The specific aims of this investigation were to: 1) compare the possible differences in anthropometric and metabolic variables between lightweight and open class rowers; and 2) find out whether and how these variables are related to the performance parameters in the lightweight and open class rowers.

MATERIAL AND METHODS

Subjects

Twenty male experienced Estonian national level rowers volunteered to participate in this study. The rowers were divided into lightweight (n=9) and open class (n=11) according to their body mass. All rowers were training regularly and had being do so for the last 4.0±1.4 and 7.2±3.2 years, respectively. Measurements took place at the beginning of the fall season (i.e., in October). The rowers were familiarized with the laboratory procedures and possible risks before providing their informed consent to participate in the experiment. The protocol of this study has been approved by the Medical Ethics Committee of the University of Tartu. Each rower was tested at the same time of the day on two separate occasions over a two week period with at least three days between the tests. The rowers were asked to avoid any physical activity within 24 hours before testing and to abstain from eating for 3 hours before it.

Anthropometrics

The height (Martin metal anthropometer) and body weight (medical balance scale) of subjects were measured and body mass index (BMI, $kg.m^{-2}$) was calculated. The sum of six skinfold thicknesses (i.e., triceps, subscapular, abdominal, supraspinale, front-thigh, medial calf) (Sum 6SF) was measured (Holtain skinfold caliper, UK) [4]. Body density was determined according to the skinfold prediction equation of Durnin and Womersley [5], and the percent of body fat was then calculated from the body density according to the equation of Siri [20]. In addition, muscle mass was calculated according to Martin et al. [14], and the skeletal mass according to Martin [15]. The cross-sectional area (CSA) of thigh was estimated according to Hawes [9].

Testing procedures

All exercise tests were performed on a wind resistance braked rowing ergometer (Concept II, Morrisville, USA). The rowers were fully

familiarized with the use of this apparatus. Power and stroke frequency were delivered continuously by the computer display of the rowing ergometer. Heart rate (HR) was measured continuously and stored at 5 s intervals during all exercise tests (Sporttester Polar Vantage NV, Kempele, Finland).

At the first measurement session, a progressive incremental exercise test to maximal intensity was performed [12,16,23]. This was carried out for the determinations of VO_{2max} (in $l.min^{-1}$ and $ml.min.^{-1}kg^{-1}$), maximal aerobic power, defined as the mechanical power where VO_{2max} is reached (Pa_{max} in W), and the power corresponding to 4 $mmol.l^{-1}$ blood lactate (LA) concentration (AT_4 in W). The test started at 150 W and power was increased every three minutes by 50W until individual maximum was reached. Stroke rate during the test varied between 18 and 34 $strokes.min^{-1}$. Capillary blood samples for enzymatic determination of LA (Lange, Germany) [6] were taken from a fingertip during a 30 s rest interval following each work intensity [12,16,23]. Expired gas was sampled continuously during the test for the measurement of VO_2 (TrueMax 2400 Metabolic Measurement System, Parvo Medics, USA). The analysers were calibrated prior to the test using commercial gases of known concentration. To establish that VO_{2max} was reached the following criteria were used: attainment of a plateau in VO_2 with increasing work rate, or lack of this plateau, a respiratory exchange ratio exceeding 1.1, the end of exercise LA concentration higher than 9 $mmol.l^{-1}$, and/or a theoretical maximal HR [16]. The AT_4 was assessed by a linear interpolation from the LA versus work rate curves. The LA concentration in blood at 350 W (LA_{350W}) was used as a parameter of "rowing economy" [12].

At the second measurement session, the subjects were asked to cover a 2000 metre distance on a rowing ergometer in the least time possible (2000 metre "all-out" test). The time (T2000) and the mean power (P2000) of the 2000 metre "all-out" rowing ergometer test were recorded. The measurement session started with a 10 minutes warm-up exercise at 40–45% Pa_{max}.

Statistical methods

Descriptive statistics (mean±standard deviation [SD]) for each of the dependent variables were determined. Independent t-tests with an

error of estimate set to 0.05 were used to compare the measured variables between lightweight and open class rowers. Pearson Product Moment Correlation coefficients were used to determine the relationship between each of the anthropometric variables and physical performance characteristics in the lightweight and open class rowers (an alpha level of 0.05 was used).

RESULTS

Height, body mass, BMI, lean body mass (LBM), thigh CSA, muscle mass and skeletal mass were significantly lower in the lightweight rowers when compared with the open class rowers. There were no significant differences in the measures of Sum 6SF and %body fat between the groups examined (Table 1).

Table 1. Mean (±SD) anthropometric characteristics of lightweight and open class rowers.

Variable	Lightweight (n=9)	Open class (n=11)
Age (yrs)	20.4±4.7	21.6±3.0
Height (cm)	182.3±3.0	191.1±4.7*
Body mass (kg)	71.4±2.0	87.1±6.2*
BMI ($kg.m^{-2}$)	21.6±0.6	23.9±1.6*
Sum 6SF (mm)	44.9±7.0	50.8±15.6
Body fat (%)	10.0±1.3	10.5±2.6
LBM (kg)	64.5±2.4	79.1±5.2*
Thigh CSA (cm^2)	459.1±80.3	588.3±95.1*
Muscle mass (kg)	44.1±3.5	55.0±4.8*
Skeletal mass (kg)	10.1±0.5	12.1±0.9*

BMI = body mass index; Sum 6SF = sum of triceps, subscapular, biceps, suprailiac, supraspinale and mid-thigh skinfolds; LBM = lean body mass; CSA = cross-sectional area.
* Significantly different from lightweight rowers; $p<0.05$.

The absolute values of VO_{2max} (in $l.min^{-1}$) were significantly lower in lightweight rowers in comparison with the open class rowers, while no significant differences were found in the relative value of VO_{2max}

(in ml.min.$^{-1}$kg^{-1}) between the studied groups. Pa_{max}, AT_4 and P2000 were significantly lower in the lightweight rowers when compared with the open class ones. No significant differences between the groups were found in the value of AT_4 (beats.min^{-1}). Similarly, the values of T2000 and LA_{350W} were significantly worse in the lightweight rowers in comparison with the open class rowers (Table 2).

Table 2. Mean (±SD) physical performance characteristics of lightweight and open class rowers.

Variable	Lightweight (n=9)	Open class (n=11)
VO_{2max} (l.min^{-1})	4.38±0.33	4.99±0.48*
$VO_{2max/kg}$ (ml.min.$^{-1}$kg^{-1})	60.1±5.0	57.8±6.4
Pa_{max} (W)	339.4±14.9	383.5±32.5*
AT_4 (W)	254.1±15.2	295.7±35.7*
AT_4 (beats.min^{-1})	176.4±6.2	177.5±10.0
LA_{350W} (mmol.l^{-1})	14.5±0.9	9.1±3.9*
P2000 (W)	311.8±14.2	379.8±40.9*
T2000 (sec)	414.0±2.8	391.2±15.3*

VO_{2max} = maximal oxygen uptake; Pa_{max} = maximal aerobic power; AT_4 = anaerobic threshold; LA_{350W} = lactate at the power of 350W; P2000 = mean power of the 2000 metre "all-out" rowing; T2000 = time of the 2000 metre "all-out" rowing. *Significantly different from lightweight rowers; $p<0.05$.

Table 3 presents the correlation coefficients between different anthropometric and physical performance characteristics in the lightweight and open class rowers. AT_4 (W) was significantly related to the thigh CSA measures in the lightweight rowers and skeletal mass in the open class rowers. The VO_{2max} values (in l.min^{-1} and ml.min.$^{-1}$kg^{-1}) were significantly correlated with the skeletal mass in the lightweight rowers but not in the open class ones. Significant correlations were ascertained between %body fat and the $VO_{2max/kg}$ as well as LA_{350W} in the open class rowers. LBM and muscle mass significantly influenced the P2000 value in the lightweight rowers. Pa_{max} and T2000 were not significantly related with any anthropometrical variables in the lightweight and open class rowers (Table 3).

Table 3. Pearson correlations between different anthropometric and physical performance characteristics in lightweight and open class (in brackets) rowers.

Variable#	Height (cm)	Body mass (kg)	Body fat (%)	LBM (kg)	CSA thigh (cm^2)	Muscle mass (kg)	Skeletal mass (kg)
AT_4 (W)	–0.35 (0.60)	0.29 (0.04)	–0.66 (–0.50)	0.42 (0.23)	0.78* (0.60)	0.35 (0.33)	–0.48 (0.67*)
Pa_{max} (W)	–0.26 (0.55)	0.39 (–0.15)	–0.35 (–0.65)	0.50 (0.05)	0.56 (0.54)	0.51 (0.16)	–0.61 (0.59)
VO_{2max} ($l.min^{-1}$)	–0.38 (0.64)	0.12 (–0.12)	–0.54 (–0.60)	0.36 (0.05)	0.48 (0.64)	0.22 (0.03)	–0.76* (0.51)
$VO_{2max/kg}$ ($ml.min.^{-1}kg^{-1}$)	–0.16 (0.20)	–0.03 (–0.61)	–0.55 (–0.87*)	0.24 (–0.46)	0.51 (0.42)	0.05 (–0.46)	–0.73* (0.40)
LA_{350W} ($mmol.l^{-1}$)	–0.30 (–0.34)	–0.52 (0.16)	–0.20 (0.68*)	–0.39 (–0.03)	–0.22 (–0.55)	–0.50 (–0.12)	–0.20 (–0.42)
P2000 (W)	–0.04 (0.54)	0.56 (–0.03)	–0.27 (–0.53)	0.72* (0.17)	0.45 (0.54)	0.70* (0.29)	–0.44 (0.64)
T2000 (sec)	0.23 (–0.56)	–0.18 (0.08)	0.22 (0.59)	–0.40 (–0.12)	–0.37 (–0.44)	–0.39 (–0.21)	0.54 (–0.61)

#Abbreviations are the same as in Tables 1 and 2.
*Statistically significant; $p<0.05$.

DISCUSSION

The present findings are consistent with previous investigations when height, body mass and leanness in the national level lightweight [2,10,13] and open class [10,17,23] rowers were taken into account (see Table 1). Ideally, the rowers' body mass should contain a high proportion of muscle mass since rowing involves approximately 70% of the whole body muscle mass [19,21]. The results of our study demonstrated that both groups of rowers presented a relatively high amount of muscle mass (see Table 1). Consistent with Jensen's [10] investigation, the results of our study demonstrated that %body fat was similar in lightweight and open class rowers. However, in contrast to the present investigation, a number of the open class rowers examined had also a substantial amount of body fat [19]. In support to our findings, Hahn [8] suggested that successful open class rowers are

tall, heavy and possess a low value of the skinfold reading in comparison with less successful open class rowers (see Table 1).

The high correlations between performance prediction equations using only anthropometric parameters (e.g., height, body mass, muscle mass) and the time of 2000 metre rowing ergometer race [12,17] demonstrated that the specific anthropometric profile of rowers is highly related to the level of performance. In accordance with this, open class rowers presented a significantly higher amount of LBM, muscle mass and skeletal mass in comparison with lightweight rowers (see Table 1). Furthermore, de Rose et al. [3] found no differences in the anthropometric profile of male lightweight competitors from untrained student controls.

Taken together, as demonstrated in many studies, a typical open class rower is tall, heavy and relatively lean with a high amount of slow-twitch muscle fibres in working muscles [7,11,21]. The anthropometric characteristics of the lightweight rowers differ significantly from those of their heavier peers (see Table 1) [19]. A large muscle mass is achieved by the long hours of aerobic training combined with weight training and genetic inheritance [17,18,21]. Metabolic efficiency is also achieved by the long hours of specific training [17,18,21] as demonstrated by the high values of VO_{2max} indices of our lightweight and open class rowers (see Table 2).

The aerobic capacity indices were similar to those obtained in previous investigations in terms of VO_{2max} and AT_4 in the national level lightweight [2,10] and open class [10,16] rowers. The indices of absolute aerobic power were significantly higher in the open class rowers when compared with lightweight rowers, while no differences between these groups were found in the relative aerobic power index (see Table 2). This again demonstrates the importance of the large body size in rowing performance. However, considering the skill requirements of rowing, individuals with very similar levels of maximal aerobic power may differ widely in competitive performance [19,21].

In summary, the anthropometric and metabolic characteristics of lightweight rowers differ from those of open class rowers. However, both groups of rowers examined appeared to be very lean and have high maximal aerobic capacity.

ACKNOWLEDGEMENT

The authors would like to thank Drs Eve Pihl and Kalle Karelson for their assistance during this project.

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Papers on Anthropology XI, 2002, pp. 81–92

RELATIONSHIPS BETWEEN BIOELECTRIC IMPEDANCE AND SUBCUTANEOUS ADIPOSE TISSUE THICKNESS MEASURED BY LIPOMETER AND SKINFOLD CALIPERS IN CHILDREN

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ABSTRACT

The aim of this study was to compare the relationships between bioelectrical impedance and thicknesses of adipose tissue measured by traditional skinfold caliper (double thickness) or LIPOMETER device (single non-compressed thickness) in 9 to 12 year old boys (n=52) and girls (n=44). In total, 9 skinfolds (triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh, medial calf, mid-axilla) were measured. Measurement for the thickness of subcutaneous adipose tissue layers (SAT-layers) by LIPOMETER were performed at 15 body sites (neck, triceps, biceps, upper back, front chest, lateral chest, upper abdomen, lower abdomen, lower back, hip, front thigh, lateral thigh, rear thigh, inner thigh, calf). Body bioelectrical impedance was measured with a multiple-frequency impedance device Multiscan-5000 (Bodystat Ltd., UK). Impedance at 50 kHz highly correlated with body mass (r= –0.47 in boys, r= –0.46 in girls, r= –0.47 in total group). The relationship with body height was significant only in girls (r= –0.42). Skinfold thicknesses measured by caliper did not correlate significantly with body impedance at 50 kHz. SAT-layers measured by LIPOMETER at triceps, front thigh, lateral thigh and rear thigh sites in boys and at lateral thigh site in girls correlated significantly with body impedance measured at 50 kHz. Stepwise

multiple regression analysis indicated that the iliac crest and front thigh skinfold thicknesses measured by caliper characterized only 5.7–12.0% of the impedance at 50 kHz in total group (n=96). From the measured 15 SAT-layers, the most significant was lateral thigh layer which characterized 20.0%, 11.9% and 13.6% of the impedance at 50 kHz in boys, girls and total group, respectively. It was concluded that the influence of subcutaneous adipose tissue to the body impedance is relatively low in children. However, SAT-layers have a slightly higher influence to the body impedance than skinfold thicknesses measured by caliper. The sum of skinfolds or SAT-layers did not correlate with body impedance in any group.

INTRODUCTION

The assessment of body composition in childhood can be performed with several sophisticated techniques [4,6]. However, in many circumstances, it is more desirable to utilize widely available and simple techniques such as the measurement of subcutaneous adipose tissue thickness. This would allow relatively quick determination of body composition without the need for specialized laboratories or expensive equipment. On the other side, the variation in the relative distribution of adipose tissue is currently a topic of major interests in epidemiological analyses where the relationships between adipose tissue distribution and risk for certain diseases have been studied [10]. A new computerized optical system ("LIPOMETER") was developed in order to permit a non-invasive, quick, precise, and safe determination of subcutaneous adipose tissue (SAT) thicknesses at 15 specific body sites [12]. Subcutaneous adipose tissue topography (SAT-top) is measured during about two minutes which is quicker when compared with skinfold thickness measurements on 10 body sites with caliper. The LIPOMETER measures a single not compressed SAT.

The aim of this study was to compare the relationships between bioelectrical impedance and thicknesses of adipose tissue measured by traditional skinfold caliper or LIPOMETER device in 9 to 12 year old boys and girls. It was hypothesised that the relationship between body impedance and subcutaneous adipose tissue measured by two different methods (caliper-double compressed thickness, LIPOMETER – single non-compressed thickness) could be different, because they based on

different principles of measurement. There will be sex differences between used methods because the body dimensions, proportions and fat quantity and distribution are known to differ between boys and girls.

MATERIALS AND METHODS

The subjects of this study were 9-to 12-year-old boys (n=52) and girls (n=44). The children were from several schools in Tartu, Estonia (about 100,000 inhabitants) and all children were of Estonian origin. All children, parents and teachers were thoroughly informed about the purposes and contents of the study and written informed consent was obtained from the parents or the adult probands before participation. This study was approved by the Medical Ethics Committee of the University of Tartu (Estonia).

Measurements were performed in the morning after emptying bladder. All children had a light traditional breakfast. The children did not exercise before the testing. Stature was measured using a Martin metal anthropometer in cm (±0.1 cm) and body mass with medical scales in kg (±0.05 kg) and BMI (kg/m^2) was calculated.

Measurement of subcutaneous adipose tissue by skinfold calipers

In total, nine skinfolds (triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh, medial calf, mid-axilla) were measured according to the protocol recommended by the International Society for the Advancement of Kinanthropometry [14]. Skinfold thicknesses were measured in triplicate using Holtain (Crymmych, UK) skinfold caliper. The sum of nine skinfolds was calculated. For each skinfold, the mean of all three trials was taken as the final measurement. All measurements were taken by a well-trained anthropometrist.

Measurement of subcutaneous adipose tissue layers by LIPOMETER

Measurements were performed by means of the optical device LIPOMETER [12]. LIPOMETER uses light-emitting diodes, which illuminate the interesting subcutaneous adipose tissue layer (SAT-layer), forming certain geometrical patterns varying in succession. A photodiode measures the corresponding light intensities back scattered in the subcutaneous adipose tissue. These light signals are amplified, digitised and stored on computer. Measurement for the thickness of SAT-layers in mm were performed at 15 original body sites (neck, triceps, biceps, upper back, front chest, lateral chest, upper abdomen, lower abdomen, lower back, hip, front thigh, lateral thigh, rear thick, inner thigh, calf) on the right side of the body in standing position [12]. The sum of 15 SAT-layers was calculated.

Measurement of bioelectrical impedance

Body impedance was measured with a multiple-frequency impedance device (Multiscan 5000, Bodystat Ltd., UK). Children were placed in a supine position with limbs slightly abduced. Skin current electrodes were placed on the right dorsal surface at the hand and on foot at the metacarpals and metatarsals, respectively, after the skin was cleaned with 70% alcohol. The distance between the source and receiving electrodes was at all times greater than 5 cm [3]. All frequencies were analyzed, but only data at 5 kHz (as a measure of ECW), 50 kHz (as a measure of TBW) and 200 kHz (as a measure of ICW) were used. The analyzer was calibrated before each test by using a standard resistor provided by the manufacturer. All measurements (skinfold thicknesses by caliper and LIPOMETER and BIA) were performed on the same day and were completed within 1 h of the commencement of testing.

Statistical analysis

Statistical comparisons between boys and girls were made using independent t-tests. Pearson correlation coefficients were used to determine the relationships between dependent variables. The effect of different subcutaneous adipose tissue thicknesses measured by caliper

and LIPOMETER to the body impedance was analyzed by stepwise multiple regression analysis. Significance was set at $p<0.05$.

RESULTS

Physical characteristics of the children are presented in Table 1. There was not any statistically significant differences between boys and girls in the main anthropometrical parameters (body height, body mass and BMI). Mean subcutaneous adipose tissue thicknesses measured by skinfold caliper and LIPOMETER are presented in Table 2. There were not any significant differences in subcutaneous adipose tissue thicknesses and in the sum of 9 skinfold thicknesses measured by skinfold caliper between boys and girls. However, the subcutaneous adipose tissue measured by LIPOMETER in some sites (triceps, biceps, front chest, front thigh, lateral thigh, inner thigh) was significantly ($p<0.05$) thicker in girls compared with boys. Sum of 15 SAT-layers was not different between boys and girls. The mean body impedance values are presented in Table 3. In all three frequencies, the impedance was significantly higher in girls compared with boys.

There were significant relationships between body mass and all measured nine skinfold thicknesses (boys: r=0.41–0.63, girls: r=0.58–0.78, total group r=0.48–0.70). However, the SAT-layers measured by LIPOMETER were not significantly correlated with body mass in total group. In boys, SAT-layers at triceps, front thigh, lateral thigh, rear thigh and calf sites did not correlate significantly with body mass. However, the relationship was significant on the other measured layers sites (r=0.28–0.50). In girls, SAT-layers at front thigh, lateral thigh and calf sites did not correlate significantly with body mass, while the relationship was significant on the other measured layers sites (r=0.33–0.68). As a rule, body height was not significantly related to the subcutaneous adipose tissue thickness. Only in girls, most of the skinfold thicknesses measured by caliper correlated significantly with body height (r=0.31–0.43), except skinfold thicknesses measured at triceps, biceps and medial calf sites. BMI correlated significantly with all measured skinfold thicknesses in boys (r=0.58–0.79), girls (r=0.70–0.87) and total group (r=0.63–0.80). Similarly, most of the SAT-layers measured by LIPOMETER correlated significantly in boys (r=0.30–0.66), except front thigh and lateral thigh SAT-layer. In girls, all SAT-layers measured by

Table 1. Main physical characteristics in children

	Boys (n=52)		Girls (n=44)		Total (n=96)	
	Mean	SD	Mean	SD	Mean	SD
Age (years)	11.57	0.79	11.17	0.90	11.39	0.86
Body height (cm)	146.5	9.0	146.4	8.9	146.5	8.9
Body mass (kg)	39.8	6.6	37.9	7.4	38.9	7.0
BMI (kg/m^2)	17.5	1.9	17.0	2.3	17.3	2.1

Table 2. The subcutaneous adipose tissue thickness (mm) measured by skinfold caliper and LIPOMETER in children

	Boys (n=52)		Girls (n=44)		Total (n=96)	
	Mean	SD	Mean	SD	Mean	SD
SKINFOLD CALIPER						
Triceps	11.5	3.6	12.1	4.4	11.8	4.0
Subscapular	9.3	4.3	9.7	5.8	9.5	5.0
Biceps	7.2	2.8	7.9	3.7	7.6	3.2
Iliac crest	11.1	6.1	10.4	6.2	10.8	6.1
Supraspinale	6.8	3.5	7.1	4.7	6.9	4.0
Abdominal	11.7	6.4	10.6	6.2	11.2	6.3
Front thigh	18.8	6.4	19.9	6.3	19.3	6.4
Medial calf	14.3	4.8	14.4	4.9	14.3	4.8
Mid-axilla	6.7	2.9	7.0	4.4	6.8	3.6
Sum of 9 skinfolds	96.3	37.9	98.8	43.0	97.6	40.8
LIPOMETER						
Neck	2.8	2.8	3.2	2.8	3.0	2.8
Triceps	7.4	2.9	8.7	3.3*	8.0	3.1
Biceps	3.4	2.4	4.8	2.5*	4.0	2.5
Upper back	3.4	2.6	4.2	3.5	3.8	3.0
Front chest	5.6	4.4	6.1	4.9*	5.8	4.6
Lateral chest	2.9	2.9	3.6	4.7	3.2	3.8
Upper abdominal	5.5	4.9	6.3	6.1	5.9	5.5
Lower abdominal	6.7	4.6	7.0	5.1	6.8	4.8
Lower back	6.0	2.9	6.8	3.6	6.4	3.3
Hip	6.5	5.1	7.2	5.3	6.8	5.1
Front thigh	5.8	2.6	7.3	2.9*	6.5	2.8
Lateral thigh	6.0	2.7	7.2	2.3*	6.6	2.6
Rear thigh	4.6	2.1	4.6	2.0	4.6	2.1
Inner thigh	6.1	2.9	8.1	3.3*	7.0	3.2
Calf	3.6	1.4	3.6	1.8	3.6	1.6
Sum of 15 SAT-layers	74.6	39.4	88.2	45.2	82.2	42.3

* $p<0.05$ between boys and girls

Table 3. Body impedance measured at different frequencies in children

	Boys (n=52)		Girls (n=44)		Total (n=96)	
	Mean	SD	Mean	SD	Mean	SD
5 kHz (Ω)	604.9	79.5	647.4	56.0*	624.2	72.7
50 kHz (Ω)	562.3	63.7	599.4	50.5*	579.1	60.7
200 kHz (Ω)	509.5	58.6	545.2	45.2*	525.7	55.6

*$p<0.05$ between boys and girls

LIPOMETER were significantly related to BMI value (r=0.44–0.81), except lateral thigh SAT-layer. Pearson correlation coefficients between subcutaneous adipose tissue thicknesses measured by skinfold caliper or LIPOMETER correlated highly each other except between lateral thigh and supraspinale sites in girls. The sum of 9 skinfolds (caliper) correlated significantly with sum of 15 SAT-layers (LIPOMETER) both in boys (r=0.83) and girls (r=0.89)

Bioelectrical impedance at 50 kHz significantly correlated with body mass (r= –0.47 in boys, r= –0.46 in girls, r= –0.47 in total group) and BMI (r= –0.47 in boys and r= –0.48 in girls). The relationship between bioelectrical impedance at 50 kHz and body height was significant only in girls (r= –0.42). Pearson correlations between body impedance at three frequencies and adipose tissue thicknesses measured by skinfold caliper or LIPOMETER are presented in Table 4. Skinfold thicknesses measured by skinfold caliper did not correlate significantly with body impedance measured at all three frequencies. However, the SAT-layers measured by LIPOMETER at triceps, front thigh, lateral thigh and rear thigh in boys and in lateral thigh in girls correlated with body impedance measured at 50 kHz. The sum of 9 skinfolds and 15 SAT-layers did not correlate significantly with body impedance in any group (Table 4).

Stepwise multiple regression analysis indicated that only iliac crest and front thigh from the skinfold thicknesses measured by caliper significantly influenced body impedance at 50 kHz in total group (Table 5). These skinfold thicknesses characterized only 5.7–12.0% of the total variance (R^2 x 100). From the 15 SAT-layers, only two sites were selected for the regression models. The most important site was the lateral thigh layer which characterized 20.0%, 11.9% and 13.6% of the total variance in boys, girls and total group, respectively. In the second model, the different layers were added (hip in boys, lower abdominal in girls and neck in total group) in all three groups.

Table 4. Pearson correlations between body impedance and adipose tissue thicknesses in children

	Boys (n=52)			Girls (n=44)			Total (n=96)		
	5 kHz	50 kHz	200 kHz	5 kHz	50 kHz	200 kHz	5 kHz	50 kHz	200 kHz
SKINFOLD CALIPER									
Triceps	–0.02	0.17	0.17	–0.06	–0.11	–0.07	0.09	0.07	–0.08
Subscapular	–0.32**	–0.02	–0.02	–0.05	–0.11	–0.09	–0.03	–0.04	–0.17
Biceps	–0.20	0.09	0.09	–0.10	–0.17	–0.14	0.03	0.01	–0.10
Iliac crest	–0.26	–0.01	–0.01	–0.19	–0.26	–0.23	–0.11	0.01	–0.04
Supraspinale	–0.24	0.02	0.02	–0.21	–0.26	–0.24	–0.07	–0.09	–0.19
Abdominal	–0.23	0.07	0.08	–0.16	–0.25	–0.23	–0.06	–0.07	–0.22*
Front thigh	–0.07	0.19	0.12	–0.05	–0.11	–0.08	0.12	–0.12	–0.24*
Medial calf	–0.17	0.06	0.08	–0.11	–0.14	–0.11	0.01	–0.01	–0.14
Mid-axilla	–0.30*	–0.06	–0.06	–0.15	–0.20	–0.18	–0.08	–0.10	–0.19
Sum of 9 skinfolds	0.11	0.07	0.09	–0.16	–0.20	–0.18	0.08	–0.16	0.20
LIPOMETER									
Neck	–0.29*	0.17	0.17	–0.08	–0.13	–0.10	0.09	0.07	-0.18
Triceps	0.17	0.37**	0.39**	0.01	–0.04	0.01	0.28**	0.24*	0.16
Biceps	0.07	0.22	0.25	–0.19	–0.14	–0.09	0.19	0.16	0.06
Upper back	–0.17	0.14	0.15	–0.03	–0.09	–0.06	0.09	0.07	–0.05
Front chest	–0.11	0.17	0.19	0.05	0.02	0.05	0.14	0.12	-0.03
Lateral chest	–0.20	0.02	0.03	–0.14	–0.18	–0.14	–0.02	–0.05	0.12
Upper abdominal	–0.18	0.05	0.06	–0.03	–0.10	–0.07	0.03	0.01	–0.08
Lower abdominal	–0.02	0.13	0.14	–0.14	–0.20	–0.16	0.03	0.01	–0.05
Lower back	0.05	0.21	0.23	–0.13	–0.19	–0.16	0.09	0.07	0.01
Hip	–0.10	0.07	0.08	–0.14	–0.19	–0.17	0.01	–0.01	–0.08
Front thigh	0.29*	0.37**	0.39**	0.26	0.23	0.24	0.38	0.36**	0.32**
Lateral thigh	0.30*	0.45**	0.46**	0.38*	0.34*	0.35*	0.46**	0.45**	0.34**
Rear thigh	0.29*	0.37**	0.37**	0.22	0.19	0.22	0.30*	0.34**	0.40**
Inner thigh	0.14	0.23	0.25	0.09	0.04	0.06	0.11	0.12	0.17
Calf	0.11	0.15	0.16	–0.01	–0.06	–0.04	0.08	0.10	0.10
Sum of 15 SAT-layers	0.09	0.25	0.19	0.08	–0.06	0.20	0.04	0.16	0.11

* P<0.05 **P<0.01

Table 5. Stepwise multiple regression analysis for impedance at 50 kHz dependent on subcutaneous adipose tissue thicknesses measured by skinfold caliper and LIPOMETER

Step and variable	Group	Regression equation for impedance at 50 kHz (Ω)	R	R^2 x 100	SEE
SKINFOLD CALIPER					
1. Iliac crest	Total	–2.86 iliac crest + 655.1	0.24	5.7	71.7
2. Front thigh		–6.78 iliac crest + 4.75 front thigh + 605.95	0.35	12.0	69.6
LIPOMETER					
1. Lateral thigh	Boys	10.54 lateral thigh + 498.82	0.45	20.0	57.5
2. Hip		15.05 lateral thigh – 3.98 hip + 497.32	0.51	26.3	55.7
1. Lateral thigh	Girls	7.40 lateral thigh + 546.25	0.35	11.9	47.9
2. Lower abdominal		11.45 lateral thigh – 4.22 lower abdominal + 546.77	0.52	26.9	44.2
1. Lateral thigh	Total	10.30 lateral thigh + 556.73	0.37	13.6	67.9
2. Neck		15.84 lateral thigh – 11.23 neck + 554.43	0.54	28.8	62.0

DISCUSSION

In our study, the subcutaneous adipose tissue thicknesses were measured using two different methods — traditional skinfold thickness measurement using skinfold caliper and a new LIPOMETER. However, the anatomical points of the measurement were different according to the ISAK and LIPOMETER standard recommendations. Surprisingly, the relationship between subcutaneous adipose tissue thicknesses measured by these two methods at the same anatomical points was not higher than between other measured points. Only correlations at the triceps (r=0.80, r=0.82, r=0.80 in boys, girls and total group, respectively), subscapular — upper back (r=0.87, r=0.89, r=0.88) and abdomen — lower abdomen (r=0.82, r=0.86, r=0.88) were slightly higher than the correlations between other measured anatomical points. The relationships between boys and girls are very similar and are in good agreement with Malina and Bouchard [9], who have indicated that the relative distribution of trunk and extremity subcutaneous fat during childhood is rather stable and the ratio of trunk to extremity skinfold thickness is similar in boys and girls. Furthermore, the triceps and subscapular skinfolds are frequently recommended to use for the measurement of body composition in children [1,13].

Theoretically, all SAT-layers measured by LIPOMETER (single non-compressed thickness) should be approximately two times thinner than skinfold thicknesses measured by caliper (double compressed thickness). However, in this study, differences were quite different depending on the measurement site (see Table 2). Probably, these differences depend on the mistakes palpating correctly specific anatomical points as well as all the possible mistakes what are related with calipers use.

BIA results are highly dependent on the conductor's length (i.e., the subject's height). In our study, the relationship between body height and impedance was significant only in girls. Probably, body height is not the true conductor length when using the four-electrode wrist-to-ankle BIA method. The true length of the conductor could be better represented by the acromial height and the arm length [7].

One hypothesis tested in this study was that the different relationship between body impedance and subcutaneous adipose tissue measured by two different methods. This hypothesis was only partially upheld. The main influencing anthropometric parameter to the body

impedance was high in both boys and girls using caliper and LIPOMETER methods. However, the subcutaneous adipose tissue on the thigh region characterized maximally 20% of the total variance. Our results are partially in agreement with previous studies, which have indicated that the main influencing factors to the body impedance are arm and leg [8]. The human body as a conductor is highly anisotropic, especially in the trunk region, which additionally leads to an indication that the relationship between whole body impedance and the conductor volume is not strictly linear [2]. Our results confirm the fact that the thinner segments of the body (i.e., legs) provide greatest impedance especially when they are also tall [5]. Finally, the differential compression of adipose tissue and gender differences of skin thickness is well known [11].

In summary, the influence of subcutaneous adipose tissue to the body impedance is relatively low. However, the single SAT-layers have slightly higher influence to the body impedance than skinfold thicknesses measured by caliper. Finally, the sum of skinfolds or SAT-layers not correlated significantly with body impedance in boys, girls and total group.

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Papers on Anthropology XI, 2002, pp. 93–112

SEXUAL DIMORPHISM: 22 DERMATOGLYPHIC TRAITS IN FIVE ENDOGAMOUS POPULATIONS OF WEST BENGAL, INDIA

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ABSTRACT

Five hundred families from five different endogamous populations, which encompass the main social rank in the caste hierarchy of West Bengal, India, were analysed for the present report. With the aim of comparing dermatoglyphic sexual dimorphism among the groups, analysis of variance and principal component analysis were performed, based on 22 dermatoglyphic variables. Sex dimorphism is homogeneous in nature in all populations, indicating common characteristics of dermatoglyphic variables within the same geographic area. But sex differences display different levels when compared with other racial groups; therefore, sex differences are different in diverse populations. This would explain the existence of the possible role of environmental prenatal factors in the realisation of the level of dermatoglyphic sex differences. A common feature of the principal component factor 1, "digital pattern size factor", in diverse populations indicates its degree of universality, and suggests that the variability of finger ridge counts is determined by the same genes which control the pattern types. The nature of variation of these components among these populations and between sexes, appears with a good similarity which suggests their biological validity of the underlying component structure.

Key words: quantitative dermatoglyphics sexual dimorphism, endogamous populations, West Bengal, India.

INTRODUCTION

In studies among various racial samples based on sex-differences in dermatoglyphic characters, females almost universally differ from males (see among others, Cummins & Midlo, 1961; Schauman & Alter 1976). Compared to males they show narrower ridges, lower frequencies of whorls and radial loops, and higher frequencies of arches and ulnar loops on the fingertips. On palmar features, females have patterns most frequently on the hypothenar and the interdigital areas than males. However, from several studies it is also known that these distinctions may be equal or even reversed in some populations (Geipel, 1935, Cummins and Midlo 1961, Holt 1968, Schauman and Alter 1976, Loesch and Martin 1984, Kobyliansky and Micle 1987, 1988, 1989; Micle and Kobyliansky 1988, 1991). Furthermore, Schwidetzky and Jantz 1979 have demonstrated that sexual dimorphism differs in diverse populations associated with race in the context of total finger ridge-count. It is known from several recent studies, that females have higher correlations for various dimensions and developmental events than males do (Mavalwala 1962; Brehme 1966; Palti et al. 1975; Jantz 1977). The prenatal sex-differences in environmental sensitivity may be significant with respect to dermatoglyphic sexual dimorphism since dermatoglyphics are formed in the early period ($3–4^{th}$ fetal months) of intrauterine development (Micle and Kobyliansky 1991). The studies on dermatoglyphic sexual dimorphism in Indian populations are very scanty and therefore, the purpose of the present study is to estimate male-female dermatoglyphic dimorphism among five caste populations of India.

MATERIAL AND METHODS

The subjects under study belong to five endogamous population groups of West Bengal from 500 families (100 each). Details of the samples, ethnohistoric background of the populations and detailed procedures of evaluation of dermatoglyphic traits have been described in papers by Karmakar et al. (2001 and 2002). Herein, we provide only information directly related to the aim of the present study. However, for the sake of convenience, the names of populations, their abbreviations and population-wise sample sizes are presented in Table 1 and 22 dermatoglyphic traits in Appendix 1.

Table 1. Sample description

Populations	Abbreviation	No. of familes	No. of individuals
Brahmin (Rarhi)	BR	100	449
Mahisya	MA	100	504
Padmaraj	PA	100	525
Muslim (Sunni)	MU	100	555
Lodha	LO	100	402
Total		500	2435

Statistical procedures, namely analysis of variance (ANOVA) and principal component analysis (PCA), were applied. ***ANOVA***: Test was used for assessment of significance of the group differences between quantitative traits. It generates a set of transformed variables to test between and within subject effects (through the proportion of group-means), and obtained F-value indicates that the population means are probably unequal. ***PCA***: multivariate analysis was performed by comparing the matrices of the correlations for each population and sex to identify the simultaneous relationships among variables. A quantitative comparison between similar matrices is accompanied by PCA, which transforms complex variable sets of diverse relationships into a small number of components or factors (data reduction) in order to explain total variation in the data. The factors link together the seemingly unrelated variables (investigate interdependence of the data) and consequently provide insight into the underlying biological interpretations. The first component represents the greatest part of the variance, while the other components express an increasingly smaller

part of the remaining variance. The results of the analysis were evaluated following orthogonal varimax rotation of the extracted factors. ***BMDP*** statistical software (Dixon 1983) was used for these analyses and data were processed at the Tel Aviv University Computer Centre, Israel, and at the Indian Statistical Institute, India.

RESULTS

ANALYSIS OF VARIANCE: Dermatoglyphic Sexual dimorphism based on 22 variables: The following results of one way analysis of variance (ANOVA) tests for sex differences among 5 populations in respect of 22 quantitative traits are presented in Tables 2–6.

FINGERS: (a) Finger ridge-counts (10 indices): It appears from the tables that in all the populations males show greater mean values than females; however, sex-differences are not statistically significant in each of the 10 finger ridge count variables. It appears from the tables that in all the populations, very marginal variations are (higher in males) if mean distribution and between males and females which clearly indicate homogeneity of sex-difference. However, there exists only the exception on the 1st finger ridge-count, which is significantly different in all 5 populations between sexes.

(b) TFRC & ATFRC (2 indices): Total and absolute ridge counts have higher mean values in males than in females and the sex-differences are statistically significant in the populations except BR and MU.

(c) PII (3 indices): Pattern intensity indices in all five populations have higher mean values in males than in females and differ significantly in BR, MA and PA, while MU and LO are homogeneous.

PALMS: (a) a-b ridge-counts (2 indices): Higher mean values of a-b ridge count in males in MA and LO; in females only in MU; and homogeneity in BR and PA. The only significant sex difference is revealed in MA.

(b) Main line (A & D) termination (4 indices): Larger mean values are evident in A&D line termini in males than in females, except MA and MU (in line A); and PA (in line D). The sex differences are not at the significant level.

Table 2. Comparison of 22 quantitative traits and indices in males and females, by ANOVA method. **Brahmin**

Variables	Males		Females		Sex differences	
	Mean	SD	Mean	SD	F ratio	Sign.(P)
Finger RC, I-r	15.75	5.78	14.06	6.55	8.14	0.00
Finger RC, II-r	10.03	6.20	10.00	6.14	0.00	0.96
Finger RC, III-r	11.47	5.43	11.12	5.01	0.49	0.48
Finger RC, IV-r	14.83	5.70	14.23	5.93	1.16	0.28
Finger RC, V-r	12.20	5.34	11.37	4.93	2.87	0.09
Finger RC, I-l	13.87	5.38	12.13	5.81	10.89	0.00
Finger RC, II-l	9.65	6.05	9.57	5.97	0.02	0.89
Finger RC, III-l	12.11	5.71	10.94	5.75	4.64	0.03
Finger RC, IV-l	14.46	5.41	13.50	5.89	3.20	0.07
Finger RC, V-l	11.47	5.03	10.18	4.75	7.78	0.01
Total RC	124.89	44.67	116.43	44.69	4.00	0.05
Absolute RC	162.70	79.94	148.79	76.63	3.51	0.06
PII, lh	6.35	1.90	6.18	2.06	0.80	0.37
PII, rh	6.63	1.79	6.24	1.87	5.17	0.02
PII, both h	12.98	3.51	12.42	3.67	2.73	0.10
a-b RC, rh	36.66	6.50	36.86	5.66	0.12	0.73
a-b RC, lh	37.66	5.86	37.41	5.64	0.22	0.64
A-line exit l	3.01	0.97	3.13	0.87	1.76	0.18
A-line exit r	3.21	0.97	3.23	0.86	0.04	0.83
D-line exit l	3.98	1.47	3.81	1.44	1.65	0.20
D-line exit r	4.78	1.49	4.56	1.53	2.32	0.13
Main line index	7.50	1.80	7.37	1.71	0.61	0.43

* The differences are statistically significant when $P<0.05$

Table 3. Comparison of 22 quantitative traits and indices in males and females, by ANOVA method. **Mahisya**

Variables	Males		Females		Sex differences	
	Mean	SD	Mean	SD	F ratio	Sign.(P)
Finger RC, I-r	16.14	5.74	14.32	5.45	13.01	0.00
Finger RC, II-r	11.17	6.13	10.23	5.52	3.20	0.07
Finger RC, III-r	11.48	5.43	11.28	5.22	0.18	0.67
Finger RC, IV-r	14.96	5.12	14.20	5.40	2.61	0.11
Finger RC, V-r	13.06	4.67	12.07	4.56	5.70	0.02
Finger RC, I-l	14.55	5.57	13.12	5.11	8.85	0.00
Finger RC, II-l	10.53	5.84	10.18	5.92	0.44	0.51
Finger RC, III-l	11.78	5.67	10.86	5.85	3.19	0.07
Finger RC, IV-l	14.59	5.01	13.62	5.29	4.43	0.04
Finger RC, V-l	12.35	4.20	11.41	4.54	5.71	0.02
Total RC	129.87	41.71	121.01	42.31	5.55	0.02
Absolute RC	178.63	82.78	162.70	78.39	4.86	0.03
PII, lh	6.92	2.02	6.74	2.13	0.93	0.34
PII, rh	7.07	1.92	6.64	1.96	5.98	0.01
PII, both h	13.99	3.79	13.39	3.89	3.09	0.08
a-b RC, rh	37.10	5.28	36.32	5.15	2.77	0.10
a-b RC, lh	37.77	5.69	36.57	5.08	6.13	0.01
A-line exit l	3.05	0.82	3.03	0.72	0.09	0.77
A-line exit r	3.26	0.90	3.19	0.83	0.82	0.37
D-line exit l	3.90	1.34	3.67	1.46	3.55	0.06
D-line exit r	4.51	1.47	4.30	1.59	2.36	0.13
Main line index	7.36	1.63	7.08	1.66	3.52	0.06

* The differences are statistically significant when $P<0.05$

Table 4. Comparison of 22 quantitative traits and indices in males and females, by ANOVA method. **Padmaraj**

Variables	Males		Females		Sex differences	
	Mean	SD	Mean	SD	F ratio	Sign.(P)
Finger RC, I-r	15.21	5.51	12.88	6.00	21.47	0.00
Finger RC, II-r	9.95	5.45	9.98	5.63	0.00	0.94
Finger RC, III-r	11.25	5.12	10.26	4.87	5.07	0.02
Finger RC, IV-r	14.04	4.90	13.02	5.87	4.68	0.03
Finger RC, V-r	12.20	4.33	11.09	4.71	7.84	0.01
Finger RC, I-l	13.31	5.42	11.70	5.53	11.36	0.00
Finger RC, II-l	9.92	5.44	8.73	5.83	5.89	0.02
Finger RC, III-l	11.29	5.36	10.22	5.64	4.97	0.03
Finger RC, IV-l	13.91	5.18	12.52	5.80	8.38	0.00
Finger RC, V-l	12.03	4.42	10.84	4.59	9.16	0.00
Total RC	122.85	38.95	111.24	43.56	10.39	0.00
Absolute RC	164.75	75.17	148.82	78.06	5.66	0.02
PII, lh	6.68	1.98	6.43	2.26	1.71	0.19
PII, rh	6.85	1.91	6.45	2.11	5.07	0.02
PII, both h	13.53	3.72	12.89	4.20	3.41	0.07
a-b RC, rh	38.22	5.29	38.39	5.31	0.14	0.70
a-b RC, lh	38.40	5.85	37.69	5.66	1.96	0.16
A-line exit l	3.00	0.68	2.94	0.86	0.73	0.39
A-line exit r	3.87	1.04	3.96	1.08	0.88	0.35
D-line exit l	3.84	1.37	3.91	1.52	0.28	0.60
D-line exit r	4.51	1.57	4.74	1.50	2.79	0.10
Main line index	7.61	1.72	7.77	1.87	1.11	0.29

* The differences are statistically significant when $P<0.05$

Table 5. Comparison of 22 quantitative traits and indices in males and females, by ANOVA method. **Muslim**

Variables	Males		Females		Sex differences	
	Mean	SD	Mean	SD	F ratio	Sign.(P)
Finger RC, I-r	15.54	5.64	13.76	5.29	14.70	0.00
Finger RC, II-r	10.77	6.12	10.85	6.07	0.02	0.88
Finger RC, III-r	11.37	5.34	11.27	5.22	0.05	0.82
Finger RC, IV-r	14.11	5.11	14.06	5.36	0.01	0.91
Finger RC, V-r	11.93	4.63	11.49	4.51	1.26	0.26
Finger RC, I-l	13.93	5.92	12.41	5.14	10.36	0.00
Finger RC, II-l	10.33	5.86	10.17	5.96	0.10	0.75
Finger RC, III-l	11.68	5.30	11.27	5.87	0.74	0.39
Finger RC, IV-l	14.22	5.08	13.80	5.51	0.88	0.35
Finger RC, V-l	11.82	4.25	11.51	4.36	0.73	0.39
Total RC	125.66	42.79	120.45	43.14	2.04	0.15
Absolute RC	171.86	79.81	163.81	77.50	1.45	0.23
PII, lh	6.89	1.98	6.88	2.07	0.00	0.96
PII, rh	7.03	1.84	6.86	1.92	1.16	0.28
PII, both h	13.91	3.62	13.74	3.77	0.30	0.58
a-b RC, rh	36.98	5.28	37.38	5.44	0.77	0.38
a-b RC, lh	36.69	5.32	37.13	5.44	0.92	0.34
A-line exit l	2.76	1.14	2.73	1.12	0.09	0.77
A-line exit r	3.93	1.14	3.86	1.12	0.56	0.46
D-line exit l	3.94	1.51	3.92	1.57	0.01	0.92
D-line exit r	4.76	1.53	4.52	1.56	3.14	0.08
Main line index	7.69	1.96	7.52	2.11	0.97	0.32

* The differences are statistically significant when $P<0.05$

Table 6. Comparison of 22 quantitative traits and indices in males and females, by ANOVA method. **Lodha**

Variables	Males		Females		Sex differences	
	Mean	SD	Mean	SD	F ratio	Sign.(P)
Finger RC, I-r	18.10	5.15	15.45	4.41	30.86	0.00
Finger RC, II-r	11.67	5.02	11.25	4.53	0.79	0.37
Finger RC, III-r	12.92	3.83	12.02	3.99	5.25	0.02
Finger RC, IV-r	13.91	4.46	13.76	4.31	0.11	0.74
Finger RC, V-r	11.61	4.01	10.63	3.95	6.11	0.01
Finger RC, I-l	15.59	4.59	13.55	4.59	19.73	0.00
Finger RC, II-l	10.68	5.06	10.28	4.61	0.68	0.41
Finger RC, III-l	12.35	4.37	11.58	4.15	3.35	0.07
Finger RC, IV-l	13.21	4.20	12.91	3.98	0.55	0.46
Finger RC, V-l	11.21	4.18	10.02	3.84	8.87	0.00
Total RC	131.26	34.17	121.08	30.98	9.77	0.00
Absolute RC	172.89	64.93	156.54	58.33	7.03	0.01
PII, lh	6.86	1.71	6.81	1.61	0.08	0.78
PII, rh	6.98	1.59	6.71	1.52	3.14	0.08
PII, both h	13.84	3.12	13.52	2.90	1.14	0.29
a-b RC, rh	38.78	5.13	38.70	5.79	0.02	0.88
a-b RC, lh	38.20	5.61	38.06	5.34	0.06	0.80
A-line exit l	2.97	0.76	3.00	0.72	0.16	0.69
A-line exit r	4.03	1.02	3.93	1.06	1.02	0.31
D-line exit l	3.73	1.40	3.56	1.42	1.45	0.23
D-line exit r	4.44	1.53	4.31	1.62	0.66	0.42
Main line index	7.60	1.70	7.40	1.73	1.29	0.26

* The differences are statistically significant when $P<0.05$

(c) MLI (1 index): No significant sex-difference is detected in the main line index although mean values are higher in males than in females, except PA

PRINCIPAL COMPONENT ANALYSIS (PCA): The principal factors were obtained from the correlation matrices of the 22 quantitative dermatoglyphic variables. Four principal factors were extracted, when the order of their extraction coincided with the decreasing order of the portion of the total variance accounted by each factor and are presented in Tables 7–11 for 5 populations. *Factor 1* includes the ridge counts of individual fingers, total and absolute ridge counts and the pattern intensity index in males and females among 5 populations. This factor may be called "digital pattern size factor" and has high loadings. This factor is the first one extracted, and in comparison with the other factors is responsible for the greatest part of the total variance. This variance between males and females in 5 populations are almost similar. The highest variance in males 47.9% (in MU) and the lowest 43.4% (in LO), while in females 48.5% (in MA, PA) and 40.6% (in LO). *Factor 2* in all the groups describes the terminations of palmar main lines A and D, main line index and also a-b ridge counts in both sexes. This factor may be called "palmar main lines factor" and has a minimum difference between the sexes, where males show higher loadings than females. This factor explains the highest variance in males, 14.8% (in MA, MU) and the lowest 14.2% (in PA, LO), while in females 16.4% (in MU) and 14.0% (in MA), respectively. *Factor 3* includes the most dominating variable a-b ridge counts in all the groups and may be called "a-b ridge counts factor". This factor also has in common high loadings for some of the variables (PII. finger ridge counts on I, IV, V, MLI, A and D lines endings etc.) as in the first and second factors which are not equal in males and females (higher loadings in males than in females). The highest variance 9.1% (in BR) and the lowest 7.2% (in MU) in males; while in females 7.5% (in MA) and 6.8% (in PA), respectively. *Factor 4* has high loadings for almost the same variables as in factor 3, which accounts for the finger and palmar traits. This factor may be called "Finger pattern diversity factor" and the sex difference is very similar. The highest variance in males, 5.3% (in PA) and the lowest 4.7% (in BR), while in females 5.4% (in LO) and 4.5% (in MU), respectively. The aforementioned 4 factors explains the highest, 75.2% (in BR) and the lowest, 70.9% (in LO) of the total cumulative variance in males, while 76.0% (in MU) and 67.6% (in LO) in females.

Table 7. Rotated factor loadings — 22 quantitative dermatoglyphic traits[1]. **Brahmin**

	Males					Females			
	Factor					Factor			
Trait	I	II	III	IV	Trait	I	II	III	IV
Total RC	.99	–	–	–	Total RC	.99	–	–	–
Absolute RC	.98	–	–	–	Absolute RC	.98	–	–	–
PII both h	.89	–	–	–	PII both h	.92	–	–	–
PII rh	.86	–	–	–	Finger RC, III-r	.87	–	–	–
Finger RC, III-l	.85	–	–	–	PII rh	.87	–	–	–
PII lh	.84	–	–.25	–	PII lh	.85	–	–	–
Finger RC, II-l	.83	–	–	–	Finger RC, IV-l	.82	–	–	–
Finger RC, II-r	.82	–	–	–	Finger RC, II-r	.81	–	–	–
Finger RC, IV-l	.81	–	–	–	Finger RC, IV-r	.81	–	–	–
Finger RC, III-r	.81	–	–	–	Finger RC, III-l	.79	–	–	–
Finger RC, V-l	.79	–	–	–	Finger RC, II-l	.78	–	–	–
Finger RC, V-r	.77	–	–	–	Finger RC, V-r	.77	–	–	–
Finger RC, IV-r	.77	–	–	–.27	Finger RC, V-l	.73	–	–	–
Finger RC, I-l	.71	–	–	.33	Finger RC, I-r	.73	–	–	–
Finger RC, I-r	.63	–	.27	–	Finger RC, I-l	.71	–	–	–
MLI	–	.96	–	–	MLI	–	.95	.25	–
A-line, l	–	.76	–	.40	A-line, r	–	.74		.44
A-line, r	–	.72	–	.47	D-line, l	–	.70	.27	–.37
D-line, l	–	.70	.42	–.31	A-line, l	–	.69		.56
D-line, r	–	.66	.46	–.31	D-line, r	–	.66	.35	–.40
a-b RC, r	–	–.28	.78	–	a-b RC, r	–	-.39	.75	–
a-b RC, l	–	–.31	.75	–	a-b RC, l	–	-.44	.73	–
V.P.	10.34	3.16	2.00	1.03	V.P.	10.47	3.25	1.50	1.10
Cum. var.	47.0	61.4	70.5	75.2	Cum. var.	47.6	62.3	69.2	74.2

[1] Loading values below 0.25 are omitted. The V.P. is the variance explained by each factor. Cum. var. is the cumulative proportion of explained variance.

Table 8. Rotated factor loadings – 22 quantitative dermatoglyphic traits[1]. **Mahisya**

	Males					Females			
	Factor					Factor			
Trait	I	II	III	IV	Trait	I	II	III	IV
Total RC	.99	–	–	–	Total RC	.99	–	–	–
Absolute RC	.98	–	–	–	Absolute RC	.97	–	–	–
PII both h	.91	–	–	–	PII both h	.93	–	–	–
PII lh	.88	–	–	–	PII lh	.88	–	–	–
PII rh	.88	–	–	–	PII rh	.88	–	–	–
Finger RC, III-l	.87	–	–	–	Finger RC, III-r	.87	–	–	–
Finger RC, III-r	.85	–	–	–	Finger RC, III-l	.86	–	–	–
Finger RC, II-l	.83	–	–	–	Finger RC, IV-l	.85	–	–	–
Finger RC, II-r	.81	–	–	–	Finger RC, II-l	.84	–	–	–
Finger RC, IV-l	.81	–	–	–	Finger RC, IV-r	.82	–	–	–
Finger RC, IV-r	.73	–	–	.37	Finger RC, II-r	.80	–	–	–
Finger RC, V-r	.72	–	–	.33	Finger RC, V-l	.77	–	–	–
Finger RC, V-l	.71	–	–	–	Finger RC, V-r	.75	–	–	–
Finger RC, I-l	.69	–	–	–	Finger RC, I-l	.68	–	–	–
Finger RC, I-r	.65	–	–	–	Finger RC, I-r	.67	–	–	–
MLI	–	.96	.26	–	MLI	–	.97	–	–
A-line, r	–	.74	–	.44	D-line, l	–	.73	–	–.40
A-line, l	–	.72	–	.34	D-line, r	–	.72	.25	–.42
D-line, r	–	.68	.41	–	A-line, r	–	.70	–	.54
D-line, l	–	.68	–	–.44	A-line, l	–	.64	–	.61
a-b RC, l	–	–.37	.82	–	a–b RC, r	–	–.26	.87	–
a-b RC, r	–	–.42	.81	–	a-b RC, l	–	–.31	.85	–
V.P.	10.21	3.25	1.65	1.09	V.P.	10.67	3.09	1.65	1.18
Cum. var.	46.4	61.2	68.7	73.6	Cum. var.	48.5	62.5	70	75.4

[1] Loading values below 0.25 are omitted. The V.P. is the variance explained by each factor. Cum. var. is the cumulative proportion of explained variance.

Table 9. Rotated factor loadings — 22 quantitative dermatoglyphic traits[1]. **Padmaraj**

	Males					Females			
	Factor					Factor			
Trait	I	II	III	IV	Trait	I	II	III	IV
Total RC	.98	–	–	–	Total RC	.99	–	–	–
Absolute RC	.97	–	–	–	Absolute RC	.97	–	–	–
PII both h	.90	–	–	–	PII both h	.91	–	–	–
PII rh	.86	–	–	–	PII lh	.88	–	–	–
PII lh	.85	–	–	–	PII rh	.87	–	–	–
Finger RC, IV-l	.81	–	–	–.34	Finger RC, IV-r	.86	–	–	–
Finger RC, II-l	.81	–	–	–	Finger RC, IV-l	.85	–	–	–
Finger RC, III-l	.80	–	–	–	Finger RC, III-l	.84	–	–	–
Finger RC, II-r	.79	–	–	–	Finger RC, III-r	.83	–	–	–.26
Finger RC, III-r	.78	–	–	–	Finger RC, II-r	.82	–	–	–.27
Finger RC, IV-r	.77	–	–	–.36	Finger RC, II-l	.80	–	–	–
Finger RC, V-l	.75	–	–	–.28	Finger RC, V-l	.77	–	–	–
Finger RC, V-r	.73	–	–	–.35	Finger RC, V-r	.77	–	–	–
Finger RC, I-l	.68	–	–	.49	Finger RC, I-r	.68	–	–	.57
Finger RC, I-r	.63	-	-	.50	Finger RC, I-l	.67	–	–	.60
MLI	–	.98	–	–	MLI	–	.97	–	–
D-line, l	–	.79	.28	–	D-line, r	–	.79	.34	–
D-line, r	–	.78	.34	–	A-line, r	–	.79	–	–
A-line, r	–	.68	–	–	D-line, l	–	.76	.29	–
A-line, l	–	.53	–	.35	A-line, l	–	.53	–	–
a-b RC, r	–	–	.85	–	a-b RC, l	–	–.36	.77	–
a-b RC, l	–	–.29	.82	–	a-b RC, r	–	–.33	.76	–
V.P.	9.97	3.11	1.80	1.16	V.P.	10.66	3.35	1.50	1.00
Cum. var.	45.3	59.5	67.6	72.9	Cum. var.	48.5	63.7	70.5	75.1

[1] Loading values below 0.25 are omitted. The V.P. is the variance explained by each factor. Cum. var. is the cumulative proportion of explained variance.

Table 10. Rotated factor loadings – 22 quantitative dermatoglyphic traits[1]. **Muslim**

	Males					Females			
	Factor					Factor			
Trait	I	II	III	IV	Trait	I	II	III	IV
Total RC	.98	–	–	–	Total RC	.99	–	–	–
Absolute RC	.98	–	–	–	Absolute RC	.97	–	–	–
PII both h	.88	–	–.27	–	PII both h	.90	–	–	–
Finger RC, III-l	.85	–	–	–	PII lh	.87	–	–	–
Finger RC, II-r	.85	–	–	–	Finger RC, III-l	.85	–	–	–
Finger RC, III-r	.85	–	–	–	Finger RC, IV-l	.84	–	–	–
PII lh	.83	–	–.26	–	Finger RC, III-r	.84	–	–	–
PII rh	.83	–	–.26	–	Finger RC, II-l	.84	–	–	–
Finger RC, II-l	.82	–	–	–	PII rh	.83	–	–	–
Finger RC, IV-r	.82	–	–	–	Finger RC, IV-r	.83	–	–	–.27
Finger RC, IV-l	.79	–	–	–	Finger RC, II-r	.82	–	–	–
Finger RC, V-l	.79	–	–	–	Finger RC, V-l	.78	–	–	–.32
Finger RC, V-r	.76	–	–	–.40	Finger RC, V-r	.74	–	–	–.42
Finger RC, I-l	.70	–	–	.29	Finger RC, I-r	.70	–	–	.27
Finger RC, I-r	.69	–	.31	–	Finger RC, I-l	.67	–	–	.37
MLI	–	.97	–	–	MLI	–	.96	–	–
D-line, r	–	.77	–	–	D-line, r	–	.80	–	–
D-line, l	–	.75	.25	–	A-line, r	–	.79	–	–
A-line, r	–	.71	–	–	D-line, l	–	.77	–	.32
A-line, l	–	.58	–	–	A-line, l	–	.65	–	–.31
a-b RC, r	–	–.38	.74	–	a-b RC, r	–	–.37	.79	–
a-b RC, l	–	–.36	.72	–	a-b RC, l	–	–.36	.78	–
V.P.	10.55	3.24	1.60	1.04	V.P.	10.59	3.60	1.54	0.98
Cum. var.	47.9	62.7	69.9	74.7	Cum. var.	48.1	64.5	71.5	76.0

[1] Loading values below 0.25 are omitted. The V.P. is the variance explained by each factor. Cum. var. is the cumulative proportion of explained variance.

Table 11. Rotated factor loadings — 22 quantitative dermatoglyphic traits[1]. **Lodha**

	Males					Females			
	Factor					Factor			
Trait	I	II	III	IV	Trait	I	II	III	IV
Total RC	.98	–	–	–	Total RC	.98	–	–	–
Absolute RC	.98	–	–	–	Absolute RC	.97	–	–	–
PII both h	.84	–	–.31	.36	PII both h	.84	–	–	.48
Finger RC, II-l	.82	–	–	–	Finger RC, IV-l	.80	–	–	–
Finger RC, III-l	.80	–	–	–	PII lh	.78	–	–	.46
PII rh	.80	–	–.28	.33	Finger RC, III-r	.77	–	–	–
Finger RC, IV-l	.79	–	–	–.30	Finger RC, II-r	.76	–	–	–
Finger RC, IV-r	.79	–	–	–.25	PII rh	.76	–	–	.43
Finger RC, II-r	.79	–	–	–	Finger RC, II-l	.76	–	–	–
Finger RC, III-r	.79	–	–	–	Finger RC, IV-r	.76	–	–	–.40
PII lh	.78	–	–.31	.35	Finger RC, III-l	.73	–	–	–
Finger RC, V-l	.77	–	–	–	Finger RC, V-l	.70	–	–	–
Finger RC, V-r	.76	–	–	–.26	Finger RC, V-r	.69	–	–	–.35
Finger RC, I-l	.60	–	–	.29	Finger RC, I-r	.65	–	–	–
Finger RC, I-r	.57	–	.27	.26	Finger RC, I-l	.47	–	–	–
MLI	–	.98	–	–	MLI	–	.96	.27	–
D-line, r	–	.80	–	–	D-line, r	–	.76	.30	–
D-line, l	–	.75	–	–	D-line, l	–	.70	.35	–
A-line, r	–	.75	–	–	A-line, r	–	.69	–	–
A-line, l	–	.37	–	–.26	A-line, l	–	.48	–	–
a-b RC, r	–	–.29	.78	.29	a-b RC, r	–	–.42	.74	–
a-b RC, l	–	–.35	.77	–	a-b RC, l	–	–.50	.67	–
V.P.	9.54	3.12	1.8	1.14	V.P.	8.94	3.21	1.53	1.18
Cum. var.	43.4	57.6	65.7	70.9	Cum. var.	40.6	55.2	62.2	67.6

[1] Loading values below 0.25 are omitted. The V.P. is the variance explained by each factor. Cum. var. is the cumulative proportion of explained variance.

DISCUSSION

A common feature was observed between males and females in five populations with respect to principal components obtained from 22 dermatoglyphic traits.

Analysis of variance: The results of the 10 indices of finger ridge-counts, PII, a-b ridge counts and MLI have higher mean values in males compared to females. This supports earlier findings (Holt 1968, Schauman and Alter 1976, Loesch and Martin, 1984, Micle and Kobyliansky 1989, 1991). Sex differences are well expressed in 10 indices of finger ridge counts including total and absolute counts, and PII with few exceptions. On the other hand, sex differences are less pronounced in a-b ridge counts. Significant sex difference is very clear in all populations only in the case of the first finger ridge counts. These results are in perfect agreement with the findings on Jewish populations of different geographical areas (Kobyliansky and Micle 1987, 1988, 1989; Micle and Kobyliansky 1985, 1988, 1991).

Principal component analysis: 22 quantitative traits. The four finger and palmar dermatoglyphic factors for both sexes identified with the present family material are namely: 1. Digital pattern size factor; 2. Palmar main lines factor; 3. A-b ridge count factor, and 4. Finger pattern diversity factor. The first three factors (4^{th} factor <atd which was not included in the present analysis) are comparable with the earlier studies of Froehlich (1976) on the Melanesian population; Chopra (1971, 1979) on German family materials; Roberts and Coope (1975) on the English population; Galaktinov et al. (1982) on Taimyr aborigines; Das Chaudhuri and Chopra (1983) on the family sample from Andhra Pradesh, India; Micle and Kobyliansky (1986, 1991) on Jewish populations; Krishnan and Reddy (1992) on fishermen of Puri, India (only for total finger count: first factor). The present study is in perfect agreement with Das Chaudhuri and Chopra (1983). This may be attributable to the characteristics of the relative homogeneity among the caste groups in Indian endogamous populations. However, the structure of the present factor is also fairly similar to the above mentioned studies, only the order of the components is slightly different; just the position of rotated factors has been interchanged. Taking into account the overall variations among different studies may be due to different combinations of variables utilised, which are reflected by the principal components as different orders of arrangements in different populations or studies. Especially, factor 1 ("digital pat-

tern size factor") is remarkable, due to its degree of universality observed in different racial/geographical and sex groups, which supports the following hypothesis: (i) the general size of the finger pattern (Chopra 1979) that no separate complexes are responsible for individual fingers. (ii) Each finger is a discrete part of a digital complex comprising ten fingers and not a separate unit acted on independently by the genes involved (Butler, 1963). (iii) This theory is also supported by Roberts and Coope (1975) and Jantz and Owsley (1977) in their studies of factor analysis on dermatoglyphic data.

CONCLUSIONS

A degree of universality is observed in different racial/geographical and sex groups with respect to factor 1 ("digital pattern size factor"), which possibly indicates that the genetic factor has more influence on these variables than environmental factors. Jantz also arrived at a similar conclusion in his comparison of American and African Negro samples. The overall variation among the remaining factors of 22 dermatoglyphic traits are different, just only for different order of arrangements in different populations/studies, which indicates biological validity perhaps exists of the underlying component structure.

ACKNOWLEDGEMENTS

We would like to express our deep gratitude to all members of the families included in this analysis for their kind cooperation and patience during the data collection. This study was partly supported by an award — Bi-National research grant, granted by the programs: International postgraduate training foundation, Sackler Faculty of Medicine, Tel Aviv University, Israel. And the Department of Anatomy and Anthropology, Sackler Faculty of Medicine, Tel Aviv University. We thank the foundations for providing the grants. We are very grateful to Prof. G. Livshits from Department of Anatomy and Anthropology Sackler Faculty of Medicine, TAU, Israel for his friendship and support. The suggestions of the two anonymous reviewers are also greatly appreciated. We would like also to express our deep

gratitude to the Editor of the *American Journal of Physical Anthropology*, Professor Szathmary, for her very useful commentaries, advises and support during the preparation of our manuscript for publication.

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Appendix 1. List of the utilised traits and indices

Finger RC, Ir	Absolute RC
Finger RC, IIr	PII, Ih
Finger RC, IIIr	PII.rh
Finger RC, IVr	PII, both h
Finger RC, Vr	MLI
Finger RC, I1	a-b RC, rh
Finger RC, II1	a-b RC, lh
Finger RC, III1	A-line exit, l
Finger RC, IVI	A-line exit, r
Finger RC, VI	D-line exit, l
Total RC	D-line exit, r
	Das VIII and IX and FIAs VIII and IX, were excluded from the analysis. Numbering of the traits remain as in our other publications, for simplification of comparison with our previous data

Abbreviations:
RC = ridge count; r = right; l = left; h = hand; PII — Pattern Intensity Index; MLI = main lineindex.

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THE BEGINNING OF TEACHING ANTHROPOLOGY AT THE FACULTY OF MEDICINE OF THE UNIVERSITY OF TARTU IN 1802

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Although the roots of anthropology (the Greek for 'the study of humans') go back to the distant past, and even the term dates from Aristotle (384–322 BC), it became established as a separate branch of science as late as in the 19th century. This had been facilitated by expeditions of discovery and the development of natural sciences, particularly of anatomy [1]. It is not always easy to tell when anthropology began to be taught at one or another university as detailed research into the matter is lacking. As far as the University of Tartu is concerned, a few shorter overviews have been published in recent years; thus the following study could serve as an addition to what has been written earlier.

During its 370 years of existence, the University of Tartu has gone through a complex and discontinuous route of development. The university has sometimes even changed its location, but throughout its history it has included the Faculty of Medicine. Among the numerous disciplines taught at the faculty, one of the oldest and most essential ones is anatomy. Its teaching began as soon as the enlightened Swedish king Gustavus II Adolphus gave permission to open a university with four faculties in Dorpat (Tartu) in war-ravaged Livonia from 15 (25) October 1632.

Considering this, we could pose the question, who and when and under which circumstances began teaching anthropology at the Medical Faculty of the University, and what the University statutes valid at the period said about the teaching of this subject. To get a comprehensive answer to this question, we should look back at the history of the Faculty of Medicine at the University of Tartu, starting from the first two periods of the university under the Swedish rule

when tuition was in Latin. By the statutes of Academia Gustaviana Dorpatensis (1632–1665) and Academia Gustavo-Carolina (1690–1710), which were modelled on the statutes of Uppsala University, the Faculty of Medicine was to have two professors. One of them was supposed to lecture on anatomy, botany and physics, and the other had to teach illnesses and their treatment. Annually a dissection was to be arranged. However, due to the small number of students, often only one professor's post was filled, and sometimes even that was vacant. All the professors of medicine who worked in Tartu were at the level of their time as they had studied at the best universities of Europe [2]. As elsewhere, professors began to pay increasing attention to the issues of human body and spirit, which corresponded to the dualist treatment typical of that time's anthropology.

Despite many difficulties, during both periods teaching and research at the university was more or less met the academic standards of the time. Unfortunately, the activity of the only Livonian university was interrupted by the epidemic of plague that broke out in the summer of 1710 during the Northern War. Opportunities to continue it came as late as at the end of the century [3].

Hoping to prevent the inflow of the ideas of the French Revolution to Russia, Paul I in his ukase of 9 April 1798 forbade Russian subjects to study at Western European universities. They were ordered to return home in a few following months. Simultaneously with the ban, the Baltic knighthoods were allowed to quickly open a local Protestant university for the whole Russian Empire, and particularly for the knighthoods of Estonia, Livonia and Courland. Its location was to be chosen by an agreement between the knighthoods. From the beginning, it was supposed to bear the name of "imperial university", although its had to be financed by the knighthoods. The representatives of the latter prepared a plan for founding the university but failed to reach an agreement about its location. Finally the Senate was offered two towns to choose from: Mitau (Jelgava) and Dorpat (Tartu). The Senate favoured the latter as the seat of the university because of its central location in the Baltic provinces, favourable climate and cheapness of foodstuffs, which was supposed to offer better opportunities for less well-off parents to send their children to the university [4].

On 4 May 1799 Paul I confirmed the resolution of the Senate and the plan for instituting the university, which in its essence became the provisional statutes of the University. The plan provided for a total of

22 professors in the faculties of theology, law, medicine and philosophy, and teachers of several subjects, mostly of languages. Thus it covered nearly all the principal research areas of that time. The system of teaching was to follow the model of Western European universities and the Russian university in Moscow. The Faculty of Medicine was to have six full professors. The subjects taught at the Faculty of Medicine were divided between them as follows: 1) physiology and pathology; 2) therapy and clinic; 3) anatomy and *medicina forensis* (forensic medicine); 4) surgery and obstetrics; 5) botany and *materia medica* (pharmacology); 6) chemistry and pharmacy.

The same plan envisaged the foundation of several ancillary institutions at the faculties. The Faculty of Medicine was supposed to have: 1) a clinical institute with 14 beds; 2) a surgical hospital with 10 beds; 3) a maternity hospital with 6 beds, and a school for midwives; 4) an anatomical theatre for dissections and preparation of anatomical specimens, with a prosector and his two assistants; 6) a chemistry laboratory. The activities of these ancillary institutions were to be supervised by the full professors of respective subjects. The university as a whole was to have a library, a manege, a dance hall and a bathing establishment. The plan also included the annual budget of the university, which covered the expenses for the staff and ancillary institutions [5].

Preparations followed for finding lecturers and putting the university into operation, as the opening of the university had been planned for 15 January 1801.

The first members of the Faculty of Medicine who were appointed to their posts on 14 December 1800 were full professor of anatomy and forensic medicine Martin Ernst Styx and full professor of chemistry and pharmacy Philipp Erdmann Heinrich Gottlob Arzt [6].

While the preparations for opening not only the Medical Faculty but the whole university were in progress, Paul I unexpectedly changed his mind and on 25 December 1800 still appointed Mitau (Jelgava) as the location of the university instead of Dorpat (Tartu) as the knighthoods of Courland and Pilten had submitted a respective application. However, the emperor's sudden death on 12 March 1801 prevented the execution of this order. The new emperor Alexander I, on 12 April 1801, appointed Dorpat (Tartu) again as the seat of the university, substantiating it with its central location, congenial surroundings and several other reasons, including the fact that there had been a university in Dorpat (Tartu) before. The situation had changed

in favour of Dorpat (Tartu) again, this time conclusively. Now it would be more appropriate to speak about the re-opening the university in Dorpat (Tartu), not its opening, as years ago, in the early 18th century it had wound up its activities there. (It would be even more exact to speak about its second re-opening as for the first time the university had been re-opened in 1690).

In such a complicated situation the curators of the university found it necessary to introduce several changes and additions to the plan of opening the university in order to strengthen their influence over the university council that consisted of professors [4].

The university statutes confirmed by the ukase of Alexander I of 5 January 1802 provided only 19 professors for all the four faculties. While the foundation plan of the university envisaged six full professors for the Medical Faculty, then the statutes confirmed two years and eight months later had reduced the number of positions to four. As hygienic disciplines had been added, the number of disciplines to be taught by the faculty had increased. The subjects were divided between the professors as follows: 1) anatomy, physiology, surgery and obstetrics; 2) pathology, semiotics, therapy and clinic; 3) dietetics, state and popular medicine and *materia medica*; 4) chemistry and pharmacy. The professor of state medicine also had to lecture on the main hygienic disciplines and forensic medicine.

The statutes did not introduce any changes into the number ancillary institutions affiliated to the Faculty of Medicine and supervision of their work [7].

In addition to the two professors who had already been appointed, the third was employed on 27 February 1802, before the re-opening of the university according to the new statutes — Daniel Georg Balk, full professor of pathology, semiotics, therapy and clinic [6].

The preparations for re-opening the university were brought to a conclusion in April 1802 when, in addition to the first professors, the first students were enrolled from 5 April. On 21–22 April 1802 the University of Dorpat (now Tartu) was festively re-opened after a long interval of 91 years and 8 months.

On 1 May work began in the four faculties of the only German-language university of the Russian Empire with 9 professors and 19 students. The Faculty of Medicine started with three full professors instead of four; all of them were engaged in teaching during the first semester, which lasted for two months. The post of the professor of

anatomy, physiology, surgery and obstetrics remained vacant. The number of students at the faculty was a modest six.

In the first years after the re-opening the university suffered not only from a shortage of lecturers who would have met the requirements but also from lack of suitable rooms. Classes were held in private houses and flats rented for that purpose. Therefore, the construction of new, up-to-date buildings became topical, as the number of students was growing fast.

At the time there were no stable obligatory curricula at the university. The duration of studies had not been fixed, although at the Medical Faculty it was initially two years. Checking of knowledge acquired by the students was superficial and unsystematic. Along with obligatory lectures professors gave students individual tuition and rarely supervised some practical work. Thus, a number of problems concerning the organisation of studies had to be solved [4].

To improve the university structure and management, new statutes were approved on 15 September 1803. These provided four full and two extraordinary professors for the Medical Faculty. The disciplines were divided between the full professors as follows: 1) anatomy, physiology and forensic medicine; 2) pathology, semiotics, therapy and clinic; 3) dietetics, *materia medica*, history of medicine and medical literature; 4) surgery and obstetrics. In addition to these, there was to be a post for a professor extraordinary in veterinary medicine. Under the statutes of 1803 the prosector of the anatomical theatre also got for the first time the rights and obligations of a professor extraordinary [8].

The university staff as envisaged in these statutes was quite numerous for its time — a total of 29 professors and 12 lecturers. Compared to the 1804 statutes of Moscow University, which provided for 28 professorships, the University of Tartu could be very satisfied; theology even got more professorships here (four) than in Moscow (two) [4]. The new statutes introduced several changes concerning the ancillary institutions of the Faculty of Medicine. As the teaching of chemistry was transferred to the Faculty of Philosophy, the chemistry laboratory was also included among the ancillary institutions of that faculty. The list of ancillary institutions of the Medical Faculty, however, had been supplemented with the collection of anatomical specimens and the pathological cabinet (science room). The former was to be supervised by the professor of anatomy and the latter by the professor of pathology. The collection of anatomic specimens was to

be located at the anatomical theatre; the location of the pathological cabinet (science room) was not specified. The clinical institute that was envisaged for the Medical Faculty in the plan of foundation of the university, was renamed by the 1803 statutes the medical clinical institute and the surgical hospital the surgical clinical institute. No changes were made in the administration of the renamed ancillary institutions and the maternity hospital [8].

The question we were interested in — what the university statutes said about teaching of anthropology at the Faculty of Medicine — could be answered, after a cursory examination: neither the statute of the Swedish university nor the foundation plan of the university (approved in 1799) and the first statutes (1802, 1803) provided for teaching of anthropology at this faculty.

However, looking through the lecture programmes of the university revealed that in the autumn semester of 1802 (from 1 August to the end of December) the list of lectures by the full professor of pathology, semiotics, therapy and clinic D. G. Balk started with lectures of medico-philosophical anthropology for the students of the Medical Faculty, four hours a week, one hour each time [9].

His lectures were based on the textbook *Medizinisch-Philosophische Anthropologie für Aerzte und Nichtaerzte* (*Medico-philosophical anthropology for doctors and non-doctors*) by Johann Daniel Metzger (1739–1805), physician in ordinary to the Prussian king, privy councillor, and professor of Königsberg University. This publication served as the recommended textbook for giving academic lectures. The book consisted of an introduction and six chapters. For its time, the first chapter gave a thorough overview of the descent of man. The following chapters dealt with medical psychology, physiology, dietetics, pathology and therapy [10].

Prof. Balk's lectures on medico-philosophical anthropology were followed by lectures on general pathology. In addition, he lectured on the influence of galvanic electricity on living and dead animals by applying an experimental method. He may have been the first lecturer in the Russian Empire to illustrate his lectures with experiments.

As the professor of anatomy had not arrived as yet, he also taught osteology, which was accompanied by a demonstration of bone specimens.

During the autumn semesters of the next two years Professor D. G. Balk taught physico-philosophical anthropology as a preparatory course for purely philosophical anthropology. Then, during the autumn

semester of 1805, he taught natural historico-philosophical anthropology as a prerequisite for purely philosophical anthropology.

During the spring semesters of 1807 and 1808 Prof. Balk taught physiologico-philosophical anthropology as an introduction to philosophical anthropology.

In total, he lectured on anthropology during four autumn and two spring semesters. In his lectures he presented an assemblage of knowledge on the human being that fully met the requirements for teaching anthropology at that time.

All the above-mentioned courses were taught within the same number of hours and according to the textbook by J. D. Metzger.

As visual aids for the lectures, Prof. Balk used specimens from his anatomico-pathological collection (which he himself called a museum). Thus he laid the foundation to the specimens collection of both normal and pathological anatomy at the University of Dorpat (Tartu) and, indirectly, also to the anthropological collection. Because Prof. Balk had started the anatomico-pathological collection, the university statutes of 1803 included the collection of anatomical specimens and the pathology study room in the list of the ancillary institutions of the Medical Faculty.

The list of Prof. D. G. Balk's lectures is not short. He taught introduction to pathology, general ja special pathology, semiotics, health science and, to law students, medico-philosophical jurisprudence according to his own study aid. He is known to have claimed as early as in 1795 that each judge should have knowledge of forensic medicine, medical police and anthropology, and should pass examinations in these subjects before taking office. Moreover, he used to teach general therapy, casuistic medicine, gynecological diseases, special pathology and therapy of children's and fever diseases, general medical science, suspended animation, diseases that may result in sudden death, the art of writing prescriptions, venereal diseases, forensic medicine, treatment of chronic skin diseases, pathology and treatment of mental diseases, introduction to surgery, surgery, medical encyclopaedia and methodology. During a number of semesters he also supervised clinical practice [11].

Next we present an overview of Prof. D. G. Balk's life and work before taking office at the university and during his service here, as in the autumn semester of 1802 he was the first to start teaching anthropology to the students of the Medical Faculty of the University of Tartu (Dorpat).

Daniel Georg Balk was born in Königsberg in the family of an amber polisher on 23 June 1764. He got his first education at home and at school from 1775 [6]. From 1780–1787 he studied at the Medical Faculties of Königsberg and Berlin Universities [12]. In 1787 he earned his doctorate of medicine at Königsberg University. His dissertation studied irritants of skin and the mucous membrane.

Thereafter he practised medicine in Courland and Lithuania. In 1796 he was appointed district physician of Jakobstadt (Jekabpils). On 28 June 1799 Balk became the doctor of Baldone health resort, which is located 33 km from Riga. The numerous medical books he wrote during this period point to the drawbacks in health service and emphasise the need to protect one's health and the social significance of health. In his opinion, training of physicians at local universities would give better results than studying abroad.

Balk's proposals concerning the health service had a reformative character and were progressive for his time. In addition, Balk revealed a literary genius and took a deep interest in the theatre. His fame grew after he took measures against the cattle plague that ravaged the entire Courland at the turn of the century. This was the reason why he was invited to become the first professor of pathology, semiotics, therapy, and clinic at the University of Dorpat (Tartu) in 1802.

As a professor, D. G. Balk became actively involved in the development of the university. In a number of his speeches he drew attention to the human being, educational problems, and the physical and intellectual development of the human being.

As the second Rector of the University of Dorpat (Tartu) (from 1 August 1803 to 1 August 1804) and four-time Dean of the Faculty of Medicine (1804–1805, 1808–1809, 1811–1812, 1815–1816), Prof. Balk made an important contribution to the development of the university and the Medical Faculty [13]. He was involved in the construction of the so-called Old Anatomical Theatre, which began on 3 June 1803. In addition, he was involved in the construction of the clinics in 1806–1808 [14].

In the first half of 1804 Professor D. G. Balk introduced clinical practicums to the curriculum. On 1 May of the same year he opened the first polyclinic in the Russian Empire, which applied rudiments of serving the population according to the territorial principle. In 1808 he set up an emergency medical aid station, which can be considered the first in Russia.

He also set up a hydropathic establishment that was affiliated to the and at a school for teaching of female nurses. Prof. Balk contributed a lot to the treatment of sick and wounded soldiers in the wars of 1807 and 1812–1813 [13].

Prof. D. G. Balk also participated actively in the administration of research.

Professor of anatomy, physiology and forensic medicine Karl Friedrich Burdach has stated that most dissertations written at the Medical Faculty of the University of Dorpat (Tartu) during its first 15 years reflected Balk's views [15].

To stimulate students' interest in independent research, the university statutes of 1803 provided that prize essays should be written. Prof. D. G. Balk also participated in supervising students' research activities. The first prizes for essays were awarded in 1805. The essay by *stud. med.* Otto Girgenson *On the Relations between Medicine and Philosophy*, which received the gold medal, was supervised by Prof. Balk [4].

Unfortunately, we do not have any photographs of Prof. D. G. Balk. Johann Wilhelm Krause (1757–1828), professor of agriculture, technology and architecture, described him as a man of noble appearance with fine features and slender build. He is said to have been characterised by wisdom, wit, sense of humour, and skill at work [16].

Because of his uncompromising character he had a number of arguments with Prof. Georg Friedrich Parrot (1767–1852), Rector of the university for several terms, and some professors of the Medical Faculty. In his later years at the university he began to spend more time in the *Musse*, drinking and gambling there. All this, including his participation in theatrical performances, served as a reason for accusing Prof. Balk of immorality. On 5 June 1817, at the age of 53, Balk was forced to leave the university, whereby he lost the privileges for himself and his children, which were provided for in the foundation plan of the university. Balk left for Tula where he died early in 1826.

Several authors have written that Prof. D. G. Balk has made an important contribution to popularisation of hygiene in the Baltics, the development of clinical medicine in Tartu, and the development of polyclinical medicine in Russia. He can be regarded as an outstanding physician in the Baltics at the end of the 18th and the beginning of the

19th century. For his diligent work Professor Balk was awarded three valuable diamonds rings [13].

The lectures on medico-philosophical anthropology by full professor of pathology, semiotics, therapy and clinical medicine D. G. Balk in the autumn semester of 1802 and this course of lectures as a whole were the first at the University of Dorpat (Tartu) in the field of anthropology.

Anthropology can be regarded as one of the first academic subjects introduced by Prof. D. G. Balk at the Faculty of Medicine of the University of Tartu 200 years ago.

In addition to Prof. Balk's lectures on anthropology that started in 1802, Prof. H. Fr. Isenflamm started to lecture on anthropology in the autumn semester of 1803, and in the spring of 1805 Professors M. E. Styx and L. E. Cichorius followed [11]. Thus, in 1805 four professors of the Faculty of Medicine out of six were involved in teaching this subject. After that the number of faculty members who taught anthropology declined constantly, and, eventually, after 13 years these lectures were discontinued.

Although lectures on anthropology at the University of Dorpat (Tartu) had ended, their impact had been so great that Karl Ernst von Baer, the prospective world-famous natural scientist, defended his doctoral disseration *About the Endemic Diseases of Estonians* in 1814, i.e. a few months after his graduation. At first, Baer`s deep interest in botany made him choose *Livonian and Estonian carexes* for the topic of his dissertation. However, Prof. K. F. Burdach disapproved of this plan in the very beninning, as compiling a monograph on carexes would have been too much even for a man like Baer. In the *Curriculum Vitae* that Baer submitted in connection with the defence of his doctoral dissertation he appreciated highly Prof. D. G. Balk who as Dean of the Faculty of Medicine had influenced the final choice of the topic of his dissertation. Baer`s dissertation consists of five chapters. Chapter 2 gives an overview of Estonian dwellings, clothing and food, and paragraph 14 deals with structure of the body and frame of mind, taking care of one`s body and lifestyles in different seasons [17]. Until now Baer`s work has been regarded as medical-geographical investigation. On the other hand, in our view, one should not neglect the elements of descriptive anthropology that are included in the dissertation. Rather, because of the description of the body build and appearance of Estonians, it would be more justified to regard this work as an anthropological-medical-geographical investigation. After

years of intense work and study, Baer published his *Lectures on Anthropology for Self-study* (Part I) in Königsberg in 1824 (525 pages). The opening lecture begins with the words "know yourself" and it closes with thoughts about anthropology as a science that deals with the human being as a whole in every sense of the word. In his published lectures Baer treats the human being and the human races, the was unable to write the second volume that was planned to deal with human mentality, evolution theory, and comparative anthropology [18].

Here it would be proper to ask when teaching of anthropology started in the other older universities of Czarist Russia. At Moscow University (the oldest university of Czarist Russia), Ivan Fyodorovich Vensovich (1769–1811), Professor of Anatomy, Physiology and Forensic Medicine, reported for the first time about the need to teach anthropology at Moscow University in 1805 in his festive speech at the celebrations of the 50th anniversary of the university [19]. By then anthropology had been taught in Dorpat (Tartu) for three years already. The year 1805 could still be considered as the peak of teaching anthropology at the University of Dorpat (Tartu) throughout its history. At that time four professors at the Faculty of Medicine were dealing with it — D. G. Balk, H. F. Isenflamm, M. E. Styx and L. E. Cichorius. It is known that they were teaching five different courses on anthropology or courses that included elements of anthropology. The other older universities of Czarist Russia were established or restored after the reopening of the University of Dorpat (Tartu) in 1802 [4]. Therefore, Prof. D. G. Balk's lectures on medico-philosophical anthropology delivered during the autumn semester of 1802, and this lecture course as a whole, can be regarded as the first of its kind at any university of the Russian Empire.

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Papers on Anthropology XI, 2002, pp. 125–134

ASSOCIATION BETWEEN BIRTHWEIGHT AND CARDIOVASCULAR DISEASE RISK FACTORS IN ADOLESCENCE

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ABSTRACT

The aim of the study was to determine the possible role of low birthweight in developing traditional cardiovascular disease risk (CVD) factors among adolescents aged 14–17. A total of 44 low birthweight and 49 normal birthweight children were examined. Low birthweight children were significantly lighter, shorter and their systolic blood pressure was lower compared to the control group. Positive correlation was revealed between birthweight and systolic/diastolic blood pressure and between current weight and systolic and diastolic blood pressure. Age and sexual maturation did not differ between the groups, but SGA (small for gestational age) adolescents were significantly lighter and shorter and their systolic blood pressure was lower compared to the control group. Gender differences in anthropometrical and lipid data were shown only among normal birthweight children but not in low birthweight ones. Lipid and apolipoprotein mean parameters did not differ in adolescents with low and normal birthweight. Low birthweight was a risk factor for higher levels of triglycerides (OR=2.65; 95% CI 0.77–7.07) and for lower levels of HDLC (OR=4.2; 95% CI 1.25–14.28).

Keywords: birthweight, adolescents, cardiovascular disease risk factors.

INTRODUCTION

Undernourishment *in utero* appears to be associated with an increased risk of coronary heart disease (CHD), non-insulindependent diabetes mellitus or impaired glucose tolerance in later life [3, 4].

Recent data from family investigations suggest that cardiovascular mortality is influenced by a factor related to birthweight rather than birthweight *per se*. Several known risk factors of cardiovascular disease, such as hypertension, impaired glucose tolerance and high plasma concentrations of cholesterol and/or fibrinogen have been epidemiologically associated with birthweight [7]. In young adults born as small for gestational age (SGA) infants the presence of some (insulin resistance) but not other (hypercholesterolaemia, hyperfibrinogenaemia) cardiovascular risk factors has been reported [16, 9, 2].

A history of mother's high blood pressure during pregnancy predicted future blood pressure in the child more eminently than birthweight [21]. Strong inverse association between birthweight and systolic blood pressure has been confirmed. Birthweight has not been related to change of blood pressure with increasing age [23].

The purpose of our study was to determine the possible role of low birthweight in developing traditional cardiovascular diseases risk factors among adolescents aged 14–17 years.

MATERIAL AND METHODS

A total of 44 adolescents (26 girls and 18 boys) with low or small for gestational age (≤2,500.0 g) and 49 (27 girls and 22 boys) with normal (>2,500.0 g) birthweight born in term in 1982–1984 in two maternity hospitals in Tallinn were examined in a case-control study.

Details of the birth records, data on mothers and pregnancy are kept in the hospitals.

Cases and controls were matched for sex, parity, gestation and mother's age.

Weight and height were measured in light clothing without shoes, and body mass index (BMI) was calculated (weight divided by height square, kg/m^2). Systolic and diastolic (5th phase) blood pressure were measured twice.

Pubertal status was assessed by Tanner [22].

Venous whole blood after 12 hours of fasting was obtained. Total serum cholesterol (TC), high density lipoprotein cholesterol (HDLC) and triglycerides (TG) were determined enzymatically using commercial reagents from HUMAN, Wiesbaden, Germany [1, 12]. Low density lipoprotein cholesterol (LDLC) was calculated according to Friedewald [8]. Analyses were provided by the Laboratory of Biochemistry of Tallinn Diagnostic Centre participating in Labquality control system, using a "Dynamic" analyser of KONE Instruments Oy, Espoo, Finland.

Apolipoprotein (apo) A-I and B were quantified by Laurell's rocket electrophoresis [10] using references of Orion Diagnostica, Espoo, Finland. The method has been intercalibrated with the immunoturbidimetric method used in the National Public Health Institute, Helsinki [19].

All statistical analyses were performed using the programmes Statistica and MedCalc (series no. V50C1706). Mean values and standard deviations were calculated. Spearman's rank correlation coefficients were used to evaluate associations of low birthweight with lipids, lipoproteins and other risk factors. Comparisons between certain groups were made by Student's t-test or Kolmogorov-Smirnov test.

RESULTS

The basic anthropometric data in adolescents with normal and small gestational age weight are compared in Table 1.

Age and sexual maturation by Tanner at the study did not differ between the two groups. Low birthweight subjects were significantly lighter and shorter and their systolic blood pressure was significantly lower than in normal birthweight adolescents (Table 1).

When data were analysed separately, systolic blood pressure was higher in normal birthweight girls compared with low birthweight ones but not in boys (Table 2). Gender differences were shown between normal birthweight girls and normal birthweight boys.

Boys were significantly higher, heavier, but BMI did not differ between the groups. Systolic blood pressure was significantly higher in normal birthweight boys than in normal birthweight girls (Table 2).

Tabel 1. Anthropometric measurements, blood pressure in adolescents according to birthweight

Parameter	Normal birthweight (>2500.0 gr), n=49, M±m	Low birthweight (≤2500.0), n=44, M±m	p
Age	15.31 ± 0.14	15.09 ±0.14	ns
Weight (kg)	62.90 ± 1.48	50.49 ± 1.50	<0.0001
Height (cm)	171.30 ±1.20	163.30 ±1.62	<0.0001
BMI	21.40 ± 0.40	18.81 ± 0.36	<0.0001
Systolic blood pressure (mm Hg)	115.33 ± 1.33	108.44 ± 1.91	<0,01
Diastolic blood pressure (mmHg)	67.40 ±1.00	64.88 ± 0.91	ns
Sexual maturation by Tanner (balls sum)			
boys	9.62 ± 0.36	8.28 ±0.80	ns
girls	12.74 ± 0.36	11.85 ± 0.44	ns

Low birthweight children differed significantly only by height (Table 2).

Sperman's rank correlation analysis in the whole group revealed significant positive correlation between birthweight and systolic ($r=0.22$; $p<0.01$) or diastolic ($r=0.20$; $p<0.05$) blood pressure. Positive correlation was also shown between current weight and systolic ($r=0.55$; $p<0.0001$) or diastolic ($r=0.38$; $p<0.01$) blood pressure.

In normal birthweight boys only systolic blood pressure correlated positively with current weight, and the correlation was weaker than in low birthweight boys ($r=0.27$; $p<0.05$).

The study of mean serum lipid and lipoprotein concentrations in relation to birthweight revealed no significant differences between the birthweight groups.

When data were analysed separately, significant gender differences in serum concentrations were revealed only among normal birthweight children. Control group girls had significantly higher ($p<0.05$) HDLC and marginally higher ($p=0.07$) fibrinogen plasma concentration compared with control group boys (Table 3).

Table 2. Anthropometric measurements, blood pressure in adolescents according to gender and birthweight

Parameter	Girls			Boys		
	Normal birthweight n=27, M±m	Low birthweight n=26, M±m	P	Normal birthweight n=22, M ± m	Low birthweight n=18, M ± m	P
Age	15.37±0.20	15.08±0.18	ns	15.23±0.18	15.11±0.26	ns
Weight (kg)	58.47±1.6***	48.53±1.38	<0.0001	68.33±2.28	53.33±3.0	<0.001
Height (cm)	166.04±.92***	160.10±1.58 •	<0.05	178.21±1.60	167.92±2.96	<0.001
BMI	21.20±0.53	18.91±0.44	<0.01	21.66±0.64	18.66±0.61	<0.05
Systolic BP, mmHg	112.74±1.67*	107.51±1.41	<0.01	118.39±2.13	109.78±4.0	ns
Diastolic BP, mmHg	67.85±1.49	65.97±1.07	ns	66.85±1.35	63.3±1.65	<0.1
Sexual maturation by tanner (sum of points)	12.74±0.36	11.85±0.43	ns	9.62±0.56	8.28±0,78	ns

Difference significant between normal birthweight girls and normal birthweight boys:
*p< 0.05; ** p< 0.01; *** p< 0.001
Difference significant between low birthweight girls and low birthweight boys
•p< 0.05; ••• p< 0.0001

Table 3. Serum lipoproteins and fibrinogen mean values in adolescents according to gender and birthweight

Parameter	Girls		Boys	
	Normal brthweight n=27; M±m	Low brthweight n=26; M±m	Nrmal birthweight n=22; M±m	Low birthweight n=18; M±m
TC, mmol/l	4.38 ± 0.11	4.27 ± 0.14	4.35 ± 0.15	4.12 ± 0.18
HDLC, mmol/l	1.44 ± 0.05 *	1.36 ± 0.06•	1.26 ± 0.05 *	1.20 ± 0.07•
TG, mmol/l	0.86 ± 0.06	0.97 ± 0.10	0.95 ± 0.12	0.82 ± 0.07
LDLC, mmol/l	2.55 ± 0.10	2.47 ± 0.14	2.66 ± 0.14	2.55 ± 0.15
HDLC/TC (%)	33.27 ± 1.28*	32.35 ± 1.63	29.3 ± 1.24*	29.37 ± 1.51
Fibrinogen, g/l	! 2.51 ± 0.08	2.33 ± 0.08	! 2.25 ± 0.12	2.28 ± 0.11
Apo A – I, mg/dl	139.76 ± 2.79	136.90 ± 3.56	137.52 ± 2.64	134.50 ± 3.86
Apo B, mg/dl	71.46 ± 3.14	69.21 ± 3.74	67.01 ± 3.26	66.53 ± 2.03

Difference between low birthweight girls and boys: • p= 0.1
Difference between normal birthweight girls and boys: * p< 0.05 ! p= 0.07

Spearman's rank correlation analyse in the whole group did not reveal any association between birthweight and serum mean lipid and lipoprotein values. Among SGA girls negative correlation between plasma fibrinogen men value and sexual maturation was observed ($r = -0.50$; $p<0.01$). In control group children weak marginally significant negative correlation between birthweight and apo A-I ($r = -0.27$; $p=0.06$) was revealed. Among boys with normal birthweight sexual maturation was in negative correlation with TG ($r = -0.63$; $p<0.01$), fibrinogen ($r = -0.61$; $p<0.01$) and apo A-I ($r = -0.42$; $p<0.05$) mean values. Normal birthweight girls showed positive correlation between sexual maturation and TG mean value ($r=0.41$; $p<0.05$).

Low birthweight was a risk factor for higher (>90th percentile) levels of TG (OR=2.65; 95% CI 0.99–7.07) and lower (<1.0 mmol/l) levels of HDLC (OR=4.2; 95% CI 1.25–14.28).

DISCUSSION

People born with low birthweight or -height or having low Ponderol index — the result of intrauterine growth retardation — have higher risk of cardiovascular diseases in the future [5, 14]. These people usually have more biological risk factors — higher blood pressure, noninsulin diabetes mellitus, disturbances in lipid metabolism and coagulation factors [9, 2]. Analogous results have been demonstrated by different researchers in different countries [12, 18, 11].

The aim of this research was to explore the possible association between low birthweight and traditional risk factors in adolescents. Children, aged 14–17 who had been born with low birthweight were studied for the first time in Estonia. The control group consisted of young people born with normal birthweight at the same period at the same maternity hospitals.

Adolescents of the research group did not differ by age, but their height, weight and systolic blood pressure were significantly lower. Positive association between weight and systolic blood pressure is common. Gender differences in clinical and physiological data were shown only among normal birthweight children but not in low birthweight ones.

According to literature, adolescents and men born with low birthweight have later higher blood pressure [6] than people with normal birthweight, but expression is lower in adolescents [11, 17].

A prospective study has shown negative correlation between birthweight and blood pressure in men and women at the age of 20 years after standardisation by weight during the study. Association was stronger at the age of 20 years compared to the age of 8 years. Positive correlation between birthweight and blood pressure has been observed in newborns and children aged 3 years [24].

A study of young adult men (aged 18–25 years) has shown negative nonstatistical association between systolic, diastolic blood pressure and birthweight [20]. Positive correlation in newborns but inconstant in adolescents might be explained by different growth rates during different periods of life [11, 15]. According to literature, antenatal developmental disorder is associated with high blood pressure in the future life. Research results have prove the hypothesis that this association amplified with age [15].

In our study the data of lipoproteins did not differ significantly between the two groups. In literature there are few data about associations between disturbances of lipids and birthweight among adolescents. Our research did not discover unexpected associations between lipoproteins and birthweight. There were notable gender differences in lipids in our control group (boys had lower HDLC compared with girls), but those associations were absent in the group of children with low birthweight.

Our study showed that low birthweight was a risk factor for higher levels of TG (OR=2.65; 95% CI 1.25–7.07) and lower levels of HDLC (OR=4.2; 95% CI 1.25–14.28).

The results of our study help to specify people with high risk of cardiovascular diseases and adjust important metabolic analyses to be performed.

Low birthweight is one of independent risk factors. Low birth weight adolescents belong to a risk group and need prophylactic intervention. They have some specific metabolic features that need to be clarified.

Some insignificant delay in sexual development in children with low birthweight was observed, but our research group was too small to discover significant differences.

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Papers on Anthropology XI, 2002, pp. 135–150

THE EFFECT OF PHYSICAL EXERCISE OF DIFFERENT INTENSITY ON THE BLOOD PARAMETERS IN ATHLETES

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ABSTRACT

Development of general and speed endurance in endurance sport athletes depends on training loads of different intensity. Physical loads of various intensity exert a specific influence on the organism, which should also be expressed in the post-load changes of the blood parameters. The aim of the present study was to find out the effect of the sport-specific load of different intensity on the blood parameters in cyclists and determine the speed of the recovery of the changes and the factors influencing it. The subjects of the study were 15 cyclists aged 16–25 years (17.9±3.14). First, for the development of general endurance, subjects cycled at a uniform speed for 3.5 hours in the heart rate zone of general endurance with an intensity of 55–65% of VO_2max. Second, for the development of speed endurance the subjects covered 25 km at a maximum speed with an intensity of 85–95% of VO_2max. Venous blood for analyses was sampled at rest, immediately after the training and at 2 and 18 hours of the recovery period after the training. Hgb, Hct, E as well as the erythrocyte indices (MCV, MCH, MCHC and RDW-CV), leukocyte number and the leukocyte formula were determined. The content of total, reduced and oxidized glutathion in the blood was measured by the Tietse method modified by Bhati. Under the influence of the less intensive general endurance training load the subjects' amount of Hgb, Hct and E increased immediately after physical strain. Maximum

changes of the white blood immediately after loading and almost complete recovery took place during 18 hours after physical strain. Under the influence of a more intensive speed endurance training load the subjects' amount of Hgb, Hct and E decreased immediately after physical strain. The most significant changes in the parameters of the white blood were not detected immediately after speed endurance training but 2 hours after physical strain, while not all white blood indices were completely restored 18 hours after loading.

Key words: blood parameeters, oxidative stress, physical exercise, endurance athletes

INTRODUCTION

In training process various loads are used aimed at the development of athletes' different physical abilities (speed, strength, endurance, coordination). Training loads directed at the development of strength, speed and endurance have a specific impact on the organism since they are related to different effects that each respective load exerts on the mechanisms of energy supply and consumption, the biomechanics of movements, the degree of the strain of the muscle fibres as well as on changes in central and local regulation. Development of general and speed endurance in endurance sport athletes depends on training loads of different intensity. In the development of general endurance physical loads of lower intensity are used, while aerobic capacity is one of the major components of development since aerobic energy supply enables to perform strenuous exercise for a longer period. In order to ensure the required level of energy production, respiratory and circulation systems and different blood components participate in transporting oxygen from the outer air to a working muscle. Development of speed endurance involves training loads of higher intensity. In this case an important component of development is anaerobic energy supply, which means that anaerobic energy production will play a more important role alongside the aerobic mechanism of energy supply. The by-products of anaerobic metabolism (lactate) increase the acidity of the tissues and blood, and the organism develops metabolic acidosis (10, 15, 17, 19). Physical loads of various intensity

exert a specific influence on the organism, which should also be expressed in the post-load changes of the blood parameters.

The aim of the present study was to find out the effect of the sport-specific load of different intensity on the blood parameters in cyclists and determine the speed of the recovery of the changes and the factors influencing it.

MATERIAL AND METHODS

The subjects of the study were 15 cyclists aged 16–25 years (17.9±3.14). In laboratory conditions their morphological and respiratory indices such as body mass, body height, body fat percentage, body fat mass, lung capacity, forced respiratory capacity in seconds and maximum ventilation were determined. Body fat mass was measured using Omron BF 300 Body Fat Analyser (Omron, Japan) and the respiratory indices were measured with the Low Screen Pro apparatus (Erich Jaeger, Germany). Functional fitness indices (maximum aerobic capacity, aerobic threshold and anaerobic threshold, spurt strength, physical working capacity and recovery speed) were determined using a test veloergometer (Monark 818E, Sweden), oxygen consumption was determined using Metamax-2 (Cortex, Germany). Stepwise increasing loads with a spurt at the end of the last load were applied. The cycling training of different intensity was used in order to study the sport-specific physical load. First, for the development of general endurance, subjects cycled at a uniform speed for 3.5 hours in the heart rate zone of general endurance with an intensity of 55–65% of maximum oxygen consumption. Second, for the development of speed endurance the subjects covered 25 km at a maximum speed in the heart rate zone with an intensity of 85–95% of maximum oxygen consumption. Venous blood for analyses was sampled at rest (1 hour before the training), immediately after the training and at 2 and 18 hours of the recovery period after the training. Clinical analysis of the blood was performed using a blood analyser "Sysmex 2000" (Japan). Haemoglobin (Hgb), hematocrit (Hct), erythrocytes number (E) as well as the erythrocyte indices [mean cell volume (MCV), mean cell haemoglobin (MCH), mean cell haemoglobin concentration (MCHC), red cell distribution width, coefficient

of variation (RDW-CV)], leukocyte number (L) and the leukocyte formula were determined.

For assessment of the organism's adaptation to the physical load and for studying the specificity of the recovery, heart rate monitoring was carried out both during the test cycling and during 18 hours of the recovery. Heart rate monitors Polar Accurex Plus and Polar XTrainer Plus (Polar Electro Oy, Finland) were used for heart rate (HR) monitoring and the obtained data were processed with the Precision Performance Software (Polar Electro Oy, Finland). Training zones were determined on the basis of the heart rate data (HR at rest, HR at aerobic threshold, HR at anaerobic threshold and maximum HR). The heart rate recording interval was 5 seconds during the test cycling and 60 seconds during the recovery period. The content of total (TSGH), reduced (GSH) and oxidized (GSSG) glutathion in the blood was measured by the Tietse method modified by Bhati. Statistical analysis of the results was performed using the Statistica software by means of which the arithmetic means and the standard deviations of the data were found; the significance of the differences between the indices was checked.

RESULTS

The functional and morphological indices of the subjects are presented in Table 1.

The athletes' indices showed a great individual variety of body mass and height; body fat percentage and body fat mass were within norm, and the functional indices of respiratory system exceeded the age dependent theoretical norm.

The functional indices of physical fitness determined on the basis of a laboratory veloergometric test characterised the athletes as possessing high aerobic capacity, high aerobic and anaerobic threshold, high spurting capacity and fast recovery.

The blood parameters of the cyclists during both the general and the speed endurance training are presented in Tables 2, 3, 4, 5 and 6.

Table 1. Morphological and functional parameters of the subjects of the study.

No	Parameters	Mean	Minimum	Maximum	SD
1.	Body hight (cm)	180.5	164.0	192.0	7.9
2.	Body weigt (kg)	66.5	46.0	90.0	9.4
3.	Body fat percentage (%)	9.35	4.0	16.3	3.8
4.	Body fat mass (kg)	6.32	2.0	11.4	3.0
5.	Lung capacity (l)	5.54	4.0	7.8	1.2
	Theoretical norm (%)	110.1	94.0	131.0	11.8
6.	Forced respiratory capacity in seconds (l/sek)	4.8	3.4	5.9	1.1
	Theoretical norm (%)	110.2	100.0	124.0	10.3
7.	Maximum ventilation (l/min)	171.2	112.0	214.0	44.2
	Theoretical norm (%)	119.7	95.0	154.0	20.4
8.	Maximum aerobic capacity – VO_2max (ml/min/kg)	67.4	60.0	77.6	5.6
9.	Aerobic threshold – HR (bpm)	147.7	135.0	160.0	7.7
10.	Anaerobic threshold – HR (bpm)	176.8	165.0	184.0	6.3
11.	Physical working capacity — PWC_{170}/kg (W/kg)	3.96	3.4	4.7	0.5
12.	Spurt (revolutions per minute)	129.8	116.0	139.0	9.1
13.	Spurt strength (W/kg)	6.74	5.8	7.4	0.62

Table 2. Changes in the subjects' red blood parameters under the general endurance training load (M±SD).

No	Parameters	1 hour before the training	Immediatel y after the training	2 hours after the end of the training	18 hours after the end of the training
1.	Haemoglobin (g/l)	141.2±4.91	143.2±6.22	139.4±5.17	139.2±7.71
2.	Hematocrit (%)	41.9±1.5	42.2±1.92	41.1±1.95	40.9±1.55
3.	Erythrocytes ($x10^{12}$/l)	4.71±0.304	4.79±0.225	4.66±0.275	4.62±0.274
4.	MCV (fL)	89.1±4.6	88.2±4.4	88.3±4.6	88.8±3.7
5.	MCH (pg)	30.0±1.59	29.9±1.47	29.9±1.48	30.1±1.31
6.	MCHC (g/l)	337.2±4.39	339.1±4.52	339.1±7.13	339.7±6.00
7.	RDW-CV (%)	12.5±0.58	12.5±0.60	12.6±0.60	12.8±0.64

Table 3. Changes in the subjects' red blood parameters under the speed endurance training load (M±SD).

No	Parameters	1 hour before the training	Immediatel y after the training	2 hours after the end of the training	18 hours after the end of the training
1.	Haemo-globin (g/l)	148.5±8.07	146.9±8.44	142.6±9.84	145.5±7.28
2.	Hematocrit (%)	43.7±2.32	43.1±2.04	41.6±2.51	42.4±2.09
3.	Erythrocytes ($x10^{12}$/l)	4.98±0.27	4.93±0.22	4.79±0.28	4.82±0.26
4.	MCV (fL)	87.6±4.8	87.4±4.5	87.0±4.9	88.1±4.8
5.	MCH (pg)	29.8±1.68	29.8±1.78	30.4±3.73	30.3±1.65
6.	MCHC (g/l)	340.2±7.8	340.9±8.3	342.5±7.3	343.3±7.0
7.	RDW-CV (%)	12.7±0.63	12.6±0.64	12.6±0.63	12.8±0.68

Table 4. Changes in the subjects' white blood parameters under the general endurance training load (M±SD)

No	Parameters	1 hour before the training	Immediatel y after the training	2 hours after the end of the training	18 hours after the end of the training
1.	Leukocytes ($x10^9/l$)	4,81±0,95	13,12±6,76	12,15±4,08	5,21±1,18
2.	Neutrophils ($x10^9/l$)	2,34±0,76	10,43±7,17	9,74±5,0	3,04±1,58
3.	Neutrophils (%)	48,6±11,1	79,5±6,34	80,2±6,8	58,3±13,7
4.	Lymphocytes ($x10^9/l$)	2,0±0,39	1,9±0,44	1,8±0,56	1,7±0,49
5.	Lymphocytes (%)	41,6±12,4	14,5±6,22	14,8±6,76	32,6±12,3
6.	Monocytes ($x10^9/l$)	0,36±0,16	0,68±0,55	0,56±0,17	0,39±0,19
7.	Monocytes (%)	7,5±2,93	5,2±2,54	4,6±2,83	7,5±3,02
8.	Eosinophils ($x10^9/l$)	0,10±0,052	0,08±0,066	0,03±0,043	0,07±0,046
9.	Eosinophils (%)	2,1±2,65	0,6±2,65	0,2±2,45	1,3±2,04
10.	Basophils ($x10^9/l$)	0,01±0,01	0,03±0,05	0,02±0,04	0,02±0,05
11.	Basophils (%)	0,02±0,02	0,02±0,03	0,02±0,04	0,04±0,03

Table 5. Changes in the subjects' white blood parameters under the speed endurance training load (M±SD)

No	Parameters	1 hour before the training	Immediatel y after the training	2 hours after the end of the training	18 hours after the end of the training
1.	Leukocytes ($x10^9/l$)	5.42±1.35	7.19±1.71	10.02±2.97	5.86±1.2
2.	Neutrophils ($x10^9/l$)	3.0±0.98	4.3±1.24	7.42±2.98	2.91±0.81
3.	Neutrophils (%)	55.4±10.7	59.8±8.1	73.8±11.0	49.5±8.3
4.	Lymphocytes ($x10^9/l$)	1.61±0.34	2.22±0.44	1.78±0.52	2.19±0.79
5.	Lymphocytes (%)	29.5±7.9	30.5±6.1	17.9±8.8	37.5±11.4
6.	Monocytes ($x10^9/l$)	0.47±0.06	0.48±0.05	0.70±0.29	0.52±0.26
7.	Monocytes (%)	8.7±2.93	6.7±2.17	6.9±2.98	8.8±4.13
8.	Eosinophils ($x10^9/l$)	0.28±0.21	0.18±0.09	0.10±0.08	0.21±0.17
9.	Eosinophils (%)	5.3±4.27	2.5±1.22	1.1±0.89	3.6±3.2
10.	Basophils ($x10^9/l$)	0.06±0.04	0.03±0.035	0.02±0.038	0.03±0.04
11.	Basophils (%)	1.1±0.57	0.42±0.53	0.29±0.48	0.51±0.88

Table 6. Changes in the subjects' indices of the antioxidant system under the different intensity endurance training load (M±SD)

		Para-meters	1 hour before the training	Immediately after the training	2 hours after the end of the training	18 hours after the end of the training
Endurance	General	TGSH (μmol/l)	1194.3±303.9	1048.2±192.2	1053.1±213.2	1144.9±325.1
		GSSG (μmol/l)	37.8±19.3	51.0±22.8	37.6±21.6	35.9±18.1
		GSH (μmol/l)	1156.5±301.8	997.2±186.9	1015.6±215.6	1109.0±325.9
		GSSG/ GSH	0.035±0.019	0.087±0.019	0.039±0.024	0.036±0.023
		HR (bpm)	54.9±10.1	143.9±18.5	91.5±16.6	56.3±6.4
	Speed	TGSH (μmol/l)	1313.4±203.9	1253.7±185.4	1101.1±229.1	1196.5±215.9
		GSSG (μmol/l)	71.1±18.2	64.1±25.6	54.0±14.1	63.3±16.3
		GSH (μmol/l)	1242.5±192.3	1189.2±179.7	1046.6±230.5	1132.7±215.9
		GSSG/ GSH	0.057±0.011	0.053±0.023	0.054±0.019	0.058±0.021
		HR (bpm)	51.9±6.69	183.3±7.54	90.8±16.6	56.4±13.69

DISCUSSION

The subjects of the study displayed a high level of aerobic capacity: VO_2max (67.4±5.67 ml/min/kg), HR at aerobic threshold (147.7±7.7 bpm) and HR at anaerobic threshold (176.5±6.3 bpm) and spurt strength (458.0±53.1 W) are comparable with the respective parameters of top cyclists (17, 30, 34). The high values of the subjects' respiratory indices (lung capacity, forced expiratory capacity in seconds) (Table 1.) indicate a great reserve of respiratory function for ensuring high aerobic work capacity.

The average HR of the subjects measured during the general endurance training was 150.1±11.1 bpm, while the maximum HR was

185.2±9.8 bpm and the minimum was 108.4±13.4 bpm. The training proceeded at a uniform speed, the fluctuations in HR were related to the track profile and to the greater exertion in the lead of the group. This particular training load was directed to the development of general endurance, which is confirmed by the large proportion (87.8%) of the time spent in the HR zone of general endurance. At the beginning of the recovery period, immediately after the training, HR was 143.9±18.5 bpm after which it started to decrease: at 2 hours after the training it was 91.5±16.6 bpm and at 18 hours after exercise it had practically returned to the pre-training level (53.6±6.4 bpm).

The indices of HR during the other sport-specific test (25 km of cycling at maximum speed) confirm that training load had been aimed at the development of speed endurance of the subjects, as energy production during the test training was of anaerobic kind. The average HR of the subjects measured during the speed endurance training was 176.0±6.46 bpm, while the maximum HR was 189.7±8.89 bpm and the minimum was 164.9±6.51 bpm. Changes in HR during recovery were unidirectional, however, the process proceeded at a different speed. Immediately after the training HR values were high (183.3±7.54 bpm). The rate of recovery was first high and 2 hours after the training HR was essentially restored (90.8±13.87 bpm); thereafter recovery rate slowed down and 18 hours after the exercise average values (56.4±13.69) reached the pre-loading level.

The main energy supply mechanism in endurance development is aerobic production, which is largely associated with oxygen transport and consumption. It was therefore assumed that changes in the red blood parameters are large. However, the results of the study demonstrate (Table 2.) that changes in the average values of the red blood parameters (Hgb, Hct, E), ensuring oxygen transport in the post-load period, have a small range and are unreliable ($p>0.05$). An increase in the parameter values observed immediately after the training indicates the involvement of the erythrocytes of the blood depot in adaptation to the load. However, as early as 2 hours after the training the average indices of the red blood were below the pre-load level and the decrease continued (their recovery during 18 hours was significantly slower compared with the recovery of HR), the lowest values being observed on the following day. The studied erythrocyte indices (MCV, MCH, MCHC and RDW-CV) did not reveal a significant change in relation to the given load, either.

The training load directed at the development of speed endurance increases the intensity of oxygen transport and assimilation. The result of the study (Table 3.) showed that the changes of the average values of red blood parameters ensuring oxygen transport had a small range and were not reliable ($p>0.05$). Immediately after training a decrease in Hgb, Hct and E was observed. 2 hours after the training, the decrease in red blood parameters continued and after 18 hours of recovery it was notably slower than the restoration of heart rate. In some cyclists the speed endurance training led to the emergence of young erythrocytes (reticulocytes) in their blood in the post-load period.

While content of Hgb, Hct and E increase as a result of the general endurance training load immediately after physical exercise, the same blood parameters under the influence of the speed endurance training decrease immediately after physical exercise. Thus, physical loads of different intensity bring about bi-directional changes in the red blood.

Training process exerts a strong influence on a top athlete's organism causing sport-specific changes. Training process also has a specific effect on the blood components, which allows to estimate the training load and its influence on the organism (21, 28). Haematological studies in athletes at rest have revealed no differences in the blood parameters between athletes and non-athletes or between representatives of different fields of sport; the blood parameters of athletes have been shown to be within norm (1, 31). Also, it has been found that endurance athletes have a significantly higher haemoglobin content and a larger blood volume (16). More attention has been paid to the investigation of haemoglobin content and erythrocyte number, since there is a real danger, particularly in female athletes (29, 35), of developing sport anaemia. Sport anaemia is induced by the strain haemolysis of the blood and erythrocyte impairment under the influence of the physical load, characterised by an increase in erythrocyte size and the growth of reticulocyte number and a decrease in haptoglobin level (5, 27, 33, 35). Important causes are also iron deficit caused by undernourishment, vegetarianism, carbohydrate rich diet, low iron content in food, a large share of special food items (sports powders, mixed food, chocolates, etc) in athletes' food ration, as well as indigestion disorder and loss in weight (5). A prolonged competition period contributes to the decrease in Hgb, Hct and E (11) caused by a decline in erythropoiesis and destruction of erythrocytes.

Oxidative stress resulting from physical loading has a negative effect on erythrocytes too (29).

Under physical loading the share of young erythrocytes increases; their higher capacity for deformation and lower affinity to oxygen increase the potential of supplying the muscles with oxygen. In order to avoid the diagnosis of pseudoanaemia, it is essential to estimate Hct, Hgb and E as well as to take into account the increase in the volume of blood plasma in athletes (10, 23). As Hgb and E determine the aerobic capacity of the organism, both allowed alpine environment (high altitudes, alpine cottage) and, regrettably, also non-allowed (blood doping, erythropoietin) means are used (4, 22, 26).

Muscle work increases the number of leukocytes in the blood. In our study changes in the average values of white blood parameters in the post-load period of the general endurance training (Table 4.) showed a definite dynamics and had a large range. Immediately after the training the leukocyte number increased ($p<0.001$), which occurred at the expense of an increase both in the absolute ($p<0.01$) and relative ($p<0.05$) number of neutrophils. At the same time, a decrease ($p<0.05$) was noted in the number of lymphocytes and monocytes. Thus, established leukocytosis and changes in the proportions of the white blood cells persisted for 2 hours after loading. Complete recovery of the parameters of the white blood cells occurred during 18 hours.

In this study, changes in the average values of the white blood parameters in the post-load period of the speed endurance training (Table 5.) showed a definite dynamics and had a large range. Immediately after the training leukocyte number increased and the increase continued for 2 hours after the loading (before the training: 5.42±1.35; immediately after the training: 7.19±1.71; 2 hours after the training: 10.02±2.97 $x10^9/l$). The increase in the leukocyte number was related to the increase both in the absolute and relative number of neutrophils. At the same time, a slight increase was noted in the absolute and a decrease in the relative number of lymphocytes and monocytes. Both the absolute number and the relative number of eosinophils and basophils decreased in the post-load period. Hence leukocytosis and changes in the proportions of the white blood cells, resulting from loading, progressed for 2 hours after physical loading and their recovery during 18 hours was not complete. The subjects also had a high eosinophil concentration before physical exercise.

The less intensive general endurance training caused a maximum increase in leukocytes immediately after exercise and a nearly complete recovery 18 hours after physical strain. The increase occurred at the expense of the increase in the number of neutrophils, while the other white blood components displayed both an absolute and a relative decline (20). The intensive speed endurance training caused small-range changes in the white blood, which progressed during 2 hours after the end of loading, and the recovery of these parameters was not complete after 18 hours. According to literature, the number of leukocytes increases after physical training, and the increase depends on the degree of the athlete's fitness: the higher is the degree of fitness, the smaller is the increase in leukocytes (2, 8). The increase in the number of leukocytes occurs at the expense of the increase in the number of neutrophils and lymphocytes (7, 12). It has been found that the phagocyte activity of leukocytes in athletes at rest is reduced about 70% compared with untrained individuals (2). The increase in both the absolute and the relative number of neutrophils under the influence of a submaximal physical load reflects the rise in phagocyte activity (2). The change of phagocyte activity in different periods of training process may be associated with the production of cortisol and epinephrine in the organism (25). As a rule, the number of lymphocytes increases immediately after intensive physical exercise, while the number of "killers" grows at a higher rate than the numbers of lymphocyte subpopulations. Further the number of leukocytes drops below pre-exercise level (8, 17). Changes in the leukocyte number and proportions reflect the fluctuations in the immunological status of the athlete's organism under the influence of physical loading (2, 14, 25).

The level of reduced glutathion (GSH) in the blood dropped after the general endurance training ($p<0.05$), while the level of oxidized glutathion (GSSG) rose ($p<0.01$). Oxidative stress induced a powerful decline in the antioxidant (GSH). The changes are clearly reflected by a sharp increase in the ratio of GSSH/GSH immediately after loading. Two hours after the training, the level of different forms of glutathiones was not yet restored; complete recovery took place during 18 hours. After the speed endurance load oxidative stress was most expressed at 2 hours after the exercise.

On the basis of the present study it can be concluded that physical loads of different intensity cause respective changes in the red and white blood:

1. Under the influence of the less intensive general endurance training load the subjects' amount of haemoglobin and hematocrit and the number of erythrocytes increased immediately after physical strain. Under the influence of a more intensive speed endurance training load the amount of haemoglobin, hematocrit and the number of erythrocytes decreased immediately after physical strain.

2. The less intensive general endurance training load caused maximum changes of the white blood immediately after loading and almost complete recovery took place during 18 hours after physical strain. An intensive speed endurance training induced changes both in the number and proportions of the white blood components. The most significant changes in the parameters of the white blood were not detected immediately after speed endurance training but 2 hours after physical strain, while not all white blood indices were completely restored 18 hours after loading.

The study was supported by the Estonian Science Foundation (grant No. 3946).

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Papers on Anthropology XI, 2002, pp. 151–163

SYSTEMATISATION OF ANTHROPOMETRIC DATA OF BODY STRUCTURE IF HEIGHT CLASS IS LARGE AND BODY WEIGHT IN THREE CLASSES

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ABSTRACT

The purpose of the present study was to investigate a statistical model — the height-weight standard deviation 3×3 (SD) classes — if all the subjects belong to the class of large height and body weight is in classes small, medium and large. Thirty-five anthropometric signs and twelve skinfolds were measured according to R. Martin [35] and R. Knussmann [26].

1123 boys at the age of 18 years from the city of Tartu, and Tartu and Põlva counties were recruited for the study. The anthropometric data were systematised into 3×3 height-weight SD-classes. For the present analysis we selected 339 individuals who belonged to three classes — with large height and small, medium or large weight.

The study showed that these classes were characterised by statistically significant differences in anthropometric variables. Although there were no changes in heights and height indices, all breadths-depths, circumferences, skinfolds, body composition indices and proportions changed with increasing of the weight class from small to medium to large. Weight increase was accompanied by an increase in bone, muscle and fat mass. Relative bone and muscle mass decreased and fat percentage increased.

Key words: body height, body weight, height and weight SD classes

INTRODUCTION

Anthropological surveys of schoolchildren and conscripts have been very popular in many countries. The enormous amount of data collected has been of great value for the study of human variability and with regard to problems of health and fitness. Radical changes in social and economic structure have also changed living conditions, and in western countries undernourishment has been replaced by frequent overnourishment and luxury consumption. Surveys of conscripts have been thankful material for investigating secular trend [8–10, 13, 14, 25, 27, 37, 40, 44], for health investigations and prognosis of future morbidity and mortality [12, 43], migratory processes [27] and also for body build model studies [5, 9].

A universally accepted model for classification of body build data does not exist [41]. Women's Clinic at University of Tartu has been studying body structure of young nondelivered women from 1974 until now [16–18]. By statistical methods it has been proved that the body structure of women is a well-correlated system, in which the leading role belongs to height and weight. Over fifty percent of the variability of other anthropometric variables is the result of different height and weight.

H. Kaarma and her pupils have recommended a SD classification of body height and weight into 3×3 SD classes [16–24, 28, 30, 31, 34, 38, 39, 41, 42, 45]. Height and weight are divided into three classes: "medium" ranges from the mean value ±0.5 SD, all values of the height and weight below these are classified as "small" and all values over the above mentioned ranges as "large". So nine classes are generated — three classes with harmony between height and weight (small, medium and large), three classes with height dominating over weight, and three classes with weight dominating over height. In all publications there has been exact statistical analysis, which shows that classes with harmony between height and weight have statistically proven differences by Sheffe test, and likewise the three classes where weight dominates and the three classes where height dominates have statistically significant differences.

The purpose of this study was to explore body structure in the "large" height classes ranking by weight into "small", "medium" and "large". We hypothesised that the height changes are small and insignificant, but, on the contrary, breadths, depths, circumferences and skinfolds changes are significant.

MATERIAL AND METHODS

The sample considered in this paper consisted of 339 conscripts aged 18 years, recruited from the city of Tartu and Tartu and Põlva counties. For anthropometric examination the subjects were dressed only in short cotton swimming trunks. The following anthropometric variables were measured: body weight and height, seven heights — height to suprasternale notch, *processus xiphoideus* height, umbilical, symphyseal, iliospinale, *acromiale* and *dactylion* heights; ten breadths and depths measurements — biacromial, chest, waist and bicristal breadths, chest and abdomen depths, elbow, wrist, femur and bimalleolar breadths; circumferences — head, neck, chest, plus chest at maximum inspiration and maximum expiration, waist, pelvis, hip, proximal and midthigh, calf and ankle, arm, arm circumference flexed and tensed, forearm and wrist circumferences; skinfolds — chin, chest, midaxillary, suprailiac, supraspinale, abdominal, subscapular, biceps, triceps, thigh and calf. From these anthropometric variables projective upper limb length (acromiale minus dactylion), sternum length (suprasternal minus processus xiphoideus), abdomen length (processsus xiphoideus minus symphyseal height) and trunk length (suprasternal minus symphyseal height) were calculated. The measurements were taken following the methods of R. Martin [35] and R. Knussmann [26]. Skinfold thicknesses were measured at standardised sites according to Knussmann [26], Lohman et al. [32], Heyward and Stolarczyk [11]. Rohrer and body mass index, body surface area by DuBois and DuBois [4], absolute and relative mass of subcutaneous fat were calculated. Local subcutaneous fat and bone-muscle component on the cross-sectional areas of the arm and thigh was calculated according to De Koning et al. [2]. Lower limb length was calculated by the formula of Jatsuta [15] — (iliospinale +symphysiale) / 2. Body fat percentage and body fat mass in kilograms were assessed by Omron BF 300 Body fat monitor [7, 33, 36]. Muscle mass was calculated according to Lee et al. — $SM=Ht\times[0.00744\times CAG^2+0.00088\ CTG^2+0.00441\times CCG^2)+2.4\times$gender — $0.048\times$age+7.8 [28] and bones mass according to Drinkwatwer et al. — $[(HB+WB+FB+AB)/4]^2\times Ht\times 0.92\times 0.001$ [3], lung vital and total capacity according to Baldwin et al [1].

For calculating the height and weight 3×3 SD classification, we computed the subjects' mean height and weight. The mean height was 179.37±6.53 cm and mean weight 69.88±9.92 kg. The lower border

for the large height class was 182.6 cm. The large height class consisted of 339 subjects. The statistical significance of differences between the three weight classes was assessed by ANOVA test and between classes by t-test for two independent groups. The level of significance was set at $p<0.05$. Statistical package SAS® for Windows 6.12 version was used for these calculations.

RESULTS

Thirty-nine subjects were classified as having small weight (61.57±3.22 kg), 149 had medium weight (69.99±2.87 kg) and the large weight class consisted of 151 persons whose mean weight was 84.41±9.49 kg. The differences between the weight classes were statistically significant ($p<0.001$).

The mean values of all anthropological values and calculated indices were compared between the three weight classes.

As seen in Table 1, there were no significant differences in length measurements — sternum, abdomen, trunk, upper and lower limb lengths (variables 3–7). Neither were there any significant differences in relative trunk, abdominal, upper and lower limb lengths (v. 48–51).

All other anthropometric variables increased with increase in weight — depths and breadths (v. 8–17), circumferences (v. 18–30), skinfolds (v. 31–41), Rohrer and body mass index (v. 42–43), body surface area (v. 44), mean skinfolds, mass of subcutaneous fat (v. 45–47). Changes in the abovementioned variables caused an increase in indices (v. 52–70) and indices of proportionality of the limbs (v. 71–79), proportions of the trunk (v. 80–82). Cross-sectional areas of the limbs (v. 86–91) also increased with weight augmentation. It is worth mentioning that weight increase changed the ratio between bone-muscle and fat areas on limbs — fat area increased more than bone-muscle area (v.89–91).

Calculated norms of the lung vital and total capacity and rest metabolic rate (v. 92–93) increased with increase in weight. Muscle mass according to Lee et al. increased with weight increase, but relative muscle mass decreased (v. 96–97). Interesting changes happened with bone mass and relative bone mass — absolute bone mass increased with weight increase but, vice versa, relative bone mass decreased (v. 98–99).

Tabel 1. Basic statistics of anthropometrical measurements, indices and body composition data of 18-year-old boys grouped into large-height and three weight classes

No	Variable	1 small weight n=39 mean	SD	2 medium weight n=149 mean	SD	3 large weight n=151 mean	SD	p-value 1,2,3	1–2	1–3	2–3
1.	weight (kg)	61.57	3.22	69.99	2.87	84.41	9.49	***	***	***	***
	Heights(cm)										
2.	height	185.56	2.68	186.60	3.28	187.67	3.49	***	*	***	**
3.	sternum length	18.02	2.57	18.53	2.72	18.67	2.65	ns	ns	ns	ns
4.	abdomen length	35.75	3.07	36.99	3.03	36.80	2.82	ns	ns	ns	ns
5.	trunk length	53.77	3.33	55.52	3.06	55.47	2.60	**	**	***	ns
6.	upper limb length	82.35	3.17	82.54	2.77	83.07	3.04	ns	ns	ns	ns
7.	lower limb length	100.45	3.18	99.67	3.25	100.17	3.55	ns	ns	ns	ns
	Breadths and depths										
8.	biacromial breadth	39.27	1.78	40.53	1.40	41.74	1.68	***	***	***	***
9.	chest breadth	26.61	1.59	27.35	1.56	29.00	1.94	***	*	***	***
10.	waist breadth	24.34	1.74	25.13	1.51	27.19	2.27	***	*	**	***
11.	bicristal breadth	28.05	1.79	28.33	1.74	29.10	1.99	***	ns	***	***
12.	chest depth	18.95	1.40	19.33	1.48	20.99	1.86	***	ns	***	***
13.	abdomen depth	16.67	1.05	17.18	1.13	19.34	2.47	***	*	**	***
14.	femur breadth	9.41	0.64	9.56	0.69	9.92	0.76	***	ns	***	***
15.	ancle breadth	7.64	0.41	7.83	0.46	8.06	0.46	***	*	**	***
16.	elbow breadth	7.03	0.33	7.39	0.38	7.55	0.43	***	***	***	***
17.	wrist breadth	5.84	0.44	5.94	0.34	6.08	0.42	***	ns	**	**
	Circumferences										
18.	head circumference	56.81	1.82	57.32	1.26	58.48	1.34	***	*	***	***
19.	minimal neck circumference	34.69	1.47	36.36	1.21	38.32	1.75	***	***	***	***
20.	chest circumference	87.26	3.72	91.46	3.34	98.81	5.92	***	***	***	***
21.	waist circumference	69.76	3.62	74.29	3.05	81.86	6.67	***	***	***	***
22.	pelvis circumference	79.35	2.89	82.36	3.57	89.28	6.82	***	***	***	***
23.	hip circumference	88.23	2.76	91.58	3.10	98.32	6.40	***	***	***	***
24.	proximal thigh circumference	50.65	2.80	54.32	3.40	61.11	4.60	***	***	***	***
25.	midthigh circumference	44.66	2.54	47.62	3.22	53.04	4.54	***	***	***	***

No	Variable	1 small weight n=39 mean	SD	2 medium weight n=149 mean	SD	3 large weight n=151 mean	SD	p-value 1,2,3	1–2	1–3	2–3
26.	calf circumference	33.64	1.68	35.77	1.84	39.33	2.36	***	***	***	***
27.	ancle circumference	22.19	2.16	23.02	1.25	24.68	1.38	***	**	***	***
28.	arm circumference	25.28	1.27	27.50	1.50	31.15	2.81	***	***	***	***
29.	forearm circumference	24.46	1.24	26.03	1.15	28.15	1.76	***	***	***	***
30.	wrist circumference	16.89	0.85	17.37	0.63	18.15	0.87	***	***	***	***
	Skinfolds(mm)										
31.	chin skinfold	3.87	0.78	4.25	1.03	5.32	2.25	***	*	***	***
32.	chest skinfold	4.33	0.97	4.92	1.38	6.95	3.58	***	**	***	***
33.	midaxillary skinfold	4.81	0.97	6.09	1.73	9.65	5.19	***	***	***	***
34.	suprailiac skinfold	6.43	2.44	8.02	2.87	12.63	6.06	***	***	***	***
35.	supraspinale skinfold	4.48	1.37	5.22	1.56	7.84	4.86	***	**	***	***
36.	abdominal skinfold	6.49	2.19	8.01	2.81	13.74	7.68	***	***	***	***
37.	subscapular skinfold	6.31	1.13	7.76	1.93	11.53	5.31	***	***	***	***
38.	biceps skinfold	3.58	1.13	4.07	1.24	5.85	2.83	***	*	***	***
39.	triceps skinfold	6.10	1.76	7.37	2.39	11.04	3.93	***	**	***	***
40.	thigh skinfold	9.50	2.71	11.63	3.28	16.27	5.35	***	***	***	***
41.	calf skinfold	6.97	2.27	8.00	2.36	11.39	4.04	***	*	***	***
	Indices										
42.	Rohrer index	0.96	0.06	1.08	0.06	1.28	0.15	***	***	***	***
43.	body mass index	18.28	1.69	20.04	1.41	23.36	2.49	***	***	***	***
44.	body surface area (m^2)	1.83	0.05	1.94	0.05	2.10	0.10	***	***	***	***
45.	mean skinfold	5.72	2.11	6.85	1.53	10.18	3.90	***	***	***	***
46.	mass of subcutaneous fat (kg)	9.40	1.91	11.94	2.74	19.51	8.54	***	**	***	***
47.	relative mass of subcutaneous fat (%)	15.24	2.81	17.02	3.62	22.55	7.18	***	**	***	***
	Proportions										
48.	relative trunk length(%)	29.08	1.63	29.77	1.57	29.60	1.33	*	*	ns	ns
49.	relative abdominal length	19.17	1.63	19.84	1.62	22.30	0.84	ns	*	ns	ns
50.	relative upper limb length	44.29	1.47	44.22	1.29	15.45	0.98	ns	ns	ns	ns
51.	relative lower limb length	54.16	1.63	53.39	1.39	53.31	1.42	**	*	**	ns
52.	relative biacromial breadth	21.18	0.97	21.77	0.78	22.30	0.84	***	**	***	***
53.	relative chest breadth	14.53	1.04	14.73	0.97	15.45	0.98	***	ns	***	***
54.	relative waist breadth										

55.	relative bicristal breadth	15.26	1.17	15.21	0.92	15.48	1.03	ns	ns	ns	*
56.	relative chest depth	10.38	0.89	10.39	0.82	11.06	0.94	***	ns	***	***
57.	relative abdomen depth	9.17	0.99	9.28	0.79	10.19	1.15	***	ns	***	***
58.	relative femur breadth	5.13	0.41	5.15	0.40	5,28	0.39	**	ns	*	**
59.	relative ankle breadth	4.14	0.24	4.21	0.26	4.30	0.23	***	ns	***	**
60.	relative elbow breadth	3.81	0.20	3.98	0.22	4.03	0.23	***	***	***	ns
61.	relative wrist breadth	3.16	0.24	3.19	0.19	3.24	0.22	*	ns	*	*
62.	relative chest circumference	47.67	3.23	49.33	2.52	52.36	2.99	***	**	***	***
63.	relative waist circumference	38.22	3.44	40.14	2.58	43.22	3.19	***	***	***	***
64.	relative pelvis circumference	43.35	3.04	44.44	2.70	47.13	3.16	***	*	***	***
65.	relative hip circumference	48.39	3.11	49.44	2.64	51.99	2.88	***	ns	***	***
66.	relative proximal thigh circumference	28.15	2.53	29.46	2.32	32.26	2.41	***	**	***	***
67.	relative calf circumference	18.55	1.34	19.39	1.33	20.84	1.14	***	**	***	***
68.	relative arm circumference	14.01	1.52	14.90	1.28	16.45	1.39	***	**	***	***
69.	relative forearm circumference	13.40	1.11	14.07	0.89	14.93	0.84	***	**	***	***
70.	relative wrist circumference	9.16	0.48	9.37	0.41	9.66	0.43	***	*	***	***
	Limbs proportions										
71.	arm circumference/upper limb length (%)	31.66	3.61	33.73	3.06	37.18	3.39	***	**	***	***
72.	forearm circumference/upper limb length	30.28	2.65	31.84	2.14	33.73	2.08	***	**	***	***
73.	wrist circumference/upper limb length	20.70	1.15	21.19	1.03	21.81	1.14	***	*	***	***
74.	elbow breadth/upper limb length	8.61	0.49	9.00	0.54	9.10	0.59	***	***	***	ns
75.	wrist breadth/upper limb length	7.13	0.50	7.23	0.47	7.33	0.57	*	ns	*	ns
76.	proximal thigh circumference/lower limb length	52.02	4.75	55.21	4.52	60.57	4.97	***	***	***	***
77.	calf circumference/lower limb length	34.26	2.47	36.32	2.54	39.12	2.37	***	***	***	***
78.	femur width/lower limb length	9.47	0.69	9.64	0.71	9.90	0.66	***	ns	***	***
79.	ankle breadt/lower limb length	7.65	0.47	7.89	0.49	8.06	0.42	***	**	***	**
80.	chest depth/chest breadth	71.61	6.09	70.72	6.43	71.76	0.66	ns	ns	ns	ns
81.	biacromial breadth/bicristal breadth	139.54	11.57	143.63	9.76	144.69	11.41	*	*	*	ns
82.	biacromial breadth/chest circumference	44.56	2.79	44.22	2.10	42.70	2.46	***	ns	***	***

No	Variable	1 small weight n=39 mean	SD	2 medium weight n=149 mean	SD	3 large weight n=151 mean	SD	p-value 1,2,3	1–2	1–3	2–3
	Areas and their proportions										
83.	total cross-sectional area of arm (cm^2)	51.01	5.16	60.38	6.61	77.88	14.86	***	***	***	***
84.	bone-muscle rate of the cross-sectional area of arm (cm^2)	45.09	5.08	52.76	5.88	65.08	10.91	***	***	***	***
85.	fat rate of the cross-sectional area of arm (cm^2)	5.92	1.61	7.62	2.32	12.80	5.73	***	***	***	***
86.	total cross-sectional area of thigh (cm^2)	204.86	22.68	235.86	33.51	299.04	46.82	***	***	***	***
87.	bone-muscle rate of the cross-sectional area of thigh	181.35	18.48	205.25	30.51	251.23	37.40	***	***	***	***
88.	fat rate of the cross-sectional area of thigh	23.52	7.26	30.61	9.07	47.81	18.58	***	***	***	***
89.	bone-muscle rate of the cross-sectional area of arm/total cross sectional area of arm	0.88	0.03	0.87	0.03	0.84	0.05	***	ns	***	***
90.	fat rate of the cross-sectional area of arm/total cross-sectional area of arm	0.12	0.03	0.13	0.03	0.16	0.05	***	ns	***	***
91.	bone-muscle rate of the cross-sectional area of thigh /total cross-sectional area of thigh	0.89	0.03	0.87	0.03	0.84	0.04	***	**	***	***
92.	fat rate of the cross-sectional area of thigh/total cross-sectional area of thigh	0.11	0.03	0.13	0.03	0.16	0.04	***	**	***	***
	Functional indices										
93.	lung vital capacity by Baldwin ml-s	4752.91	68.73	4779.50	83.95	4807.02	89.51	***	*	***	**
94.	total capacity by Baldwin ml-s	5941.13	85.91	5974.38	104.94	6008.77	111.88	***	*	***	**
	Masses										
95.	body fat % by OMRON	7.71	2.60	9.29	2.74	15.74	4.93	***	*	***	**
96.	body fat kg by OMRON	4.82	1.64	6.58	2.06	13.83	6.61	***	***	***	***
97.	muscle mass by Lee (kg)	33.38	2.06	34.86	1.23	37.87	2.53	***	***	***	***
98.	muscle mass by Lee percentage	52.49	2.82	49.89	1.74	46.42	2.30	***	***	***	***
99.	Bone mass by Drinkwater (kg)	9.57	0.86	10.15	0.93	10.81	1.11	***	***	***	***
100.	Bone mass by Drinkwater percentage	15.56	1.28	14.51	1.33	12.89	1.44	***	***	***	***

	176,1cm	182,6 cm	
74,70 kg			Large (large height and weight) n=151
64,90 kg			Height class dominating (large height and medium weight) n=149
			Height class dominating (large height and small weight) n=39

Figure 1. Classification of 18-year-old-boys into 3x3 SD classes

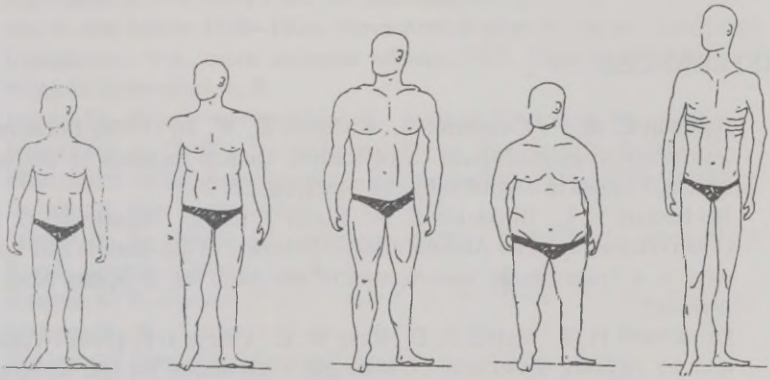

Figure 2. Five classes — small, medium, large, weight class dominanting and height class dominanting

DISCUSSION

In the previous studies of Tartu University Women's Clinic and Centre for Physical Anthropology it has been hypothesised that a multivariate statistical model is useful for systematising body build into classes created with height and weight mean ±0.5 SD. A number of publications have described changes in classes of harmony between weight and height (small-medium-large) and in contralateral classes

with weight preponderance or height preponderance [16–24, 28, 30, 31, 34, 38, 39, 41, 42, 45].

In this paper we examined changes in one height class — large (above 182.6 cm), between three weight classes — small, medium and large. In a five class system these groups would belong to class five (with height preponderance) and to the large class with harmony of height and weight.

Our hypothesis that three classes created within the limits of the large height class will be different by multivariate statistics was fully confirmed for anthropometric variables, body composition characteristics and indices of proportionality. Height-weight SD classes can be considered a possibility of systematising individuals into classes by body build if only height and weight are known.

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Papers on Anthropology XI, 2002, pp. 164–172

ASSESSMENT OF THE DIASTOLIC FUNCTION OF THE LEFT VENTRICLE — A POSSIBLE SELECTIONAL MARKER FOR ATHLETES

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ABSTRACT

To explain the individual differences of diastolic function among young males with athletic body type, 73 tall young males aged 18–28 years with high aerobic working capacity were studied; 24 out of them were top athletes. The aerobic working capacity in general population was 2.9±0.48 W/kg and among top athletes 3.9±0.32W/kg. Difference in heart dimensions was only in length. The study revealed that active relaxation process of left ventricle (IRT, RFP) is shorter not only in absolute but also in relative values among top athletes compared with general population. Comparing endurance-trained top athletes with strength-trained top athletes we found that diastolic filling in rapid filling phase occurs in endurance-trained athletes to a greater degree, and the role of atrium's contraction is smaller than in strength-trained athletes.

Because of the small number of subjects more studies are needed to prove this fact.

Key words: top athletes, echocardiography, diastolic function, aerobic working capacity

BACKGROUND

Values of maximal aerobic working capacity and maximal oxygen consumption to a large degree depend on heart work and equalise indirectly with cardiac output. The majority of studies have focused on the morphometry and systolic function of the heart [5, 11] because systolic efficiency of the heart is represented in the stroke volume, cardiac output and effects of the myocardial contraction, which are well measurable in a non-invasive way. Recently more and more attention has been paid to assessment the diastolic function of the left ventricle [7, 9], as this is the premise for great stroke volume. Unlike systolic function, presentation of a unified view of diastolic function is uncommon. Diastole consists of several functionally distinct hemodynamic phases during which the geometry of heart changes. During diastole the following hemodynamic phases occur:

1. Isovolumic relaxation (IR). Diastole starts phase if the left ventricular pressure falls below aortic pressure and the aortic valve closes. During IR the volume of left ventricle remains constant and mitral valve is closed. Left ventricular pressure exceeds left atrial pressure but it falls constantly by myocardial relaxation.
2. Rapid filling phase (RFP). Blood leaves the left atrium and enters the ventricle down a pressure gradient generated by continued ventricular relaxation, its velocity decreased by time. The ventricle fills around 70% to 90% of volume.
3. Diastasis. Atrial and left ventricular pressure are essentially in equilibrium and no filling occurs.
4. Late filling phase (LFP) By atrial contraction and the ejection further amount of blood enters into the left ventricle. The volume of blood during atrial systole may be around 10% to 30% of ventricular diastolic volume normally.

The non-invasive measurements of the left ventricular filling pattern are based on the information about the velocity of blood flow across the mitral valve into the ventricle. The transmitral flow velocity profile is determined by the multiple factors (Figure 1), which complicates the assessment of the diastolic function. The study of diastolic function is concentrated on clarifying the distinction between normal and pathological diastolic physiology. There are only a few studies [1, 9] where superior diastolic function has been found in endurance-

trained athletes in comparison with untrained population. Normal values of diastole are generally based on age-related changes and on small numbers of studies subjects.

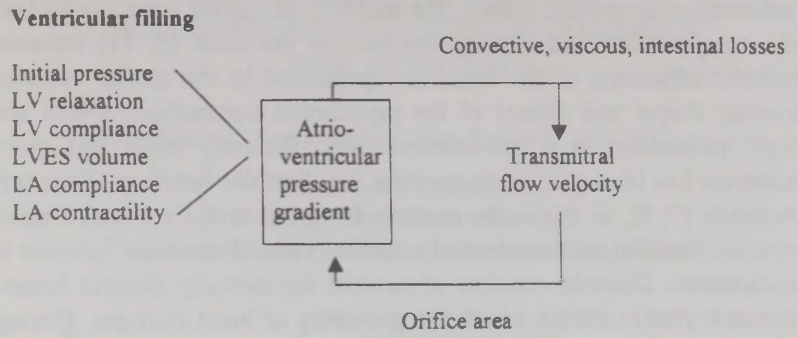

Figure 1. Summary of multiple determinants of the transmitral flow velocity profile ES= end systolic; LA= left atrial; LV =left ventricular From Choong C. Y. Left ventricle diastolic function — its principles and evaluation. In: Weyman A. E. (1994) Principles on Practice of Echocardiography. Philadelphia: Lea and Febiger, chp. 24:736

The aim of this study was to examine individual differences of diastolic function between top athletes and a healthy general population, which consisted of physically active males with similar age and similar somatometric characteristics.

MATERIAL AND METHODS

The sample included 73 healthy males aged 18–28 years. Among them there were no subjects with increased blood pressure or chronic lung disease. All subjects were physically active, but 24 of them were top athletes who belonged to the national team or to the first ten in the list of classification in Estonia. The top athletes included 6 nordic skiers, 5 rowers, 8 decathlonists, and 5 wrestlers.

All subjects had high aerobic working capacity (mean for the group 3.4 W/kg, for top athletes 3.9±0.32 W/kg, for general population 2.9±0.48 W/kg)

The male were examined anthropometrically [2]. The dimensions and physiology of heart were studied with Aloka SSD 700 system according to ACC [8]. The diastolic function of heart was investigated by Doppler echocardiography from the apical four-chamber view with the sample volume positioned at the tips of the mitral valve leaflets.

The following values and indices were measured and calculated:

- isovolumetric relaxation time (IRT)
- relative IRT (IRT %), expressed as percentage on the total diastole
- time of rapid filling phase (RFP)
- relative RFP (RFP%), expressed as percentage on the total diastole
- peak of early diastolic velocity (E)
- peak of late diastolic velocity (A)
- ratio E/A
- medium velocity of filling (MVEL)
- acceleration time of early diastolic velocity (AcT)
- acceleration rate of early diastolic velocity (Acc)
- deceleration time of early diastolic velocity (DcT)
- deceleration rate of early diastolic velocity (Dcc)
- ratio AcT/DcT

We examined the following heart's values and indices:

- left ventricular inner diameter (mm) in diastole (LVIDd) and in systole (LVIDs)
- left ventricular intracavity long axis in diastole (mm) (LAXd)
- left ventricular volume (ml) in diastole (LVVd) and in systole (LVVs) by area length formula
- thickness (mm) of intraventricular septum in diastole (STd) and systole (STs)
- thickness (mm) of posterior wall of left ventricle in diastole (PWd) and in systole (PWs)
- left ventricle mass (g) (LVMASS) by Devereux formula
- left ventricle mass adjusted to body surface area (BSA) (LVMASS/BSA) (g/m^2)
- left ventricle mass adjusted to weight (LVMASS/kg) (g/kg)
- relative thickness of posterior wall of left ventricle (RPWT) RPWT=2*PWd/LVIDd
- volume of left ventricle adjusted to BSA (LVVd/BSA)
- volume of left ventricle adjusted to weight (LVVd/kg)

Statistical analysis was performed with the statistical package STATISTICA.

RESULTS AND DISCUSSION

The subjects did not differ significantly by their somatometric characteristics (Table 1) as well by heart measurements (Table 2). They formed a homogeneous population of healthy young males who, according to the 3×3 SD height-weight classification [6], belonged to the class of big stature with medium or large weight. The values and indices of the left ventricle demonstrated differences between general population and top athletes only in the value of long axis (LAXd).

The parameters characterising the diastolic function of the left ventricle (Table 3) showed that in top athletes the relaxation process was shorter compared with general population both in absolute (IRT, RFP) as well relative (RFP%, IRT%) terms. The shortening of relaxation process time occurred during the isometric relaxation phase (IRT) and in acceleration time of early diastolic velocity (AcT). Diastolic function characteristics (E and A peaks, ratio E/A, deceleration time DcT) used in everyday clinical practice did not differ. Correlation analysis demonstrated the correlation between aerobic working capacity and rapid filling time ($r=0.547$) and ratio E/A ($r=0.733$) at rest. The heart values did not correlate with aerobic working capacity or diastolic parameters. To compare the values of diastolic parameters in the subgroup of top athletes, they were divided into two groups. The first group consisted of prevalently intensively endurance-trained athletes — nordic skiers and rowers; the second group was formed prevalently from strength-trained athletes, such as decathlonists and wrestlers. Significant differences occurred only in the acceleration time of rapid filling phase (AcT) ($p<0.05$), which was shorter in endurance-trained subjects. Ratio AcT/DcT, which reflects the accordance of increasing and decreasing of blood flow speed in rapid filling phase, was also smaller in the first group. MVEL had a tendency to increase in the second group, but the difference was insignificant.

Table 1. Somatometric characterisation of subjects

Parameter	Top athletes n=24		General population n=40		Signi-ficance
	x	δ	x	δ	
Height (cm)	185.7	5.85	181.2	5.18	–
Weight (kg)	82.8	8.84	74.66	5.12	0.05
Body surface area (BSA) m^2	2.08	0.19	1.81	0.05	–
Body mass index (BMI)	24.0	1.78	22.83	2.00	0.05

Table 2. Measurements and indices of the left ventricle of subjects

Variable	Top athletes		General population	
	x	δ	x	δ
LVIDd (mm)	52.3	4.8	50.1	3.9
LVIDs (mm)	35.9	6.0	32.8	3.4
LAXd (mm)	105.0	2.5	73.0	0.9*
LVVd (ml)	129.8	35.4	130.7	23.8
LVVs (ml)	54.5	12.6	49.0	15.7
STd (mm)	10.9	1.9	10.5	1.4
STs (mm)	14.5	1.7	14.0	2.0
PWd (mm)	10.8	1.4	10.0	1.7
PWs (mm)	16.9	2.1	15.2	2.8
LVMASS (g)	223.3	53.7	194.0	34.4
LVMASS/BSA (g/m^2)	107.0	23.6	105.3	18.1
LVMASS/kg (g/kg)	2.7	0.4	2.7	0.5
RPWT	0.4	0.1	0.4	0.1
LVVd/BSA (ml/m^2)	63.0	16.4	72.1	12.8
LVVd/kg (ml/kg)	1.6	0.4	1.7	0.3

* $p<0.05$

Table 3. Diastolic parameters and indices of left ventricle at rest

Parameter	Top athletes n=24		General population n=49	
	x	δ	x	δ
IRT (sec)	0.053	0.002	0.076	0.02*
IRT %	8.0	1.02	13.7	3.5*
RFT (sec)	0.234	0.05	0.240	0.04*
RFT %	36.1	10.0	40.4	8.4*
E (m/sec)	0.76	0.02	0.83	0.02
A (m/sec)	0.37	0.05	0.38	0.09
E/A	2.09	0.4	2.4	0.3
MVEL (m/sec)	0.31	0.09	0.34	0.09
AcT (sec)	0.075	0.01	0.083	0.02
Acc (m/sec^2)	9.0	0.3	11.12	4.3
DcT (sec)	0.161	0.05	0.162	0.03
Dcc (m/sec^2)	5.2	0.2	5.37	0.1
AcT/DcT	0.539	0.02	0.556	0.17
HR(b/min)	56.9	4.8	68.6	13.9*

* $p<0.05$

Table 4. Diastolic parameters of left ventricle in athletes according to different events at rest

Parameter	I group		II group	
	x	δ	x	δ
IRT (sec)	0.051	0.024	0.054	0.02
IRT %	6.9	3.3	9.39	4.1
RFT (sec)	0.581	0.16	0.615	0.02
RFT %	37.2	0.84	38.7	0.9
E (m/sec)	0.77	0.12	0.75	0.09
A (m/sec)	0.35	0.05	0.37	0.04
E/A	2.24	0.41	2.0	0.3
MVEL (m/sec)	0.25	0.09	0.36	0.16
AcT (sec)	0.072	0.008	0.077	0.021
Acc (m/sec^2)	7.62	0.2	10.0	0.4
DcT (sec)	0.147	0.02	0.170	0.05*
Dcc (m/sec^2)	5.36	1.53	5.09	1.37
AcT/DcT	0.496	0.02	0.539	0.3*
HR (b/min)	57.0	3.2	56.8	2.8

* $p<0.05$

The low volume of blood flow and short time in late filling phase refer to more complete left ventricular filling already in the rapid filling phase, which might be one of the essential functional reserves during exercise.

Relaxation is an active process influenced by many factors as concentration of intracellular calcium, sympathic innervation and availability of ATP. The potential of diastolic functional reserve has not been fully explored. Physiologic variations of relaxation process are probably associated with genetic factors that need further studies.

Tissue-doppler analysis [4] showed that long axis motion of left ventricle correlated with filling velocities, particularly in early diastole. However, it is important to keep in mind the fact that diastolic filling and diastolic function are not synonymous. During myocardial disease, which may develop at all ages, diastolic dysfunction appears before systolic dysfunction [3]. Besides, symptoms of diastolic dysfunction may occur during exercise before they become expressed at rest. Today studies in this field are practically missing.

CONCLUSION

Independently of heart morphometry, healthy young males of the same age group have significant variety of diastolic function, which is connected with aerobic working capacity. In selection of athletes, particularly for endurance events, one criterion could be diastolic function activity characterised parameters.

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Papers on Anthropology XI, 2002, pp. 173–189

ANTHROPOMETRIC AND TECHNICAL FACTORS INFLUENCING THE DISTANCE FROM SKIN TO LIGAMENTUM FLAVUM DURING LUMBAR EPIDURAL PUNCTURE

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ABSTRACT

For successful performance of epidural anaesthesia the exact identification of the epidural space is of paramount importance. The depth D from skin to ligamentum flavum is not known in advance as it is influenced by many factors which are not only governed by the shape of the patient but depend also on technical details during puncture.

In a prospective study, data for D of 442 epidural punctures performed in lateral decubitus on orthopaedic patients were collected. Weight, height, age and gender served as independent anthropometric variables. Position of the patient during puncture, choice of lumbar interspace, deviation from midline and the cranial and lateral angles of the advancing needle, which allowed defining a correcting factor, were taken into account as independent technical variables.

The range of D was 2.6 to 8.3 cm with a mean of 5.24 ±1.04 cm and a rather high coefficient of variability (CV 19.9 %). All of the above anthropometric variables except gender showed significant correlations with D ($p<0.05$). Correlation factors for all technical variables were smaller albeit significant ($p<0.05$) except interspace and lateral angle, which did not reach significance. Punctures not performed in the midline were larger on average. This effect was especially pronounced in males and has never been reported before.

Weight-height classification revealed a significant increase in D between the small, medium and large classes as well as between lepto- and pycnomorphs. In no other but the leptomorph group, a significant difference of D between male and female patients ($p<0.025$) was observed.

Key words: anthropometry; distance skin — ligamentum flavum; effect of technical factors; epidural puncture

INTRODUCTION

The distance D from skin to epidural space is an anthropometric measure not well defined. Its important role becomes evident while performing an epidural puncture for anaesthesia, which requires precise identification of the epidural space with the advancing needle. Too short an insertion of the needle will produce no anaesthesia after application of the anaesthetic solution. If, however, the needle is inserted too far and the dura mater penetrated, complications would ensue, e.g. postdural puncture headache, total spinal anaesthesia with breakdown of respiration and circulation, even paraplegia and lethal outcome. Though there are means for identification of the correct endpoint, i.e. the moment of piercing the ligamentum flavum much depends upon the skill of the anaesthetist. The knowledge of the influence of anthropometric variables on D and the effect of technical details during puncture are not only useful from a practical point of view but also for heuristic reasons and would help avoiding the untoward effects mentioned.

For long it has been known to the practising anaesthetist that the insertion depth depends upon the size of the patient. In 1937 Gutiérrez [1] presented data for D of 3200 epidural punctures in a merely descriptive way and only from the 1980s attempts have been made to look at correlations between D, body weight, and other variables. These have been based almost exclusively on indices derived from body weight and height. Recently multivariate procedures have been applied which take into account the influence of other variables on D as well.

Two-way classifications of body weight and height have been shown to be most useful in the description of human shape and in

disclosing characteristic patterns of individual constitutional groups [6]. The aim of this study was to also apply this methodology to data, which had been obtained previously and have already been thoroughly looked at from the aspect of correlations between D and weight-height indices, and the predictive value of their regression equations [10].

PATIENTS AND METHODS

From February 1994 to August 1995 data were prospectively collected from a total of 442 epidural punctures (part of these were used and discussed earlier [7]) from patients (202 male and 206 female) scheduled for orthopaedic surgery under lumbar epidural anaesthesia. All punctures were performed in lateral decubitus position of the patients and were subject to the condition to keep the needle as orthogonally as possible. Having identified the epidural space by means of the loss of resistance technique the distance from skin to epidural space was measured by using the centimetre markings on the shaft of the needle. Weight and height of the patients were taken on the ward under normal hospital circumstances disregarding strict anthropometric rules. As some effect of technical details during puncture on D was anticipated, the following variables were considered as well:

- left or right decubitus position o (left = 1; right = 2) of the patient;
- the interspace i of the lumbar spine used for puncture (Th12/L1 = 0; L1/L2 = 1; L2/L3 = 2; L3/L4 = 3; L4/L5 = 4; L5/S1 = 5);
- the deviation s of the needle from midline which was estimated by palpation and rated in arbitrary units (exact median puncture: 0; sagittal punctures: 0 to 1 mm: ±1; 1 to 3 mm: ± 2; 3 to 5 mm: ± 3; + was used for deviations to the non-dependent side and — for deviations to the dependent side of the patient); deviations of more than 5 mm from midline were not accepted and such a puncture had to be repeated irrespective whether it would have been successful or not; this constitutes a certain bias and overestimates the exactness of median puncture.

In addition, the angles of cranial inclination of the needle in the sagittal (α) and of lateral inclination in the transverse (β) planes were measured with a sterile protractor after identification of the epidural space. The oblique needle direction from skin to the point of entering the epidural space represents a space diagonal of a cuboid. The cranial

and lateral angles α and β can be used to convert D to the "true distance" T, which is the edge formed by the sagittal and transverse planes, by multiplying D with factor $f = (1+ \cot^2\alpha + \cot^2\beta)^{-1/2}$ [11]. Such a transformation is necessary especially in those cases where angles deviate more than 30° from orthogonality, which at times may occur for α and gives rise to small figures for f ($f<0.87$ for $\alpha<60°$). Figures for the corrected values T were calculated for all subgroups in order to gain some information about their importance.

Patients who had more than one lumbar puncture at different times during the study period (10/15 m/f patients had 2 punctures; 1 male patient each had 3, 4 and 5 punctures) were not excluded from the database, and the number of punctures was used as number of patients in each group.

Data underwent weight-height-classification primarily into nine classes according to the well-established practice. Non-corresponding groups were conjoined. Hence grouping finally resulted in five distinct classes: small, medium and large as well as leptomorphous and pycnomorphous. Further statistical processing included inter-group comparisons (one-way ANOVA; Kruskal-Wallis-test) and was performed with a statistical package (SPSS Inc.). Significance level was set at $p=0.05$ unless otherwise indicated.

RESULTS

For the entire data pool (n=442) results of descriptive statistics are presented in Table 1. There was a wide scatter in body weights from 32 kg to 138 kg, which gave rise to a large standard deviation and hence also to a large coefficient of variability (CV) (entire group: range 32 kg to 138 kg; CV 21.2%; male: range 32 kg to 138 kg; CV 18.1%; female: range 35 kg to 110 kg; CV 20.1%). Heights ranged from 140 cm to 204 cm (CV=5.8%; male: range 141 cm to 204 cm, CV 4.8%; female: range 140 cm to 181 cm; CV 4.1%) and age from 10 years to 85 years (male 10.4 to 82.8; female: 12.1 to 84.8). Depths D ranged from 2.6 cm to 8.3 cm with a mean value of 5.24±1.04 cm (CV 19.9%; male: 2.6 cm to 8.3 cm; CV 19.1%; female: 2.7 cm to 8.3 cm; CV 20.7%). The histogram for D showed positive excess (0.41) and negative kurtosis (–0.014). After transformation to T excess remained unchanged (0.41) and kurtosis

became slightly positive (0.13). D failed significance between male and female patients (5.33±1.02 vs. 5.15±1.07; p=0.080). However, after grouping for gender, T became significantly different (5.24±0.97 vs. 5.04± 1.02; p=0.036) despite the fact that the correcting factor f did not reach significance between male and female patients (p=0.067). Age had a considerable influence on D (<21 years: 4.34±0.81 (n=40) vs ≥21 years: 5.33±1.02 (n=402); p<0.001).

Positions o during puncture were equally distributed in the entire group (46% left side vs. 54% right side) and likewise between male and female patients (Table 1). For patients in the left decubitus position D and T were somewhat longer than for right decubitus, but this difference disappeared after grouping for gender (Table 2).

Table 1. Basic statistics (mean ± SD) and results of significance testing between male and female patients

	Entire group (n=442)	Male (n=221)	Female (n=221)	Signi-ficance m/f
	Mean ± SD	Mean ± SD	Mean ± SD	
Body weight w [kg]	74.0 ± 15.7	80.9 ± 14.6	67.1 ± 13.5	**
Height h [cm]	171.9 ± 9.9	178.1 ± 8.6	165.7 ± 6.8	**
Age y [yrs]	46.3 ± 18.8	43.7 ± 16.9	48.9 ± 20.2	*
Depth D [cm]	5.24 ± 1.04	5.33 ± 1.02	5.15 ± 1.07	NS
Position o	1.5 ± 0.5	1.5 ± 0.5	1.5 ± 0.5	NS
Interspace i	3.4 ± 1.1	3.3 ± 1.0	3.4 ± 1.2	NS
Distance s	–0.56 ± 0.84	–0.51 ± 0.85	–0.62 ± 0.84	NS
Cranial angle α	83.2 ± 7.8	84.6 ± 7.4	83.0 ± 8.1	*
Lateral angle β	89.6 ± 4.4	89.5 ± 4.2	89.7 ± 4.6	NS
Factor f	0.982 ± 0.029	0.985 ± 0.026	0.980 ± 0.031	NS
Depth T [cm]	5.14 ± 1.00	5.24 ± 0.97	5.04 ± 1.02	*

* = p<0.05; ** = p<0.01

Table 2. Depths D and T (mean ± SD) in left and right decubitus position o, and results of significance testing for the entire group and after grouping for gender

Position o		Entire group	Male	Female	Significance m/f
Left (1)	D	5.36 ± 1.10 (202)	5.45 ± 1.03 (100)	5.27 ± 1.17 (102)	NS
	T	5.25 ± 1.05	5.35 ± 0.98	5.16 ± 1.12	NS
Right (2)	D	5.14 ± 0.99 (240)	5.23 ± 1.00 (121)	5.05 ± 0.97 (119)	NS
	T	5.05 ± 0.94	5.15 ± 0.96	4.94 ± 0.18	NS
Significance					
1/2	D	*	NS	NS	
	T	*	NS	NS	

Figures in parentheses are number of cases; * = $p<0.05$

For the estimated deviations s from midline 52% of cases were on the dependent side, while 7% were on the opposite side and only 41% were exactly in the midline. The difference between D and T was statistically significant ($p<0.001$).

Lumbar interspaces i used for puncture ranged from Th12/L1 to L5/S1. The number of cases in different interspaces i was different ($p<0.001$). About 3/5 to 4/5 of cases were done between L3/4 and L4/5 with a tendency for male patients to be punctured at L3/4 and female at L4/5 (Table 1). No significant difference in D was encountered for any of the groups and interspaces. Only for T there was an almost negligible difference between male and female patients in the L3/4 interspace (Table 3).

The estimated distance from midline deviated mainly to the dependent side (Table 1). The difficulty to insert the needle exactly in the midline is shown clearly by the fact that more than 50% of punctures in any group were off midline, either on the non-dependent or, mainly, on the dependent side, and only about 40% were performed exactly in the median plane (Table 4). Deviations s from midline had some effect on the insertion depth D. There was a statistical difference between the means for punctures performed in the median ($s=0$) and in the sagittal ($s\neq0$) planes for D (5.02±1.00 vs 5.40±1.05; $p<0.001$) which persisted even after correcting for T (4.92 ±0.95 vs 5.30±1.00; $p<0.001$) and was significant for males ($p<0.001$). These means had a minimum at $s=0$ which increased for

s>0 as well as for s<0 and were more pronounced in male patients (male p<0.001; female p=0.062).

Table 3. Depths D and T (mean ± SD) in different interspaces of the lumbar spine for the entire group and after grouping for gender, and results of significance testing

Interspace i		Entire group	Male	Female	Significance m/f
Th12/L1	D	4.98 ± 0.52 (9)	5.13 ± 0.15 (3)	4.90 ± 0.64 (6)	NS
	T	4.73 ± 0.62	5.04 ± 0.13	4.57 ± 0.73	NS
L1/2	D	4.85 ± 0.90 (21)	4.84 ± 0.72 (9)	4.86 ± 1.04 (12)	NS
	T	4.70 ± 0.87	4.77 ± 0.75	4.65 ± 0.97	NS
L2/3	D	5.53 ± 1.06 (47)	5.55 ± 0.92 (22)	5.51 ± 1.20 (25)	NS
	T	5.38 ± 1.00	5.41 ± 0.83	5.36 ± 1.15	NS
L3/4	D	5.27 ± 1.01 (155)	5.40 ± 0.96 (92)	5.08 ± 1.05 (63)	p=0.058
	T	5.19 ± 0.97	5.34 ± 0.93	4.98 ± 0.98	p=0.028
L4/5	D	5.23 ± 1.06 (150)	5.27 ± 1.07 (82)	5.18 ± 1.05 (68)	NS
	T	5.13 ± 1.00	5.19 ± 1.02	5.07 ± 0.98	NS
L5/S1	D	5.15 ± 1.15 (60)	5.19 ± 1.38 (13)	5.13 ± 1.09 (47)	NS
	T	5.06 ± 1.13	5.01 ± 1.31	5.07 ± 1.09	NS
Significance					
	D	NS	NS	NS	
	T	NS	NS	NS	

Figures in parentheses show the number of cases

Cranial angles α ranged from 45° to 105° which means that there were cephalad deviations from orthogonality up to 45° and caudad deviations up to 15°. However, lateral angles β were nicely concentrated around an almost orthogonal insertion mean of 89.6° (range 78° to 115°). These angulations resulted in correcting factors f (range 1.000 to 0.699) which in a considerable number of depth measurements corrected D by more than 2% (40.7%) or more than 1 mm (26.5%) (Table 5). The angle β never contributed to f more than 0.05%, and there were no correlations of β with any other variable.

Table 4. Depths D and T (mean ± SD) for different classes of deviation from midline for the entire group and after grouping for gender, and results of significance testing

Distance s		Entire group	Male	Female	Significance m/f
–3	D	5.22 ± 1.02 (5)	5.85 ± 1.63 (2)	4.80 ± 0.30 (3)	NS
	T	5.10 ± 0.93	5.68 ± 1.44	4.71 ± 0.33	NS
–2	D	5.46 ± 0.98 (45)	5.64 ± 1.00 (19)	5.34 ± 0.97 (26)	NS
	T	5.39 ± 0.96	5.56 ± 0.97	5.26 ± 0.96	NS
–1	D	5.41 ± 0.98 (180)	5.56 ± 1.12 (90)	5.26 ± 1.03 (90)	NS
	T	5.31 ± 0.96	5.47 ± 1.05	5.16 ± 0.99	*
0	D	5.02 ± 1.00 (183)	5.03 ± 0.84 (94)	5.02 ± 1.15 (89)	NS
	T	4.92 ± 0.95	4.95 ± 0.82	4.90 ± 1.08	NS
1	D	5.17 ± 1.11 (22)	5.26 ± 1.12 (11)	5.08 ± 1.14 (11)	NS
	T	5.01 ± 1.01	5.13 ± 1.03	4.89 ± 1.03	NS
2	D	5.39 ± 0.46 (7)	5.54 ± 0.43 (5)	5.00 ± 0.28 (2)	NS
	T	5.30 ± 0.53	5.49 ± 0.44	4.83 ± 0.50	NS
Significance (a)	D	*	*	NS	
	T	**	*	NS	

Figures in parentheses show the number of cases; * = $p<0.05$; ** = $p<0.01$
(a)= Kruskall-Wallis-Test

Table 5. Percentage of cases for a given value f and for the difference between D and T

Factor f / % cases	≤ 0.90 / 3.6 %	≤ 0.95 / 11.5 %	≤ 0.98 / 40.7 %
D – T [cm] / % cases	≥ 0.5 / 4.1 %	≥ 0.25 / 9.5 %	≥ 0.1 / 26.5 %

Correlations between the dependent variable D and independent anthropometric and technical variables are given in Table 6. Correlation with gender failed significance for D (r= –0.083; p=0.080), but not for T (r= –0.100; p=0.036). For all patients correlations with T were the same as with D, except height in males (r(D.h)=0.125; p=0.064; r(T.h)=0.138; p=0.040). After excluding younger patients (<21 years), height as well as gender (for D and T likewise) lost

significance in the remaining group of "adult" patients (≥21 years) as did position in the group of male patients, while in the female group no changes were encountered. In the younger age group (<21 years), D significantly correlated only with w, h and age, additionally with s in the younger males. In the younger females, D (and T) correlated exclusively with body weight.

Table 6. Correlation coefficients r between dependent variable D and other anthropometric and technical variables, and results of significance testing

	Entire group (n=442)		Male (n=221)		Female (n=221)	
Weight w	0.615	**	0.639	**	0.655	**
Height h	0.103	*	0.125	NS	–0.006	NS
Age y	0.347	**	0.377	**	0.353	**
Position o	–0.103	*	–0.107	NS	–0.101	NS
Interspace i	–0.007	NS	–0.039	NS	0.008	NS
Distance s	–0.127	**	–0.182	**	–0.087	NS
Cranial angle α	–0.183	**	–0.199	**	–0.189	**
Lateral angle β	–0.001	NS	0.031	NS	–0.024	NS
Factor f	–0.242	**	–0.255	**	–0.248	**

* = $p<0.05$; ** = $p<0.01$

As age was positively correlated with body weight ($r(w.y)=0.253$; $p<0.001$) and remained correlated even after excluding younger patients, it was assumed that the correlation r(D.y) might be biased by weight. However, keeping weight constant, the partial correlation coefficient decreased from $r(D.y)=0.377$ to $r(D.y)|w=0.289$, yet remained significant ($p<0.001$). For both the male and female groups these partial correlations also remained significant.

Taking into account only patients' characteristics regression models for D and T were estimated in a stepwise manner (Table 7).

All models listed were significant. The most important arguments were weight and height, and the least important was age. Even when all significantly correlated variables from Table 6 were included, only a corrected $R^2=0.521$ was obtained. There was no significant model which included gender. Excluding the younger patients (<21 years)

produced the same significant arguments but did not improve R^2 neither in the entire group nor after grouping for gender. In the younger age group body weight was the only significant argument in the entire group and in the groups classified according to gender (Table 8).

Table 7. Regression models for D and T by weight, height and age for the entire group and for male and female subgroups

	Model	Intercept	Weight	Height	Age	R^2
Entire group D	A	2.21	0.041	–	–	0.378
	B	7.48	0.054	–0.036	–	0.456
	C	6.29	0.049	–0.030	0.008	0.476
Entire group T	A	2.19	0.040	–	–	0.391
	B	6.96	0.051	–0.033	–	0.463
	C	5.87	0.047	–0.027	0.007	0.478
Male D	A	1.74	0.044	–	–	0.408
	B	6.48	0.053	–0.031	–	0.459
	C	5.32	0.048	–0.025	0.011	0.488
Male T	A	1 .73	0.043	–	–	0.430
	B	1.46	0.040	–	0.013	0.479
	C	5.00	0.047	–0.023	0.011	0.507
Female D	A	1.68	0.052	–	–	0.429
	B	6.35	0.056	–0.030	–	0.462
Female T	A	1.76	0.049	–	–	0.420
	B	5.94	0.052	–0.027	–	0.449

Table 8. Arguments for regression model A for the younger age group

		Intercept	Weight	R^2
Entire group (40)	D	2.13	0.037	0.598
	T	2.04	0.038	0.633
Male (17)	D	2.02	0.037	0.755
	T	1.98	0.036	0.746
Female (23)	D	1.62	0.048	0.459
	T	1.41	0.051	0.555

Figures in parentheses show the number of cases

Figures for D and T after weight-height classification (entire group, male, female) are listed in Table 9a for the corresponding classes and in Table 9b for the non-corresponding classes.

Table 9a. Depths D and T (mean ± s.d.) for corresponding groups of weight-height classified data

	Small	Medium	Large	Signi-ficance
D entire group	4.60 ± 0.97 (70)	5.38 ± 0.91 (71)	5.69 ± 0.87 (76)	p<0.001
Male	4.47 ± 0.88 (29)	5.40 ± 0.79 (41)	5.85 ± 0.98 (30)	p<0.001
Female	4.55 ± 0.82 (30)	5.31 ± 0.90 (34)	5.78 ± 0.80 (25)	p<0.001
Significance m/f	NS	NS	NS	
T entire group	4.53 ± 0.96 (70)	5.22 ± 0.81 (71)	5.60 ± 0.83 (76)	p<0.001
Male	4.40 ± 0.87 (29)	5.30 ± 0.74 (41)	5.74 ± 0.93 (30)	p<0.001
Female	4.49 ± 0.81 (30)	5.32 ± 0.82 (34)	5.69 ± 0.79 (25)	p<0.001
Significance m/f	NS	NS	NS	

Figures in parentheses show the number of cases

Table 9b. Depths D and T (mean ± SD) for non-corresponding groups of weight-height classified data

	Leptomorphous	Pycnomorphous	Significance
D entire group	4.65 ± 0.70 (129)	6.05 ± 0.94 (96)	p<0.001
Male	4.82 ± 0.64 (70)	6.15 ± 0.92 (51)	p<0.001
Female	4.46 ± 0.75 (75)	6.02 ± 0.92 (57)	p<0.001
Significance m/f	**	NS	
T entire group	4.58 ± 0.68 (129)	5.92 ± 0.91 (96)	p<0.001
Male	4.78 ± 0.63 (70)	6.00 ± 0.89 (51)	p<0.001
Female	4.38 ± 0.73 (75)	5.891± 0.91 (57)	p<0.001
Significance m/f	**	NS	

Figures in parentheses show the number of cases; **=p<0.025

Weight-height classification was not performed in the younger age group, as there were only 17 male and 23 female patients.

There was a highly significant difference of D and T between male and female patients in the leptomorphous group. This result persisted even after removing the younger patients (aged <21 years).

Correlations of the classified data with indices derived from body weight and height (w/h, w/h^2, w/h^3) are shown in Table 10. Best correlations with indices derived from body weight and height were obtained for the "small" group and with an exponent of 1 (or 2 as for the leptomorphs), but in neither case was Rohrer's index a good predictor of either D or T.

Table 10. Correlation coefficients between body weight-height-indices and classified data for D and T

	Small	Medium	Large	Lepto-morphous	Pycno-morphous
	D / T (n=70)	D / T (n=71)	D / T (n=76)	D / T (n=129)	D / T (n=96)
Index w	0.657 / 0.644	0.246 / 0.238	0.566 / 0.577	0.346 / 0.356	0.373 / 0.383
Index w/h	0.688 / 0.672	0.268 / 0.260	0.588 / 0.601	0.392 / 0.401	0.377 / 0.373
Index w/h^2	0.666 / 0.649	0.266 / 0.265	0.584 / 0.597	0.416 / 0.423	0.341 / 0.321
Index w/h^3	0.601 / 0.584	0.249 / 0.240	0.562 / 0.576	0.378 / 0.381	0.268 / 0.235

DISCUSSION

In 1938, Alberto Gutiérrez from Buenos Aires published the first large collection of measurements of the depth D from skin to the epidural space. Re-evaluating his frequency table yielded D=4.19±0.84 [cm] (CV=19.9%; range 2.0 to 10.5; n=3199[1]) with the histogram showing a positive skewness (0.933) and a positive kurtosis (2.33). No correlations were given. His data allowed him to draw some qualitative

[1] The number of cases in Gutierrez' frequency table (n=3199) does not tally with the figure of 3200 given in his text

conclusions for practical purposes, namely that (1) there is great variability in the skin to epidural space distance between one subject and another; (2) if spinal processes are easily seen under the skin then the distance will be very short and vice versa; (3) the distance encountered most often is 4 cm.

Today, the median values reported are roughly 1 cm longer. This may be attributed to the fact that, in general, nowadays the nutritional status is better. Ethnic factors may play a role as well which was shown in a comparative study between a Caucasian and an Asian obstetric population (4.89±1.06; n=125 vs 4.34±0.84; n=33; $p<0.005$) [8].

Another large-scale study on depth measurements in an obstetric population was presented 50 years after Gutiérrez' publication and resulted in D=4.82±0.94 (CV=19.4 %; range 2.5 to 9.5; n=3011) [9]. Variabilities from both papers compare well with the results of this study (CV=19.9). Therefore, one would suggest that this large variability is genuine to D as an anthropometric measure.

The following factors may be considered to influence D: (1) characteristics of the patient such as weight, height, age, gender; other appropriate measures of shape or physical status; extreme kyphosis or lordosis of the spine; and possibly race; (2) technical details during puncture such as the position of the patient (sitting vs decubitus); interspace chosen; deviations from midline (the extreme being the obvious difference between the median and paramedian techniques); angulations of the advancing needle, which may be very steep in the thoracic spine due to the shallow angle of the spinous processes; bending of a long and soft epidural needle; dimpling of the skin at the insertion point of the needle; the technique used for identifying the epidural space (loss of resistance vs hanging drop, which had been proposed earlier [2] but has been disproved later [4]).

The influence of several of these variables upon D was looked at in this study. To gain some information about the effect of inclinations, D was in most cases also transformed to the corrected values T. From all anthropometric variables investigated body weight exerted the strongest effect on D showing the highest correlation coefficients (Table 6) and being the most important predictor in different regression models (Tables 7 and 8). Height was not very well correlated with D. Surprisingly, age gave rise to considerably high correlation coefficients, a result which held true even after reducing the entire database to adult patients solely after exclusion of 40 punctures from patients under the age of 21 years. This contrasts with other

publications where age was not significantly involved in correlations with D.

It was also assumed that the effect of age upon D might be via an increase in body weight with age. However, keeping weight constant while calculating partial coefficients r(D.y)|w did not eliminate this age effect.

There was no statistically significant difference in D between male and female patients, which again contradicts published results.

There is no satisfactory account for the results from Table 2, which demonstrate a significant difference in D for patients being either in their left or right decubitus position, and for the fact that this difference disappears after grouping according to gender.

In addition, the choice of a certain lumbar interspace did not have an effect upon D (Table 3), and there emerged a difference for T only for punctures in L3/4. This again is in contrast to other studies. For example, Harrison and Clowes [2] have studied the influence of interspace on D in an obstetric population with punctures also being done in decubitus position and have published the medians for each interspace (Table 11). Harrison's figures peak at L3/4 whereas figures from this study show a maximum at L2/3.

In the Mann-Whitney test no significant difference was found between D at L2/3 and L3/4 levels, and not even between L1/2 and L2/3, which shows the largest absolute difference in depths. This finding opposes the results by Harrison who was able to demonstrate a statistically significant difference between each of the adjacent interspaces. But, identifying the L3/4 interspace under clinical conditions may render difficult. A study on cadavers has shown that there is a tendency to perform lumbar puncture in a higher interspace than intended [5]. This may certainly happen under clinical conditions and could explain the maximum to be in a higher interspace in this study but would not explain why our data did not produce comparable results with respect to significant interspace differences in D.

Several publications have demonstrated that an exact midline puncture is very difficult to perform. Deviations to either side have been shown to occur, obviously depending on technique. Hodgson [3] has claimed that epidural needle placement might significantly deviate towards the non-dependent side, whereas in our study deviations were mainly to the dependent side. Irrespective of to which side needles deviate, it has never been shown that these deviations may constitute an influencing factor upon D. Table 4 shows that any deviation from

midline increases D. This effect is more pronounced in male patients, and the means between maximally deviating punctures differed almost 8 mm. As the corrected distances T in sagittal planes still remained longer than in the median plane, an anatomical explanation was sought for this result: the skin above the spinal processes is more or less fixed and forms a groove in the dorsum of the human body. The erector spinae with its large muscular mass fills up this vertebral groove on each side thus making skin to epidural space distance longer. This is likely to be more pronounced in the male. For female patients this effect was missing statistical significance in this study.

Most scientists agree that an inclination of the needle during puncture will increase the distance from skin to ligamentum flavum. Simple geometry demands such an effect. In one study [13], however, researchers were not able to prove such a relation. In this study cranial angles α were highly correlated with D, whereas lateral angles β were not. Certainly, the influence of β is small and maximum only if $\alpha=90°$. Theoretically, for a small distance D=2.5 cm the lateral opening in the L3/4 interspace would only allow for $\beta=\pm 18°$, which results in f =0.988. This is only a small figure compared to the effects caused by shallow angles α — as usual in the thoracic level of the spine. In this study about a quarter of punctures had to be corrected for more than 0.1 cm due to these angulations.

Comparing regression models (Table 7) with those from literature shows very roughly that the regression equations with weight as independent variable have an intercept of about 2. To this 3 to 5% of the body weight is added.

Preusser, A.[12], 1985:

Male patients (n = 217)	$D = 1.88 + 0.028\ w\ (R^2 = 0.208)$
Female patients (n = 231)	$D = 2.24 + 0.036\ w\ (R^2 = 0.322)$

This study (Table 7)

Male patients (n = 221)	$D = 1.74 + 0.044\ w\ (R^2 = 0.408)$
Female patients (n = 221)	$D = 1.68 + 0.052\ w\ (R^2 = 0.429)$

Such an interpretation is meaningful for practical purposes because it states that even in the small adult (with theoretically no body weight) the minimum distance from skin to epidural space is about 2 cm and hence an inadvertent dural puncture should not be expected up to this depth. This baseline depth then increases by about 0.5 cm per 10 kg body weight for obtaining the appropriate depth. Such a consideration can only serve as a rough guide because in no case R^2 exceeded 0.5

which means that 50% of the variability is not explained by the regression equation and is attributed to individual factors, which are normally not under control.

Furthermore, it was interesting to see that for the younger age group body weight was the sole argument (Table 8), a fact that is known from paediatric regression equations for D as well [14].

Weight-height classification revealed some interesting results: all inter-group comparisons were highly significant and the increase in D between the small and the medium class was more pronounced than between the medium and large class. The difference in means between the lepto- and pycnomorphous was almost 1.5 cm. The only significant difference caused by gender was found in the group of leptomorphs, which represent 29% of all punctures. If only such a small part of the total population is responsible for a significant difference in D after grouping for gender, then it must not be expected to detect a difference in non-classified data.

As weight height classification showed significant differences for D between male and female patients at least in one class, it was hoped that depths in one of the lumbar interspaces might differ as well in order to explain the discrepancy of Table 11. Indeed, there was a statistically relevant difference for D (and T) in the group of pycnomorphs ($p(D)=0.033$; $p(T)=0.022$), but it remains unclear whether this result would explain Harrison's data.

Table 11. Figures from literature and from this study for medians of depth D [cm] in different interspaces

	L1/2	L2/3	L3/4	L4/5
Harrison	4.23	4.86	4.93	4.78
This study D	4.85	5.50	5.00	5.10

To check the hypothesis that indices derived from weight and height are reasonable descriptors of body shape and assuming that shape is a determinant of D, correlation coefficients were estimated between D (and T) and widely used indices for all weight-height classified groups (Table 10). Best correlations were obtained for the smalls, the worst for the medium group. But in no case was Rohrer's index (w/h^3) the best choice. Maximum figures were always allocated around

Quetelet's index (w/h), and only for the leptomorphs body mass index (w/h^2) was the best one. This result shows that indices are probably not suitable to produce reasonable correlations in a mixed population when this task fails even for less biased subgroups.

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Papers on Anthropology XI, 2002, pp. 190–199

HUMAN LIFE SPAN AND MORTALITY IN BULGARIAN MEDIEVAL POPULATIONS FROM THE XI–XII CENTURIES AD (BASED ON ANTHROPOLOGICAL MATERIAL)

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ABSTRACT

Anthropological data concerning the age and sex distribution of skeletal material from necropolises from Bulgarian territory, dating from the XI–XII centuries AD, have been studied. In some of the sites deviations in sex structure have been found. Age-specific mortality and survival in the populations, represented in the material from the necropolises, have been discussed and specifics in paleodemographic structure accentuated. The conclusions obtained provide a basis for comparison with the situation in preceding and later paleopopulations from Bulgarian lands.

Key words: XI–XII c. AD necropolises, survival, mortality

INTRODUCTION

A considerable amount of anthropological material has been found in Bulgarian lands from XI–XII centuries AD necropolises. For most of this period (after 1011 and before 1186) Bulgarian lands were part of the Byzantine Empire. It is of interest to study the development of paleopopulations in this period; in addition it provides data for synchronous and asynchronous comparative analysis with other materials from Bulgaria and south-east Europe.

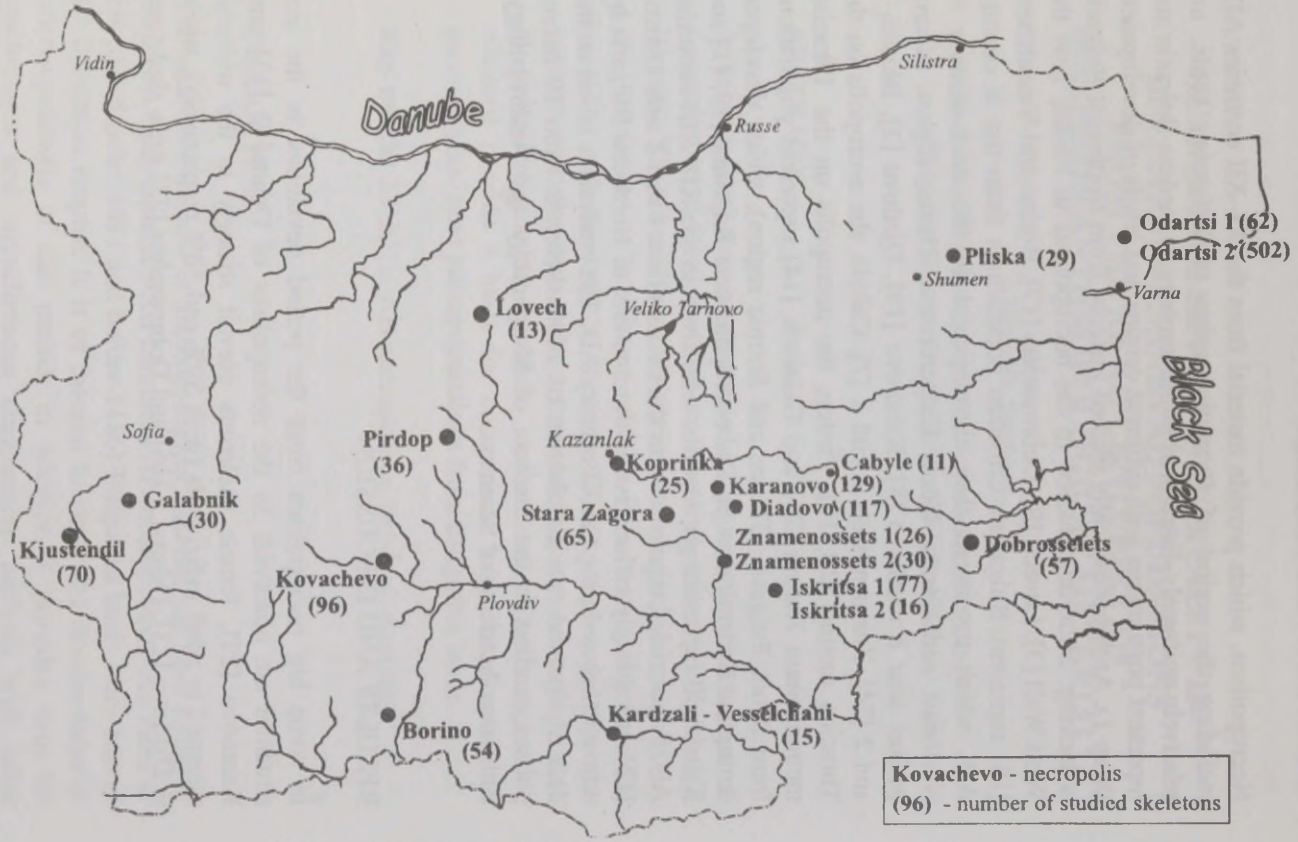
MATERIALS AND METHODS

Necropolises, which provide material from the XI–XII centuries AD, including the period of Byzantine reign of Bulgarian lands, are relatively uniformly distributed in the territory of modern Bulgaria and represent populations with different origins and levels of development (Map 1). Anthropologically studied material from Northwest Bulgaria is lacking. Materials studied in the necropolises in Pliska, near the West Wall [3], Lovech [9], Dobrosselets [17], Borino and Vesselchani [18] represent Bulgarian Christian populations from the X century AD, which continued their development in the next century in Northeast and Central-North Bulgaria and Thrace region. Necropolises near Kovachevo [8], Karanovo [19], Djadovo [2], Iskritsa 1 and 2 [24], Znamenossets 1 and 2 [7], Cabyle, the necropolis on the Thracian mound [20, 10], Pirdop, the necropolis on the Thracian mound, Stara Zagora [25] and Galabnik [14] represent populations from South Bulgaria (Thrace and Struma region), which developed during the Byzantine reign. The necropolis near Koprinka [19, 11] and Kyustendil represent populations who lived in the XII–XIII centuries AD. Populations, represented in the necropolises 1 and 2 near Odartsi [12], are strongly influenced by the invasion of Northeast Bulgaria by nomadic tribes during the XI century AD. The analysis is based on the data of age and sex distribution of 1456 skeletons from 19 necropolises, studied in the Institute of Morphology and Anthropology, Bulgarian Academy of Sciences.

RESULTS AND DISCUSSION

In some big necropolises from the period deviations in the sex structure are observed. In the necropolises of Odartsi 2 [13] and Karanovo [22], female skeletons prevail strongly in the material assigned to adult individuals (with 59% and 58% respectively), while in Djadovo [23], Odartsi 1 [16] and Dobrosselets [23] male skeletons

Map 1. Anthropologically studied necropolises in the Bulgarian territory, XI–XII centuries AD



are predominating (with 56%, 57% and 58% respectively). In the necropolises of Kovachevo [1], Iskritsa 1 [23], Znamenossets 1 and 2 [23], Kjustendil, Stara Zagora [23], Borino [4] and Pirdop both sexes are relatively equally represented in the studied anthropological material. In some small necropolises, in which the number of skeletons of adult persons does not exceed 20, uneven distribution between skeletons of both sexes is strongly pronounced. Male skeletons prevail more often: in Iskritsa 2 with 57%, Vesselchani with 64%, Pliska, West wall [6] with 69%. Female skeletons prevail only in two necropolises — Koprinka (71% in skeletons of adult individuals) and Galabnik (59%). In Cabyle [1], necropolis on the Thracian mound, Znamenossets 1 and 2 both sexes are relatively equally represented. Material from the necropolis in Lovech is not representative because of its insufficient anthropological investigation. It can be supposed that some external factors have reduced the male population of Odartsi 2. Such hypothesis is supported by the very high absolute number of female skeletons compared to male skeletons (144 to 100) and in juxtaposition with the necropolis of Odartsi 1, where male skeletons prevail. Diminution of male population, most probably caused by political factors, could be supposed to have also affected the population represented in anthropological material from Karanovo. It is too early to draw firm conclusions, but from data obtained from small necropolises it could be supposed that in some small populations, which probably lived in isolation during the period, sex distribution was uneven because of internal factors.

Distribution of skeletons in five years age groups and relative number of skeletons (Fig. 1) of each age group is the basis of research into mortality and survival. In some of the sites the relative number of skeletons in the first age group (0–4 years) is very small and does not allow us to draw conclusions about mortality and survival in this age group. These reduced values are most probably caused by bad conservation of infant skeletons, careless treatment of infant dead or poor investigation level. In the necropolises from the period, where infant skeletons are found in sufficient number and the percentage of infant skeletons found exceeds 40% from the whole material, values of relative number of dead in the age group of 0–4 years are the highest. The highest infant mortality in this age group was established in the population from Karanovo (31.78% of skeletal material). In population from Odartsi 2 (Fig. 1) the relative number of dead in the first age group (0–4 years) is also high (25.70%) and could be even

higher according to the field documentation where skeletons of very young children were recorded but then destroyed during the excavation (27.20%). The relative number of dead in the first age group (0–4 years) is lower in Djadovo (23.41%), Stara Zagora (20%) and Koprinka, necropolis on the Thracian mound (20%). High infant mortality is reflected in the values of the relative number of the survived, which in necropolises with highest infant mortality reaches 50% of population in an early age of 20–24 years — Odartsi 2 and Karanovo, in population from Stara Zagora in the next age interval (Fig. 2).

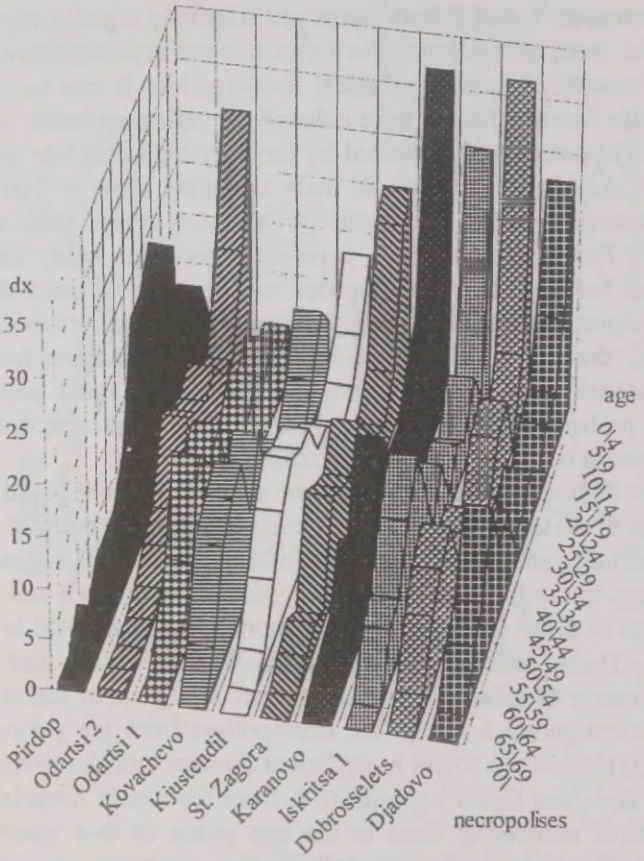


Figure 1. Relative number of dead, according to data from anthropological material from necropolises, dated XI–XII centuries AD in Bulgaria

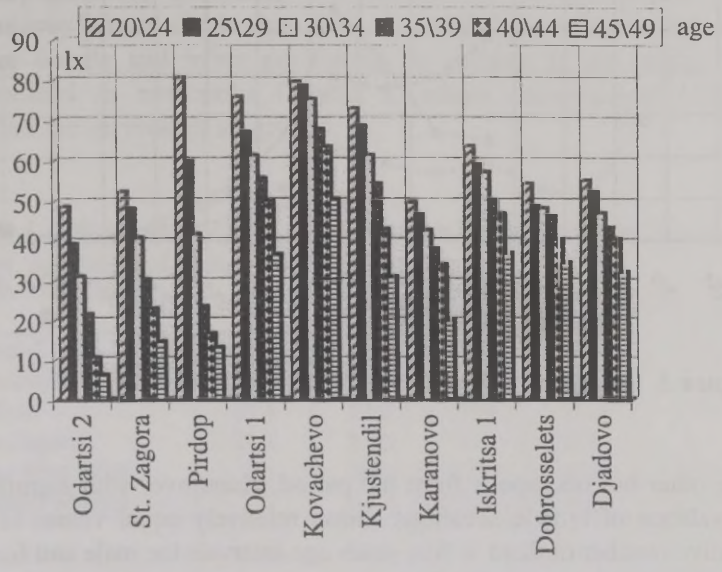


Figure 2. Age, in which the relative number of the survived is calculated to be 50%, in populations from XI–XII centuries, according to the studied anthropological material

In the period there are significant differences in age-specific mortality between the two sexes. A high relative number of dead among young females as compared to males of the same age is characteristic of the studied population, like in all societies at a low level of demographic development. This tendency is strongly pronounced in the material from Odartsi 2, where the relative number of female skeletons in the first age group of adults (20–24 years) reaches 24.30% of all female skeletons, a value twice higher than the relative number of male skeletons in the same age group — 12% of all male skeletons (Fig. 3). In this necropolis values of the relative number of dead are higher in the age group of Adultus (five years intervals between 20–40 years) for both sexes compared to the material from other necropolises from the period. In consequence the relative number of the survived in this population reaches 50% in the relatively earlier age of 30–34 years for females and 35–39 for males, after which age the relative number of the survived rapidly goes down and the relative number of skeletons, determined as from individuals in the age group of Maturus is very limited for both sexes.

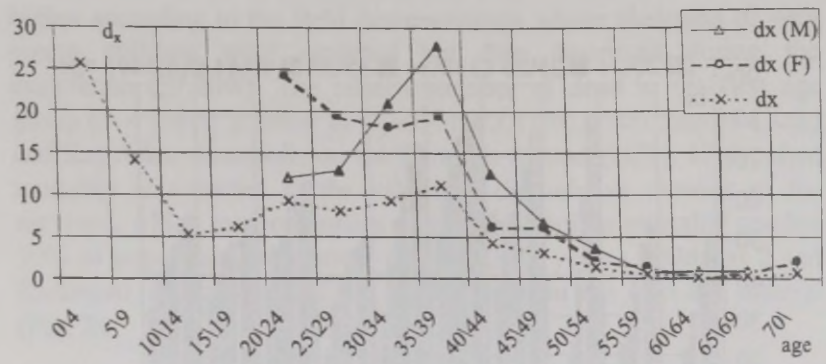


Figure 3. Relative number of dead in necropolis Odartsi 2

The other big necropolis from the period, Karanovo, with significant prevalence of female skeletons shows relatively equal values of the relative number of dead in five-years age intervals for male and female population, except for the first age group, where male skeletons are not recorded. This specific deviation in age-sex distribution of material from this necropolis, with missing male skeletons in first age interval and significant prevalence of female skeletons could be a mark that the entire male population was not represented in the material.

It is difficult to draw conclusions about life expectancy in all populations from the period represented in the anthropological material from the necropolises of XI–XII centuries AD. In the cases, where the relative number of infant skeletons reaches and exceeds 40%, it is possible to assess life expectancy in the first age group (Table 1). The values of this coefficient are the lowest in the population from the necropolis Odartsi 2 — 20.2 years, and even lower if material recorded during excavations is regarded. Life expectancy in this necropolis, calculated for first age group of adults (Table 1), is one of the lowest in the entire period of Bulgarian Middle Ages, with values of 16 years for males and 13.5 for females [15]. In the population from Karanovo life expectancy in the first age group reaches 24.4 years. The data of life expectancy in this population point to a relatively equal life expectancy in the five years age intervals between both sexes, with the exception of the first age group of adults (20–24 years), in which male skeletons have not been recorded (Table 1). Probably the bad survival conditions of this population affected in general some of the age-sex groups, probably from the

male population, smoothing the differences in age-specific life expectancy between both sexes (Fig. 4), and did not reflect as strongly on the female and infant population, in contrast to the population represented in necropolis Odartsi 2, where inconvenient factors affected the survival of all groups.

Table 1. Life expectancy for first five years intervals of age groups of Infant, Adultus and Maturus and for both sexes

	E_0	$E_{20}M$	$E_{20}F$	$E_{40}M$	$E_{40}F$
Odartsi 2	20,2	16	13,5	7,9	10,6
Karanovo	24.4	20.8	22	10.5	8.8
Djadovo	28.4	27.6	23.8	11.7	11.8
Stara Zagora	23.3	22.7	15.1	7.5	8.5
Pliska West Wall	X	23.3	25	10.8	11.7
Koprinka Mound	27	27.5	20.8	10.8	6.4

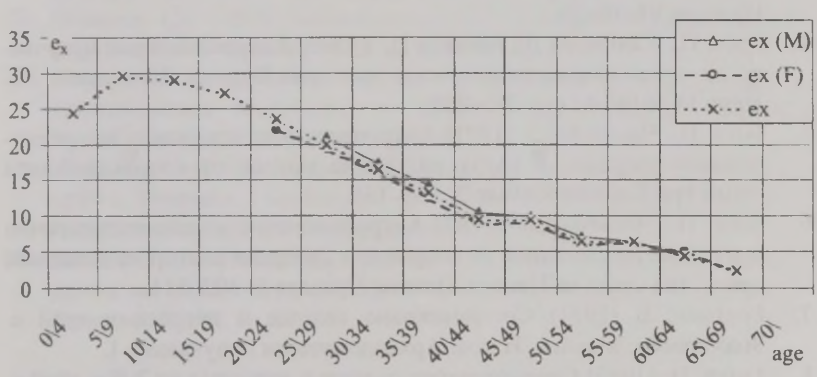


Figure 4. Age-specific life expectancy in population from Karanovo

Other big necropolises from the period show relatively high life expectancy for the first age group as related to the populations from the IX–X centuries AD [15]. In the population from Djadovo the values of life expectancy in the first age group (0–5 years) reach 28.4 years. Values of life expectancy in the populations from the XI–XII centuries AD from Bulgaria remain relatively high (Table 1) in age groups of adults in comparison with medieval populations from the

IX–X centuries AD [15]. This observation, as well as dating of these necropolises — a number of them represent populations, which developed from the X century AD, others originated from the XI century AD and continued their development in the XIII century AD — represent the period as one with good survival conditions for the studied populations.

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Papers on Anthropology XI, 2002, pp. 200–206

NUTRITION OF ELDERLY PEOPLE IN MERIVÄLJA NURSING HOME

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ABSTRACT

In Merivälja nursing home the actual nutrition of 105 elderly people in 2000 was calculated with the local ANKE-PC-program from menus at 10 days intervals in January and April and compared with the nutrition data of the same nursing home in 1978.

Over 20 years there has been only modest improvement in nutrition (P/C ratio has achieved 0.5 and dietary cholesterol has decreased) and in choice of healthier foods at the nursing home. Calculated total food energy was high, depending on highly planned carbohydrates (from cereals and sugar) content (57–63% of total energy in 2000 vs. 46% in 1978); in 1978 more animal foodstuffs were used as the main protein (60%) and fat sources (87%) than in 2000 (41–46%) and 64–74%); minerals and vitamins met recommended level, expect calcium (because of reduced consumption of milk and milk products).

Nutrition should receive much more attention in provision of food and nursing to the elderly in nursing homes.

Key words: elderly, dietary intake

INTRODUCTION

The aim of the study was to characterise nutrition of the elderly in Merivälja nursing home and demonstrate some trends in food choice over a 20 years interval.

Our earlier studies on nutrition and metabolism of the elderly (publications by E. Vagane, M. Saava, V. Pauts, 1977, 1981, 1982) are based on the materials of residents of nursing homes (Iru, Merivälja). [1, 2, 3]. This was part of a programme covering the whole of the former Soviet Union, *Prolonging of life expectancy*, which was conducted by the Institute of Gerontology and Geriatrics in Kiev. Reports were presented at all-Union congresses (Kiev, 1976; Chisinau, 1982) and Trans-Caucasian conferences (Yerevan, 1980; Baku, 1984; Tbilisi, 1990).

In 1995 we studied home-living retired people in Tallinn as a vulnerable group of population [4]. The results of this study helped the Ministry of Social Affairs to estimate the nutrition situation of the retired and compose the recommended food-basket for the elderly.

Results of the recent studies compared to our earlier data have been reported at the 2nd and 3rd European Congresses on Nutrition and Health of the Elderly People (Elsionore, Denmark, 1995; Madrid, Spain, 2000) [5,6].

MATERIALS AND METHODS

We calculated the composition of the diet for the elderly residing at Merivälja nursing home. Energetic value and nutrient intake were calculated from the quantities of foodstuffs in the menus during 10 days intervals in January and April 2000. A special PC-program (ANKE-PC) with a local database was used [7]. ANKE-PC has been validated as reliable in our previous study to some others available in Estonia programs (DanKost 2 and Micronutrica) [8].

For estimating how healthy the composed menus are, the recommended food-basket (1995, 1979) for the elderly and overall suggested proportions between macronutrients were juxtaposed in Tables 1 and 2 (Estonian Nutrition Recommendations, 1995 and Food Guidelines, 1998) [9, 10]. The diet for the elderly in 2000 was

compared with an earlier investigation of nutrition in the same Merivälja nursing home in 1978 [11].

Table 1. Total energy (kcal) and macro- and micronutrients (g or mg per day, E%) in the menus of Merivälja nursing home

Year / Nutrient	Recommendation 1995 (1979)	2000 January	2000 April	1978 November
Total protein, g	85.3 (72)	95.5	92	101
E%	15% (10-12%)	12.3%	12%	14%
Animal protein, g		45.5	41	61
Vegetable protein, g		54.4	51	40
Total fat, g	88 (67)	108.6	86	133
E%	35%	31.2%	25%	40%
Animal fat, g	(30–32%)	64.5	65	115
Vegetable fat, g		35.4	21	18
Carbohydrates, g	278 (289)	444	477	370
E%	50% (56–60%)	56.6%	63%	46%
Energy, kcal	2277 (2100)	3134	3049	3004
Vitamin A, mg RE	1.0	0.78	1.0	0.64
Beta-carotene, mg	–	2.79	3.76	1.99
Vitamin B1, mg	1.0	1.74	1.0	1.68
Vitamin B2, mg	1.2	1.96	1.57	2.08
Vitamin E, mg	10	23	17.0	19.8
Vitamin C, mg	60	85.6	71.9	62.0
Calcium, mg	1000–1500	970	931	1156
Magnesium, mg	400	473	448	422
Phosphorus, mg	1600	1867	1664	1841

Table 2. Mean composition of 10-day-menus of the elderly in Merivälja nursing home: Food items (grams per day) and their percentage in food energy distribution (E%)

Foodstuff	Rec	Grams per day			Energy % (E%)		
	1995	2000 Jan	2000 Apr	1978 Nov	2000 Jan	2000 Apr	1978 Nov
Milk and milk products		501	5041	635	21.4	19.2	28.6
Milk, yoghurt	410	408	393	454	7.8	7.7	8.8
butter	10	28.2	29.3	35	6.7	7.2	8.7
cream	15	16.8	24.6	55	1.1	1.7	4.5
cheese	10	8.2	5.2	19	0.9	0.5	2.1
milk-products	40	39.8	52.0	72	1.2	1.8	4.5
Meat and meat-products	100	97.6	83.9	135	8.5	6.7	10.5
Fish	80	10.3	12.6	34	0.8	0.8	1.0
Eggs pc.	0.4	31	17.6	23	1.6	0.9	1.1
Fruit and berries	150	54.1	58.5	125	1.3	1.7	3.4
Vegetables	300	165	1687	125	2.5	2.7	1.6
Potatoes	200	193	144	146	5.6	4.3	4.1
Vegetable oils, margarine	20	21.5 11.4	10.9 3.3	6 14	8.3	3.7	5.3
Bread (rrye, wheat)	160+50	390	393	388	27.5	32.4	28.7
Cereal, grain	90	139	107	57	15.7	12.4	5.8
Sugar, sweets	50	86.4	126	84	10.7	15.1	9.7

RESULTS AND DISCUSSION

Food and nutrient intake data

Tables 1 and 2 present the nutrient intake and food consumption data in 2000 and 1978. As expected, the calculated total food energy (3000 kcal) was much higher than recommended (Table 1). It depends on the method that gives higher data than other methods (for example the 24-hour-recall-method) that take data from the table and estimate very exactly the real quantities eaten. The residents of the nursing home do not eat up everything in the planned menu; a lot of it goes to waste, especially the part rich in carbohydrates.

The basic trend common to the present menu of Merivälja nursing home in comparison with the diet of 1978 is the very highly planned carbohydrate content (444–477 g/d) that covers 57–63% of total food energy; in 1978 it was 46%. At the same time animal fat and protein content has decreased. As seen in Table 2, in the diet of 2000 all kinds of bread covered 29–32%, other cereals 12–16%, and sugar and sugar-containing sweets 11–15% of energy against 29%, 6% and 10% in 1978.

As regards the other main sources of nutrients, we can see that in the 1970s animal foodstuffs predominated as protein and fat sources. 60% of proteins and 87% of fats were of animal origin because of high content of milk and fatty meat products in the diet. Now 41–46% of proteins and 64–74% of fats are animal, as meat, fish, cheeses and other milk products (cheese) are expensive to be consumed in recommended quantities. Meat and meat products cover 7–8% of food energy, while butter makes up 8%, and sugar and sweets 11–16% of food energy.

The availability of fruit and berries has decreased. The amount of potatoes and bread has remained at the same level.

The only very positive trends in foodstuff choice appeared in the increase of vegetable oils and vegetables; the fat composition of diet has changed in the recommended direction (P/S ratio has achieved 0.5), and dietary cholesterol is low enough (only 187 mg/d). Nevertheless the servings of vegetables do not reach the recommended level. Potatoes and cereals have to ease the shortage of vegetables and fruit on the table.

Calcium content is low and has decreased because of reduced milk and milk products. The proportion of calcium to phosphorus (1:1.68 –

2.0) has changed in an unfavourable direction in comparison to previous data (1:1.6) (recommended ratio Ca/P =1:1.5–1.6).

Food availability depends greatly on prices. At low cost it is impossible to compose menus that meet the recommended requirements in all details. Therefore, the calcium and vitamin A supply may be insufficient.

In conclusion, over more than 20 years interval, there has been only a modest improvement in choice of healthier foods, which have a lower fat content and contain more unsaturated fatty acids and less cholesterol. Animal products are less available in menus today. On the one hand, this might be estimated as a positive trend, but on the other hand, it may cause some imbalances in nutrition (for example deficiency of antioxidants and calcium). The high proportion of carbohydrates (and sugar) can cause overweight, especially in the physically inactive elderly. More low-fat but rich in calcium milk and fructose-containing fruit would be good for the health, for prevention and treatment of osteoporosis and improvement of the vitamin status. Nutrition should receive much more attention in provision of food and nursing to the elderly in nursing homes.

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Papers on Anthropology XI, 2002, pp. 207–220

AGE VARIABILITY OF SCHOOLCHILDREN'S BODY BUILD CHARACTERISTICS IN THE CITIES OF BELARUS WITH DIFFERENT URBAN SATURATION

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ABSTRACT

Research of three age groups (8, 13 and 17 years) of secondary school children in cities of Belarus with a different urban saturation was carried out. Minsk and Gomel are cities with a high level of urbanisation, and Pinsk and Krichev — cities with a medium level of urbanisation. A tendency to greater gracility of skeletal sizes, smaller degree of subcutaneous fat deposit and brachymorphy in boys and girls in cities with middle level of urbanisation was detected. An opposite tendency was characteristic of schoolchildren in cities with a high level of urbanisation. Besides having a somewhat greater chest volume, they tend to have its significantly smaller excursion in all age groups of boys and only in the 8-year-olds' group of girls ($p<0.001$). Such a peculiarity can be explained by the strain on adaptation mechanisms of the respiratory system in the heavily polluted air in highly urbanised cities. Some respiratory deficiency in all age groups of boys in highly urbanised cities is due to the greater sensitivity of the man's organism to the negative action of environmental factors.

INTRODUCTION

The formation of a child's organism happens under the continuous positive or negative influence of various combinations of ecological (natural and social) factors of habitat [3–5]. In the process of increasing urban saturation of a settlement the combination of these factors becomes complicated, and the load on children's compensatory mechanisms increases, especially during the acceleration of growth processes [9, 10]. At the turn of the millennium the negative environment pressure on populations in large cities of the Republic of Belarus has increased owing to intensification of urbanisation processes [1, 8]. The differences in morphological indices of physical development of schoolchildren living in the cities of Belarus at a medium level of urbanisation situated in three geochemical provinces had been studied earlier. These provinces differ in the degree of concentration of vital micro- and macroelements in potable water and soils [6]. The analysis of changes in the physical development of the schoolchildren of Minsk and Lodz (from the 1980s to the end of the 1990s) has allowed us to establish negative dynamics in a series of their morphological indices [7, 11]. The research of pupils of secondary schools in the centre of Gomel and its Volotova district has revealed differences in the adaptive abilities of the cardiovascular system within the limits of one city. The comparison of these data with similar ones from Minsk reflects a strain on adaptation mechanisms in pupils from Minsk and the Volotova district of Gomel [12].

MATERIAL AND METHODS

Three age groups (8, 13 and 17 years) of secondary school students of Minsk (1999—2000), Gomel (1998—2000), Pinsk (2001) and Krichev (2001—2002) were investigated under an anthropological program. The total number of subjects amounted to 1966 persons (930 boys and 1036 girls). The measuring was carried out according to the program described in the methodical manual by V. V. Bunak [2]. Leg length was represented as the difference between height and sitting height.

Body mass index (BMI):

$$BMI = \text{weight (kg)} / \text{height}^2 (m^2),$$

index of relative lower limb length (RLLL):

$$RLLL = \text{lower limb length (cm)} / \text{height (cm)} * 100$$

and chest depth/breadth index (CD/B):

$$CD/B = \text{chest depth (mm)} / \text{chest breadth (mm)} * 100$$

were calculated.

The material is presented by sex and age groups of schoolchildren taking into account urban saturation of the settlements where research was carried out. A high level of urbanisation (HU) is characteristic of large industrial centres — Minsk and Gomel. Pinsk and Krichev are localities at a medium level of urbanisation (MU).

The standard statistical data processing was carried out. The method of Student's t-criterion was chosen for definition of statistical reliability of among-group differences.

RESULTS

An attempt was undertaken to reveal the differences between schoolchildren from cities with a different degree of urbanisation, applying the basic traits of physical development — height, weight and chest circumference.

Among the cities where research was carried out, Krichev is the least urbanised locality; in ascending order of urbanisation it is followed by Pinsk, Gomel and Minsk.

The analysis of the data showed a marked tendency towards augmentation of height when the urbanisation of a settlement increases.

So, the height of 8-year-old children increases with the augmentation of the urbanisation degree. In the cities at the medium urbanisation level it is somewhat smaller, reaching in Krichev 129.3 cm in boys and 127.4 cm in girls, in Pinsk — 127.7 cm and 128.3 cm respectively. In highly urbanised cities it is characterised by the following numbers: in Gomel — 129.8 cm and 128.5 cm, in Minsk — 130 cm and 129.8 cm.

At the age of 13, the boys (158.1 cm) and girls (158.9 cm) from Pinsk surpass their coevals from other cities — Krichev (152.6 cm and 153.5 cm), Gomel (156.1 cm and 157 cm) and Minsk (157.7 cm and 157.1 cm respectively).

Among 17-year-olds the smallest height was observed in the young men from Krichev (175.8 cm) and girls from Pinsk (162.9 cm). Height increases among the young men in the following sequence: in Gomel — 176.4 cm, in Minsk — 176.7 cm and in Pinsk — 177.3 cm; and among girls: in Krichev — 163.6 cm, in Gomel — 165.2 cm, in Minsk — 166.3 cm respectively. The large height of the young men of Pinsk cannot be considered significant because of the small size of the sample (n=24).

Among all the compared territorial groups there were significant differences in height only between 13-year-schoolchildren from Krichev and Pinsk: the boys of Krichev were 5 cm shorter ($p<0.01$) and the girls of Krichev 5.5 cm shorter ($p<0.001$).

The comparison of the weight and chest circumference of schoolchildren from Krichev and Pinsk revealed a significant lag in 13-year-old girls from Krichev — their weight was smaller by 3.5 kg ($p<0.05$) and chest circumference by 3 cm ($p<0.02$). The comparison of Minsk and Gomel schoolboys revealed a significant difference only in 8-year-old boys' chest circumference, which was 2.5 cm smaller in Minsk ($p<0.001$).

The absence of significant differences between groups of one sex and age from cities with an identical urbanisation degree in most characteristics allowed us to aggregate the materials from Krichev and Pinsk in cohort MU (from localities at a medium urbanisation level), and from Minsk and Gomel — in cohort HU (from localities at a high urbanisation level). The basic statistical parameters are presented in Tables 1 and 2.

Table 1. Basic statistics of anthropometrical measurements and indices of boys grouped into HU (Minsk, Gomel) and MU (Pinsk, Krichev) cohorts (8-, 13-, 17-year-olds)

Variable	HU (Minsk, Gomel)				MU (Pinsk, Krichev)			
	n	Mean	m(x)	SD	n	Mean	m(x)	SD
8 years								
height (cm)	209	129.86	0.40	5.79	105	128.48	0.49	5.01
sitting height (cm)	209	69.88	0.21	2.97	105	69.17	0.25	2.60
lower limb length (cm)	209	59.97	0.28	4.11	105	59.31	0.34	3.51
weight (kg)	209	27.52	0.34	4.94	105	26.17	0.42	4.31
Circumferences (mm)								
head	209	529.93	1.02	14.80	103	529.29	1.32	13.43
chest	209	607.74	3.06	44.28	105	607.20	3.64	37.28
waist	209	558.26	3.16	45.72	105	559.60	4.19	42.89
forearm above wrist	209	130.14	0.65	9.36	105	127.82	0.89	9.10
shin above ankle	208	177.12	0.97	13.99	105	172.32	1.18	12.10
Breadth measurements (mm)								
biacromial breadth	209	274.61	1.10	15.94	105	273.57	1.24	12.70
bicristal breadth	209	202.24	0.95	13.79	105	198.72	1.13	11.58
chest breadth	209	195.51	0.77	11.10	105	193.48	1.07	10.92
chest depth	209	138.64	0.68	9.84	105	136.89	0.93	9.54
humerus (elbow) breadth	209	54.68	0.21	3.01	105	54.30	0.28	2.92
femur (knee) breadth	208	80.75	0.28	4.04	105	79.66	0.37	3.78
Skinfolds (mm)								
cheek	209	9.56	0.16	2.26	105	9.50	0.21	2.17
chin	209	5.43	0.15	2.19	105	5.12	0.18	1.87
subscapular	209	6.28	0.20	2.90	105	5.74	0.24	2.48
abdominal	209	7.57	0.32	4.61	105	6.81	0.40	4.13
triceps	208	10.97	0.25	3.65	105	10.15	0.35	3.56
biceps	208	4.91	0.14	2.07	105	4.91	0.19	2.00
mean skinfold	208	7.42	0.18	2.64	105	7.04	0.24	2.42
Excursion of chest and indices								
EC (mm)	209	60.17	0.79	11.45	105	63.45	1.01	10.34
BMI (kg/m^2)	209	16.23	0.14	1.98	105	15.79	0.19	1.95
RLLL (%)	209	46.15	0.13	1.82	105	46.14	0.15	1.49
D/BC (%)	209	71.00	0.32	4.57	105	70.82	0.43	4.37

Variable	HU (Minsk, Gomel)				MU (Pinsk, Krichev)			
	n	Mean	m(x)	SD	n	Mean	m(x)	SD
13 years								
height (cm)	241	156.57	0.54	8.38	109	155.48	0.92	9.62
sitting height (cm)	241	79.39	0.28	4.27	109	79.71	0.47	4.89
lower limb length (cm)	241	77.18	0.33	5.06	109	75.77	0.52	5.46
weight (kg)	241	44.39	0.56	8.71	109	44.47	0.96	10.02
Circumferences (mm)								
head	239	545.18	1.08	16.68	109	547.84	1.48	15.46
chest	241	722.87	3.76	58.31	109	724.87	6.35	66.27
waist	241	633.51	4.04	62.75	109	643.68	5.53	57.73
forearm above wrist	241	145.59	0.79	12.25	107	146.80	1.28	13.26
shin above ankle	240	206.31	1.18	18.32	109	203.43	1.77	18.51
Breadth measurements (mm)								
biacromial breadth	241	327.46	1.25	19.33	109	328.31	2.24	23.43
bicristal breadth	241	240.36	1.18	18.31	109	239.90	1.71	17.83
chest breadth	241	228.15	1.14	17.72	109	230.34	1.82	19.03
chest depth	241	160.02	0.95	14.76	109	159.79	1.57	16.43
humerus (elbow) breadth	241	64.82	0.28	4.28	108	65.16	0.47	4.90
femur (knee) breadth	238	92.20	0.32	4.94	106	91.65	0.56	5.74
Skinfolds (mm)								
cheek	241	9.24	0.15	2.26	109	9.25	0.21	2.19
chin	241	5.60	0.14	2.17	109	5.40	0.18	1.84
subscapular	241	7.44	0.23	3.56	109	7.18	0.26	2.68
abdominal	241	9.24	0.34	5.32	109	9.63	0.54	5.65
triceps	241	11.46	0.29	4.53	109	11.82	0.41	4.28
biceps	241	4.95	0.16	2.44	109	5.52	0.25	2.61
mean skinfold	241	7.99	0.20	3.10	109	8.13	0.28	2.91
Excursion of chest and indices								
EC (mm)	241	67.59	0.89	13.76	109	71.96	1.10	11.44
BMI (kg/m^2)	241	17.99	0.17	2.61	109	18.21	0.25	2.64
RLLL (%)	241	49.28	0.09	1.38	109	48.72	0.12	1.27
D/BC (%)	241	70.29	0.38	5.83	109	69.46	0.52	5.41

Variable	HU (Minsk, Gomel)				MU (Pinsk, Krichev)			
	n	Mean	m(x)	SD	n	Mean	m(x)	SD
17 years								
height (cm)	190	176.41	0.44	6.00	76	176.30	0.79	6.88
sitting height (cm)	190	90.94	0.26	3.62	76	91.65	0.42	3.64
lower limb length (cm)	190	85.46	0.28	3.82	76	84.64	0.53	4.64
weight (kg)	188	64.92	0.72	9.82	76	65.30	1.25	10.88
Circumferences (mm)								
head	189	568.00	1.08	14.86	74	568.12	1.68	14.42
chest	190	865.86	4.31	59.35	76	863.84	7.67	66.90
waist	190	727.09	4.59	63.27	76	727.20	6.42	55.94
forearm above wrist	190	162.83	0.64	8.86	76	165.68	1.46	12.69
shin above ankle	190	222.82	0.99	13.67	75	222.09	1.79	15.53
Breadth measurements (mm)								
biacromial breadth	190	378.34	1.44	19.79	76	382.05	2.41	20.98
bicristal breadth	190	277.66	1.20	16.50	76	278.97	1.87	16.32
chest breadth	190	271.86	1.58	21.77	76	273.99	2.22	19.36
chest depth	190	185.14	1.32	18.20	76	183.30	2.21	19.24
humerus (elbow) breadth	190	71.82	0.24	3.33	76	72.53	0.47	4.11
femur (knee) breadth	188	97.01	0.32	4.45	76	97.29	0.61	5.33
Skinfolds (mm)								
cheek	190	7.56	0.14	1.99	76	7.79	0.23	2.01
chin	190	4.53	0.13	1.78	76	4.63	0.22	1.92
subscapular	190	9.46	0.26	3.64	76	8.86	0.32	2.77
abdominal	190	11.26	0.45	6.27	76	10.00	0.66	5.76
triceps	190	10.23	0.28	3.84	76	9.55	0.40	3.47
biceps	190	4.10	0.14	1.91	76	4.33	0.24	2.12
mean skinfold	190	7.86	0.21	2.90	76	7.53	0.31	2.70
Excursion of chest and indices								
EC (mm)	190	75.77	1.08	14.93	76	82.66	1.62	14.13
BMI (kg/m^2)	188	20.84	0.20	2.80	76	20.95	0.34	2.93
RLLL (%)	190	48.44	0.09	1.26	76	48.00	0.16	1.36
D/BC (%)	190	68.39	0.54	7.49	76	66.96	0.67	5.83

EC – Excursion of chest
BMI – body mass index
RLLL – relative lower limb length
D/BC – chest depth / chest breadth

Table 2. Basic statistics of anthropometrical measurements and indices of girls grouped into HU (Minsk, Gomel) and MU (Pinsk, Krichev) cohorts (8, 13, 17 years old)

Variable	HU (Minsk, Gomel)				MU (Pinsk, Krichev)			
	n	Mean	m(x)	SD	n	Mean	m(x)	SD
8 years								
height (cm)	226	128.85	0.35	5.31	102	127.85	0.57	5.77
sitting height (cm)	226	69.09	0.19	2.86	102	68.38	0.27	2.77
lower limb length (cm)	226	59.76	0.23	3.39	102	59.47	0.36	3.59
weight (kg)	226	26.31	0.29	4.31	102	25.48	0.43	4.34
Circumferences (mm)								
head	223	517.15	0.81	12.14	102	522.76	1.43	14.48
chest	225	590.64	2.50	37.57	102	588.88	3.61	36.46
waist	226	531.35	2.89	43.52	102	535.65	4.44	44.86
forearm above wrist	226	126.09	0.55	8.28	102	126.99	0.96	9.72
shin above ankle	226	175.61	0.82	12.33	102	173.41	1.37	13.83
Breadth measurements (mm)								
biacromial breadth	226	270.16	1.11	16.68	102	269.93	1.84	18.59
bicristal breadth	226	200.90	0.99	14.87	102	197.80	1.33	13.42
chest breadth	226	189.03	0.66	9.96	102	188.92	1.09	11.05
chest depth	225	131.79	0.65	9.75	102	131.19	1.10	11.16
humerus (elbow) breadth	226	52.07	0.21	3.15	101	52.00	0.29	2.87
femur (knee) breadth	224	76.15	0.27	3.97	101	76.14	0.42	4.27
Skinfolds (mm)								
cheek	226	10.33	0.15	2.29	102	10.74	0.22	2.26
chin	226	5.93	0.13	1.98	102	5.86	0.21	2.10
subscapular	226	7.12	0.21	3.17	102	6.59	0.25	2.51
abdominal	226	8.78	0.30	4.46	102	8.16	0.41	4.10
triceps	226	12.85	0.25	3.75	102	12.61	0.37	3.74
biceps	226	5.88	0.15	2.31	102	6.32	0.23	2.29
mean skinfold	226	8.48	0.18	2.67	102	8.38	0.25	2.57
Excursion of chest and indices								
EC (mm)	226	57.69	0.72	10.81	102	64.81	1.02	10.35
BMI (kg/m^2)	226	15.80	0.13	1.94	102	15.52	0.18	1.86
RLLL (%)	226	46.36	0.09	1.34	102	46.49	0.11	1.16
D/BC (%)	225	69.81	0.33	4.92	102	69.48	0.46	4.66

Variable	HU (Minsk, Gomel)				MU (Pinsk, Krichev)			
	n	Mean	m(x)	SD	n	Mean	m(x)	SD
13 years								
height (cm)	279	157.04	0.46	7.64	107	156.38	0.71	7.37
sitting height (cm)	279	81.27	0.25	4.21	107	81.14	0.42	4.30
lower limb length (cm)	279	75.77	0.29	4.83	107	75.24	0.44	4.50
weight (kg)	279	45.54	0.53	8.80	107	44.32	0.89	9.16
Circumferences (mm)								
head	278	540.23	0.89	14.88	104	539.92	1.47	15.04
chest	279	729.67	3.43	57.37	107	721.75	6.10	63.09
waist	279	616.76	3.54	59.09	107	617.07	5.71	59.10
forearm above wrist	279	144.37	0.71	11.79	107	143.28	1.20	12.38
shin above ankle	279	205.83	0.94	15.74	107	201.23	1.72	17.84
Breadth measurements (mm)								
biacromial breadth	278	325.79	1.10	18.32	107	324.44	1.94	20.08
bicristal breadth	278	249.41	1.10	18.28	107	245.50	1.81	18.71
chest breadth	278	224.78	0.91	15.26	107	224.85	1.72	17.78
chest depth	278	155.88	0.81	13.57	107	156.27	1.61	16.65
humerus (elbow) breadth	278	60.54	0.20	3.32	106	60.96	0.38	3.94
femur (knee) breadth	279	85.99	0.28	4.60	106	85.25	0.39	4.00
Skinfolds (mm)								
cheek	279	10.30	0.14	2.33	107	10.21	0.23	2.34
chin	279	6.15	0.14	2.28	107	6.25	0.19	1.97
subscapular	279	9.72	0.24	4.07	107	9.21	0.37	3.81
abdominal	279	12.42	0.33	5.52	107	11.70	0.53	5.45
triceps	279	14.28	0.26	4.26	107	14.31	0.47	4.81
biceps	279	6.48	0.16	2.68	107	7.01	0.31	3.23
mean skinfold	279	9.89	0.19	3.15	107	9.78	0.31	3.25
Excursion of chest and indices								
EC (mm)	279	69.07	0.86	14.34	107	71.84	1.14	11.74
BMI (kg/m^2)	279	18.35	0.16	2.65	107	18.05	0.31	3.23
RLLL (%)	279	48.23	0.10	1.63	107	48.11	0.15	1.55
D/BC (%)	278	69.46	0.33	5.53	107	69.56	0.56	5.75

Variable	HU (Minsk, Gomel)				MU (Pinsk, Krichev)			
	n	Mean	m(x)	SD	n	Mean	m(x)	SD
17 years								
height (cm)	241	165.46	0.35	5.39	81	163.31	0.65	5.84
sitting height (cm)	241	86.75	0.20	3.11	81	86.86	0.32	2.90
lower limb length (cm)	241	78.71	0.22	3.47	81	76.46	0.51	4.62
weight (kg)	241	55.23	0.47	7.32	81	54.58	0.86	7.76
Circumferences (mm)								
head	240	549.40	0.95	14.65	79	550.91	1.78	15.78
chest	241	794.95	2.76	42.77	81	798.51	5.26	47.30
waist	241	648.06	3.27	50.78	81	658.75	5.96	53.62
forearm above wrist	241	150.60	0.54	8.46	81	153.69	1.73	15.60
shin above ankle	240	214.14	0.86	13.28	81	210.67	1.24	11.17
Breadth measurements (mm)								
biacromial breadth	241	341.58	0.98	15.23	81	344.07	2.50	22.54
bicristal breadth	241	269.19	0.99	15.38	81	272.15	1.78	16.01
chest breadth	241	240.72	0.89	13.82	81	243.32	1.91	17.15
chest depth	241	164.92	0.83	12.94	81	163.81	1.64	14.73
humerus (elbow) breadth	240	61.51	0.19	2.96	81	62.60	0.32	2.92
femur (knee) breadth	239	88.55	0.27	4.11	80	87.49	0.52	4.62
Skinfolds (mm)								
cheek	239	10.81	0.13	2.02	81	11.25	0.26	2.33
chin	239	7.12	0.12	1.79	81	7.63	0.23	2.06
subscapular	240	12.69	0.28	4.36	81	12.88	0.50	4.53
abdominal	240	15.51	0.33	5.09	81	15.79	0.65	5.87
triceps	240	18.16	0.27	4.23	81	18.58	0.42	3.81
biceps	240	7.82	0.19	2.92	81	8.56	0.29	2.58
mean skinfold	239	12.02	0.18	2.84	81	12.45	0.33	3.01
Excursion of chest and indices								
EC (mm)	241	73.88	0.91	14.15	81	74.95	1.67	14.99
BMI (kg/m^2)	241	20.17	0.16	2.49	81	20.45	0.29	2.61
RLLL (%)	241	47.56	0.08	1.17	81	46.79	0.19	1.70
D/BC (%)	240	68.67	0.37	5.73	81	67.53	0.73	6.54

Length measurements and weight

Irrespective of a sex, the 8-year-old children in the MU cohort differ from their coevals from HU by smaller values of body height, sitting height, lower limb length, and weight. Boys differ significantly in the first two characteristics ($p<0.05$) and girls only in sitting height ($p<0.05$). The weight of MU boys ($p<0.02$) is significantly smaller. This trend in differences continues in girls at the age of 13 years in all variables but does not reach a significant level, and MU boys lag behind HU only in lower limb length ($p<0.05$) and height. At 17 years the difference between urban cohorts of young men, though keeping the same direction, becomes insignificant. The cohort of MU girls is characterised by significantly smaller height ($p<0.01$) and lower limb length ($p<0.01$).

Circumferences

In these characteristics 8-year-old MU boys were distinguished by significantly smaller circumference of forearm above wrist ($p<0.05$) and shin above ankle ($p<0.01$). The girls of same urban cohort had significantly larger head circumference ($p<0.001$). Chest circumference of MU girls and boys exceeded a little that of their HU coevals. In 13-year-olds almost all circumferences of MU boys were somewhat larger than in HU, only shin above ankle remained a little smaller. In MU girls head and chest circumferences were smaller, and also distal departments of shin above ankle ($p<0.02$) and forearm above wrist. In 17-year-old MU girls only shin circumference above ankle was smaller ($p<0.05$), and in young men circumferences of chest and shin above ankle.

Breadth measurements

Eight-year-olds cohorts of MU children of both sexes were distinguished by a small lag of biacromial and bicristal breadth, breadth and depth of chest, and also breadth of epiphyses of humerus (elbow) and femur (knee). Only bicristal breadth of boys ($p<0.02$) was significantly smaller. In 13-year-olds there were no significant differences, but the same trend of differences continued as in 8-year-old boys in

pelvis breadth and chest depth, breadth of epiphysis of femur, and in girls in biacromial and bicristal breadth, epiphysis of femur. In 17-year-olds nearly all differences between the urban cohorts were insignificant. Chest depth remained somewhat smaller in MU boys and girls. Breadth of epiphyses of humerus and femur in MU young men was bigger than in HU, and in MU girls breadth of epiphysis of humerus was significantly bigger ($p<0.02$), but breadth of epiphysis of femur was somewhat smaller.

Subcutaneous fat deposit

The tendency of less expressed subcutaneous fat in MU schoolchildren of both sexes was observed in the area of face, trunk and limbs. There were no significant differences.

Excursion of chest and indices

In all age groups of HU boys and girls excursion of chest was smaller. The differences were significant in boys in the age groups of 8 ($p<0.01$), 13 ($p<0.01$) and 17 years ($p<0.001$), and in girls only in the 8-year-olds group ($p<0.001$).

In BMI there were no significant differences, although at the age of 8 it was somewhat smaller in MU children of both sexes. In older age groups of boys BMI increased. In 13-year-old girls it was somewhat smaller, but at 17 years exceeded that of their HU coevals.

At the age of 8 the RLLL index was approximately identical in both urban cohorts without sexual differences. In 13-year-olds there were small sexual differences — the index was somewhat smaller in girls in comparison with boys, and it was smaller in MU children of both sexes — the difference between the cohorts of boys was significant ($p<0.001$). By the age of 17 the girls had become relatively more long-legged, and marked differences between MU and HU cohorts in 13-year-olds, increased a little. Thus the tendency to brachymorphy noticed in 13-year-olds increased significantly by 17 years both in young men ($p<0.001$) and girls ($p<0.02$).

The CD/B index (ration of chest depth to its breadth) was somewhat smaller in MU children at 8 years, at 13 years in MU boys and HU girls, and at 17 years was is smaller in MU young men and girls. The differences were not significant.

DISCUSSION

The results of the study showed that after the first acceleration of body height by 8-year-old children of both sexes in cities at a medium urbanisation level lagged behind their coevals from cities with a high urbanisation level in length and breadth measurements of the body and degree of subcutaneous fat. After the second (pubertal) acceleration of height by 13 years MU girls lagged behind HU in height, sitting height, lower limb length and weight, head and chest circumferences, and also in other skeletal sizes: in biacromial and bicristal breadth, breadth of epiphysis of femur, circumferences of distal departments of forearm and shin. MU boys whose pubertal acceleration of body height only begins at 13 years were distinguished by smaller height combined with smaller values of lower limb length, breadth of pelvis, depth of chest, circumference of shin above ankle and breadth of epiphysis of femur. Such features testified to greater gracility of skeleton of MU pupils in comparison with HU. By 17 years the values of height in MU and HU young men had become almost identical, but in the cities at a medium urbanisation level it happened mainly because of more intensive longitudinal growth of the spine, but in cities at a high urbanisation level — mainly because of more intensive growth of lower limbs. This statement was also proved by the direction of age variability of the relative lower limb length index. Better characteristics of forming and subcutaneous fat deposit in pupils in cities at a high urbanisation level may be explained by more varied and balanced nutrition. However, in HU boys and girls smaller excursion of chest, tendency to greater volume of chest retained during the whole period of studies at school together with worse functional parameters of the cardiovascular system mentioned by us earlier [12], probably reflect the intensity of compensatory processes in the cardiovascular system in the process of adaptation to the increased pollution of air in cities with a high urbanisation level. These peculiarities were more intensely expressed in all age groups of boys, which is due to the greater sensitivity of the male organism to negative influence of environmental factors.

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Papers on Anthropology XI, 2002, pp. 221–237

THEATRUM ANATOMICUM IN HISTORY AND TODAY*

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ABSTRACT

The first dissections of the human body were performed in small makeshift rooms. Early designs of anatomical theatres were produced by Alexander Benedictus from Padua in 1497 and Carolus Stephanus from Paris in 1564.

A new era for anatomy began with Andreas Vesalius (1514–1564), who published the first systematic textbook of anatomy based on findings of human bodies. This replaced the dominating theories of Galen (130–201), who had gained his knowledge from animal sections. The first *temporary anatomical theatres* were built in the 16th century in Italy, where the term *THEATRUM ANATOMICUM* comes from. The first *permanent anatomical theatre,* which was opened in Padua in 1594, became the model for many anatomical buildings. A most representative type was built in Bologna in 1649, the first *solitary anatomical theatre* originates from Paris (1694). Progress in anatomical knowledge gave birth to *anatomical institutes,* which were erected in different architectural styles during the 18th century. Common to all of them was the separation between teaching and research facilities. The stylistic elements came from the *axial type*, e.g. the *Senckenberg* institute of anatomy in Frankfurt (1776), and the *Sömmering type*, which was opened in Kassel 1779. Dorpat adopted the axial type, starting with the rotunda in 1803–1805, to which wings were added in 1825–1827. Progress of sciences in the 19th century gave impulses

* Special lecture on the occasion of the 370th anniversary of the University of Tartu

for new architectural designs of the *German-European type* and the *Anglo-Saxon-American type*. The auditorium was removed from its central position and changed to a cinema with audio-visual equipment. This was once and for all the end of the traditional *THEATRUM ANATOMICUM*.

Key words: medical history, University of Tartu, anatomical dissection, Institute of Anatomy

WITNESS TO THE 19TH CENTURY

The development of anatomical theatres has been a part of academic history for nearly 600 years, and the University of Tartu is also involved in it. Established by the King of Sweden in 1632, re-established by Alexander I of Russia in 1802, Tartu was the only German-language University in the Russian Empire during the 19th century, before Estonia became independent. The historic German name Dorpat is closely connected with the world-famous scientists, such as Karl E. v. Baer, Karl Kupfer, August Rauber, Carl B. Reichert, Oswald Schmiedeberg, Rudolf Buchheim, Nicolai Pirogov and others. Last but not least Dietrich Barfurth, who was Professor of Anatomy at the University of Dorpat from 1889 and was awarded the title of "Imperial Tzarist Counsellor of State", was called to the University of Rostock in 1896, where the author of this article became his successor in 1959. One remnant of this glorious century is the old anatomical theatre in Tartu, where thousands of doctors received their training before the most modern Biomedicum was completed.

ANATOMY IN THE ANCIENT WORLD

Anatomy belongs to natural sciences because of its subject, which is an integral part of nature. Detailed factual anatomical knowledge was already documented in the writings of Assyrian and Babylonian astrologers after hepatoscopy, where sacrificed animals were investigated by temple priests, who searched for the liver and mapped the findings. The liver was known as the collecting point of blood and

was believed to be the centre of life. Terracotta and bronze models were used for teaching students to prophesy or prognosticate the future.

The first dissections, probably on animals, date back to Greece (Hippocrates 460–377 BC, Aristotle 384–322 BC) and Alexandria a few centuries BC, but more than a thousand years passed before the first dissection was carried out in the Occident. The dogmatic scholastic ideology of the Middle Ages paralysed the natural sciences to such an extent that no need for anatomical buildings arose. Teaching of anatomy was based on the textbook by Galen (130–201), a Greek living in Rome, who had gained his anatomical knowledge from dissection of animals (Fig. 1).

FIRST DISSECTION OF THE HUMAN BODY

The first dissection is supposed to have been made in Bologna in 1302 by Mondino de Luzzi; further dissections followed in Montpellier, Padua, Perugia, Prague, Venice, Florence, and Lerida at irregular intervals [6]. Because of the rarity of dissections during the 14th and 15th centuries, they were performed in any poor provisional rooms and, if even these were not available, in the open air. Practical anatomy was not introduced in the curriculum before the 18th century.

The new era of anatomy began with Andreas Vesalius (1514–1564), who, after studying in Paris, came to Padua to teach surgery and anatomy. His textbook *De humani corporis fabrica libri septem* that referred to anatomical findings of human bodies became famous and refuted the theories of Galen.

EARLY DESIGNS OF ANATOMICAL THEATRES

Anatomical dissections of human bodies required a special auditorium, which gave rise to the history of the THEATRUM ANATOMICUM. The first model of a special auditorium for dissection was taken from the ancient amphitheatres in Rome and Verona. The first design of an anatomical auditorium, which pointed the way to the

future, was produced by the anatomist Alexander Benedictus from Padua in 1497 [2]. He suggested

- a large auditorium for an adequate number of visitors
- with good visibility for the visitors;
- a well illuminated dissection table in the centre of the auditorium
- sufficient ventilation
- two guards for protection against unwanted persons
- and an admission fee.

Another architectural idea that came from Carolus Stephanus [8] is documented in his book *De dissectione partium corporis* (1545). He described a wooden building with a capacity of 500 seats and covered by a tent roof. Although the size of this anatomical theatre was a pure illusion, the semicircular arrangement of the seats became very common in the 19th century.

THEATRUM ANATOMICUM TEMPORARIUM

It was in Italy where the first anatomical theatre was set up in the late 16th century, founded on the ideas of Benedictus and influenced by the ancient amphitheatres in Rome and Verona. This was a wooden construction installed into a permanent building, which could be dismantled when the dissection was finished.

THEATRUM ANATOMICUM PERMANENTUM

Progress in anatomy gave rise to establishment of permanent anatomical theatres, which started in Padua in 1594, where anatomy had a high reputation at that time (Fig. 2). This was the *practical-scientific type* that served as a model for many anatomical buildings, e.g. in Leiden (1597), Groningen (1654–1655), Copenhagen (1640–1643), Uppsala (1662), Amsterdam (1691), Altdorf (1650), Halle (1727) and Berlin (1720).

Figure 1. Dissection of a human body at the beginning of the 16th century. Woodcut, title vignette from Anatomia MUNDINI 1514. Library, University of Rostock. (Taken from [6])

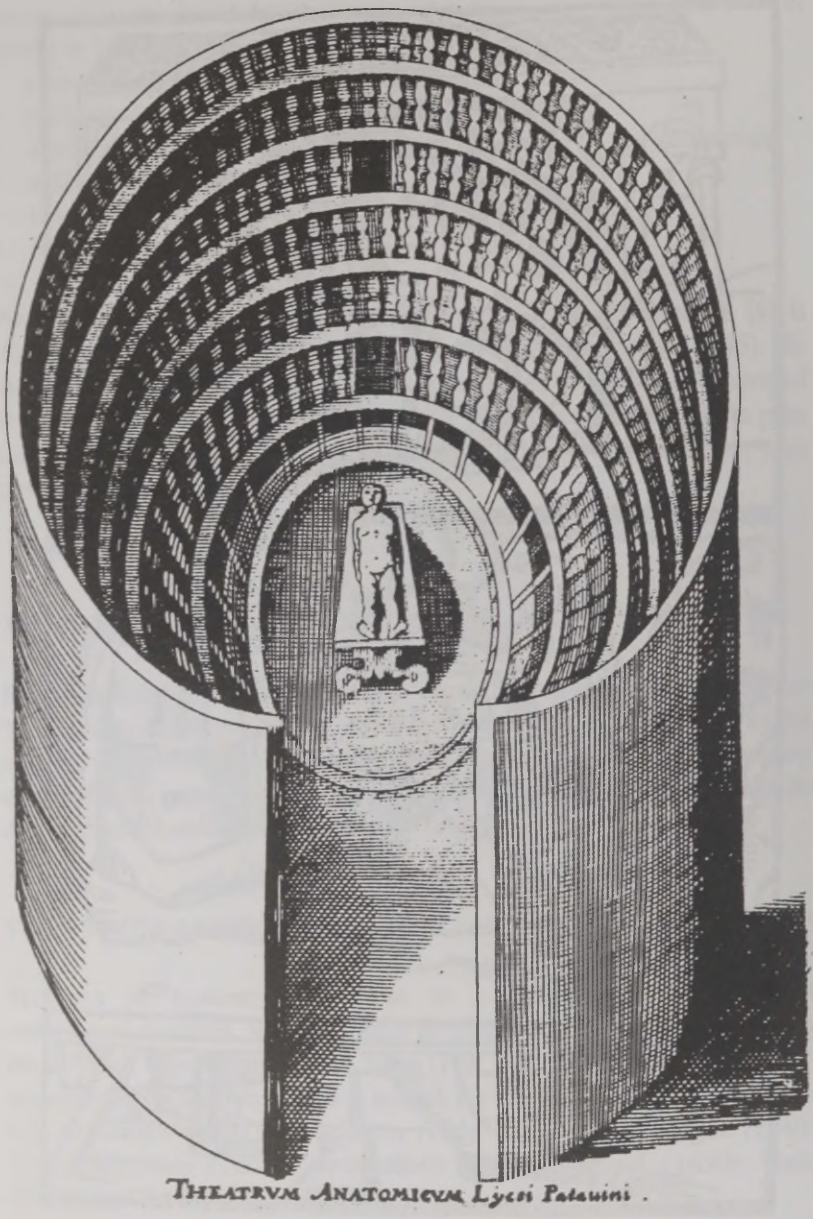

Figure 2. Theatrum anatomicum of Padua. Copperplate engraving. In: J. Ph. Tomassini, Gymnasium Patavinum, libris V comprehensum, Undine 1654. (Taken from [10])

Figure 3. Anatomy lecture of PIETER PAAW. Copperplate engraving, probably 1615. (Taken from [10])

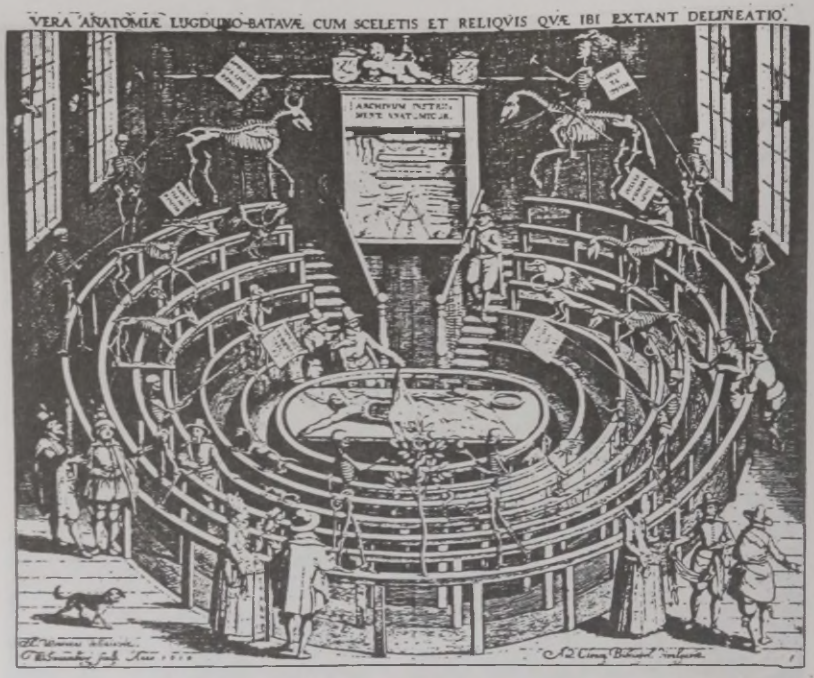

Figure 4. Theatrum anatomicum in Leiden. Copperplate engraving 1610. (Taken from [10])

Figure 5. ANDREAS VESALIUS: De humani corporis fabrica libri septem, Basel 1543. Woodcut, title page. (Taken from [9])

The permanent anatomical theatre of Padua was incorporated into a building of the University and had the following architectural characteristics:

Size 8.75×10.0 m, height 12.0 m, equipped with seats in 6 steeply ascending rows, each 0.92 m in height.

The tunnel-shaped auditorium had some unfavourable side effects:

- the absence of daylight required artificial illumination with candles or torches
- the narrow rows of chairs were inconvenient for passage in the auditorium
- the place for dissection and demonstration suffered from limited space
- the extreme height of ascending seats required an adequate tall building, which was very rare in the universities at those days.

This permanent anatomical theatre in Padua was used for 278 years before it became a museum in 1872.

A more favourable construction was used for the anatomical theatre in **Leiden**, designed by Peter Paaw and opened in 1597 (Fig. 3). Peter Paaw got his doctorate in Rostock 1587 and was called to Leiden as Professor of Anatomy in 1597 [9]. The auditorium was equipped with 6 wide flatly ascending rows of seats; so the large windows remained uncovered and daylight could flow in for illumination. Whenever the dissection was finished, the auditory was changed to an attractive museum (Fig. 4). A fantastic illustration of the historical theatrum anatomicum in Leiden is to be found on the title page of Vesal's book *De humani corporis fabrica libri septem* (1555) (Fig. 5). This type was widely imitated, e.g. in Groningen (1654–1655) and Kiel (1666) as well as in some universities of the Nordic countries.

A mediator between Leiden and the Nordic countries was Rostock. The anatomist Simon Paulli, born in Rostock and elected as Professor of Medicine in Rostock in 1603, designed the *Domus anatomica* in **Copenhagen** (1640–1643) after the model of Leiden, where he had started his career [6]. The auditorium is reported to have been equipped with a rotating dissection table, which made it possible to turn the tabletop towards the direction of the sunrays.

An anatomical building with a domed roof was the *Gustavianum* (1662) in **Uppsala**. The interior was tunnel-shaped, similar to the Padua type, but in contrast to it the illumination with daylight was

ensured from the cupola. This was the most progressive solution in this period.

The famous permanent anatomical theatre in **Bologna** (1649) has its own history. Around the 16th century public dissection became popular in Bologna, especially during the carnival season [8]. This gave rise to an impressive rectangular auditory similar to a medieval meeting place, decorated with beautiful panel boards and sculptures of two musclemen supporting the canopy. This theatre was used for 154 years before it became a museum in 1803. During World War II it was damaged, but after restoration it is open for visitors. The only similar construction of this imposing type is known from Ferrara (1731).

THEATRUM ANATOMICUM SOLITARIUM

The 18th century brought major modifications to the structure of anatomical buildings, caused by the discovery of conservation methods, progress in morphological findings and the increasing number of students. The pioneer on the way to new architecture was the anatomical theatre of the Academy of Sergeon in **Paris** (1694). It was the first solitary anatomical theatre, which looked like a Protestant church. Common to both of them was the capacity, visibility and acoustics for a great number of visitors [5].

INSTITUTE OF ANATOMY

Conservation methods of human bodies opened a new era in anatomy. Dissections were not limited to a few days; their prolongation gave an opportunity for their integration into the curriculum and for compiling anatomical collections. The accumulation of anatomical knowledge required a number of additional rooms for storage of cadavers, preparation, maceration, research and exhibition. All these demands diminished the importance of the traditional theatrum anatomicum and gave birth to the anatomical institute. Institutes of anatomy were erected in different architectural styles and spread widely; common to them was the separation of the teaching area and rooms for laboratory work.

ANATOMICAL BUILDINGS 1770–1830

In contrast to the architecture of the anatomical theatre in Paris was the strong symmetric German style (Fig. 6), represented by the *Senckenberg Institute of Anatomy* in **Frankfurt** (1768–1776). The name *Senckenberg* comes from its sponsor. This type was a stretched building with a centrally located auditorium, bordered on both sides by wings, which contained rooms for preparation and maceration, a fountain, etc. The Senckenberg *Institute of Anatomy*, which was in use till 1908, was the model for Dorpat (1827) and Erlangen (1826–1827), probably designed by the same architect Prof. Wilhelm Krause.

The construction of the Institute of Anatomy in **Dorpat** started with the rotunda in 1803–1805 and continued with the wings, which were completed in 1825–1827. The arched shape of this building was caused by the limited space on the hill (Fig. 7).

New inspirations for further designs arose from the anatomist *Sömmering* [7], who created the *Sömmering type*. His experience started with the anatomical institute in Kassel, which was opened in 1779 and later transferred to Marburg [1]. Some ten years passed before he designed an anatomical building for the University of **Mainz** (Fig. 8). Although the project was never realised, a sketch of the ground floor has survived. This was a solitary rectangular building with an extended auditorium in the front, equipped with semicircular rows of seats that resembled the design of Stephanus. The extension of the auditorium had a positive effect on lighting and ventilation. In contrast to the *Senckenberg type*, where the long wings were a burden on communication between the rooms, it had a very favourable functional construction. *Sömmering*'s ideas affected the anatomical institutes in Munich (1826) and Göttingen (1828–1829). Even the old anatomical institute of Rostock (1790), which was designed by the anatomist Josephi [4], has been influenced by Sömmering's style.

ANATOMICAL BUILDINGS FROM 1830 UP TO NOW

Progress of natural sciences in the 19th century necessitated adequate solutions of highest functional and architectural perfection. In contrast to the simple anatomical buildings of the past, modern institutes of anatomy grew into giant organisms. Many different designs arose,

which could be divided into two groups, the *modern axial type*, also called the *German-European type*, and the *grouped type*, also known *as Anglo-Saxon-American type*.

The *German-European type* of the 19th century resembles the *Senckenberg* institute of anatomy. It had a continuous passage between the lateral ends, which facilitated to the communication between the rooms on both sides. The main idea was functional localisation of rooms and improvement of hygienic conditions, e. g. separation of all rooms with bad smell, such as the dissection hall and maceration. To achieve this, three requirements had to be fulfilled: (1) perfect lighting, (2) complete ventilation and (3) maximal cleanliness.

Some of the most important anatomical buildings of this type were erected in Zürich (1842), Berlin (1863-1865), Freiburg (1867), Bonn (1872), Prague (1876), Strasbourg (1877) and Sofia (1929). The modern axial type was mainly restricted to Germany and the neighbouring countries, therefore it became known as the *German-European type*.

The *Anglo-Saxon-American type* was also a creation of the 19th century. The auditorium was displaced from its central position to a peripheral location in the building and equipped with seats in semicircular arrangement. This was a break with the past and the auditorium was seen on the same level with the dissection hall. The teaching region was separated from the area of research and administration; connecting passages were used for demonstrations. This type became predominant internationally because of its operational and architectural advantages. The first anatomical buildings of this type were put up in Tübingen (1832–1835), and Leipzig (1875), similar constructions followed in Breslau (1897), Marburg (1902), Basel (1921) and Helsinki (1928).

A different development took place in the USA, where, in contrast to the solitary anatomical institute, anatomy got integrated into a large biomedical building as a *department of anatomy*.

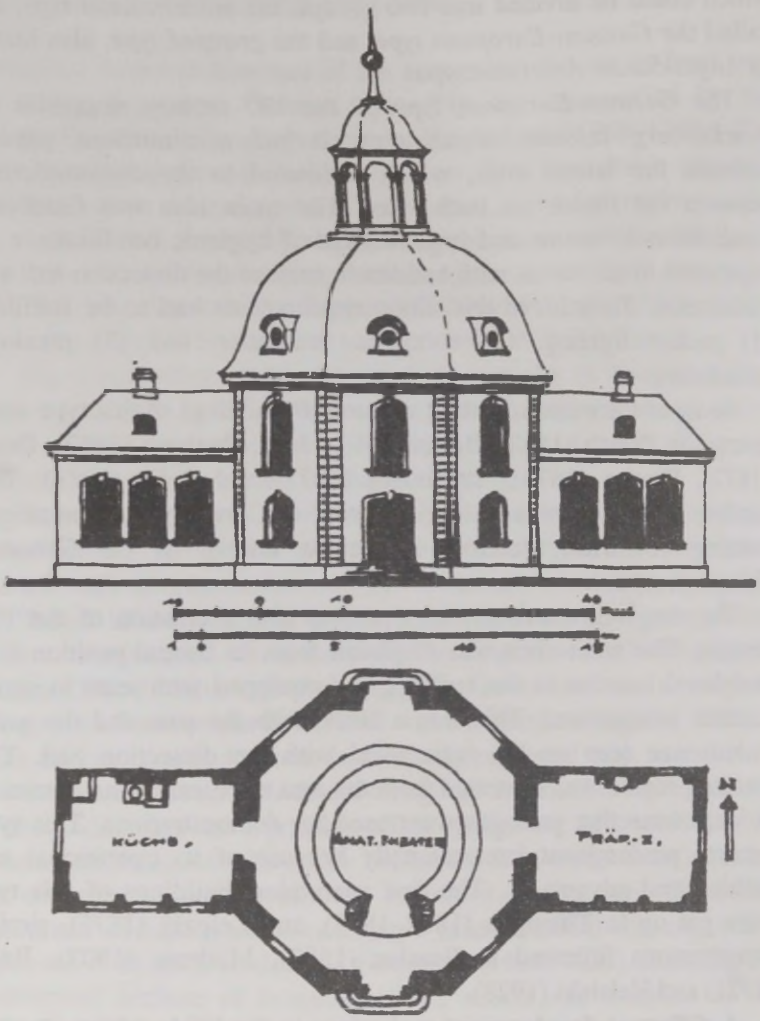

Figure 6. SENCKENBERG Institute of Anatomy, Frankfurt a. M. 1768. (taken from [5])

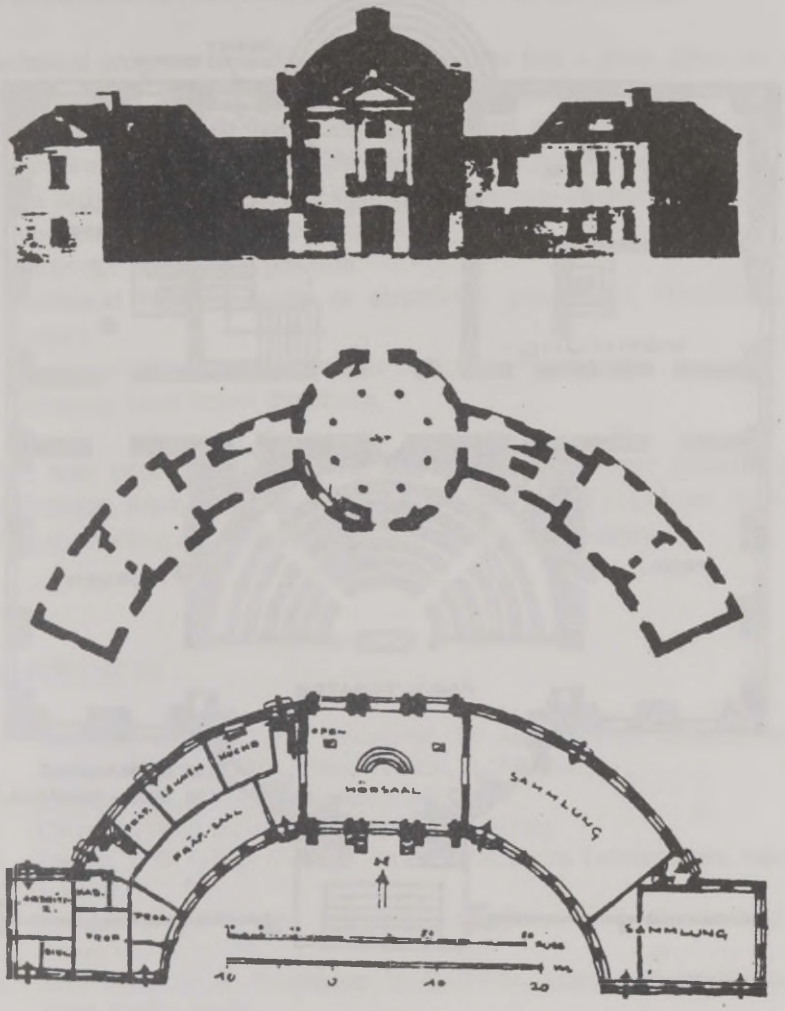

Figure 7. Anatomical buildings. Above and middle: Institute of Anatomy, Dorpat 1803–1827, below: Institute of Anatomy, Erlangen 1827. (Taken from [5])

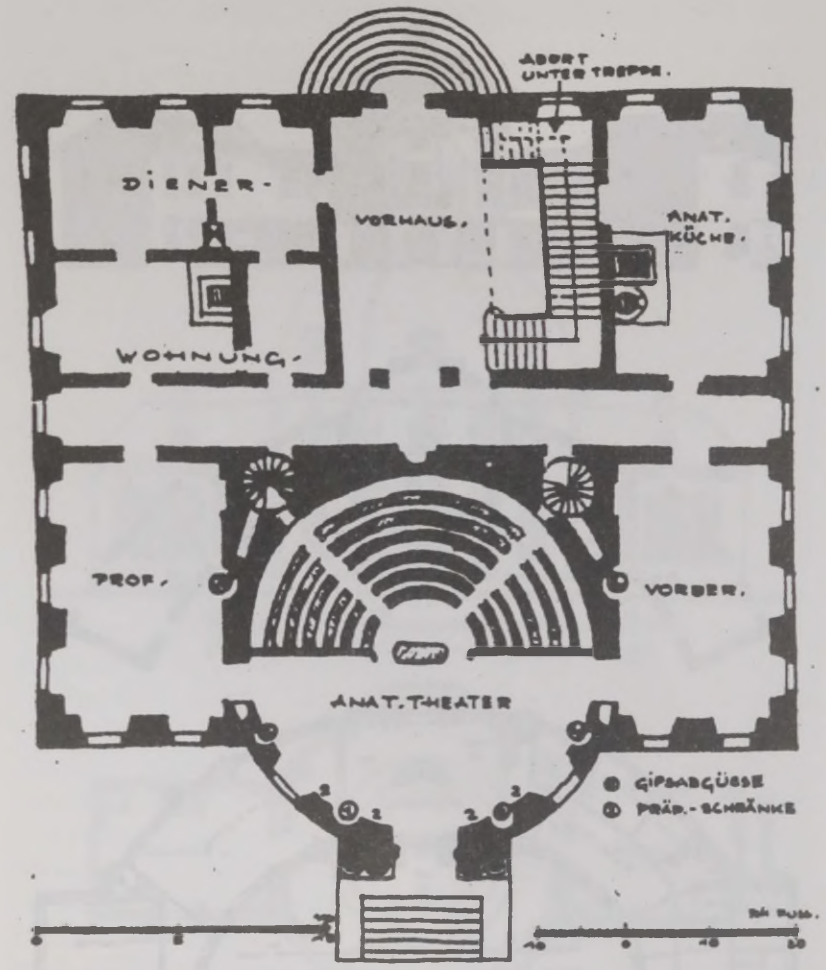

Figure 8. Design, Institute of Anatomy, Mainz 1787. (Sömmering type, taken from [5])

ANATOMICAL AUDITORIUM AS A MOVIE THEATRE?

Technical progress of audio-visual equipment had a great effect on a new start for the reconstruction of the auditorium. In 1872 the physiologist Czermak from Leipzig designed a model of a modern auditorium that he named Spectatorium [3]. For this he required:

- an auditorium of sufficient size with horseshoe-shaped seating
- convenient seats with good visibility
- projector in a central position
- technical facilities, such as electricity, gas, water, blackboard, screen
- demonstration room beneath the chairs or near to them
- dressing room below the chairs.

This was once and for all the end of the traditional anatomical auditorium, since the modern anatomical lecture hall could not derive from the ancient amphitheatre but from the modern cinema.

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Papers on Anthropology XI, 2002, pp. 238–252

PROGRAMMED CELL DEATH AND MACROPHAGE ACTIVITY IN THE LIVER OF RATS IN EXPERIMENTAL SEPSIS

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ABSTRACT

The molecular mechanisms underlying the process of accelerated apoptosis are not fully understood. In vitro studies indicate that depressed macrophage response in immune dysfunction appears to be associated with an increased rate of apoptotic cells.

It is not yet clear whether hematopoietic cells are induced to undergo apoptosis during microbial sepsis. During sepsis, a host of cytokines is capable of inducing apoptosis (tumour necrosis factor [TNF] and interleukins [IL-1 and IL-6] are produced intracellularly in many different cells and may also be released into the systemic circulation).

The aim of the study is to evaluate how experimental sepsis, based on intraperitoneal *E. coli* infection influences macrophage activity and programmed cell death.

Experimental sepsis was called forth inoculating rats intraperitoneally with *E. coli* cells 2×10^7 /g of body weight. 2, 6, 24, 48 hours and 5 days after the inoculation, the liver tissue was obtained to evaluate macrophage activity and programmed cell death.

The macrophage activity was studied in liver by applying immunohistochemical staining, using the Avidin-Biotin method, and "In Situ Cell Death Detection Kit" was used to detect apoptotic cells.

The activated macrophages achieved the highest level at the end of the 2nd h after inoculation with *E. coli*, after that the

number started to decrease and showed a continuous decrease until 48h had passed since the inoculation. The number of apoptotic cells in the liver was not significantly higher 2 h after the *E. coli* inoculation but was the highest 6 h after the inoculation. Then it started to decrease, and that tendency lasted until the end of the experiment, at which the number achieved approximately the same level on the 5th day as it was 2h after the inoculation.

The characteristics and localisation of the apoptotic cells indicate that there were macrophages, lymphocytes and neutrophiles that died in the septic process by apoptosis.

The results suggest that the high level of activated macrophages 2h after the inoculation with *E. coli* might be partially caused by bacterial endotoxins triggering the full sepsis cascade. The high level of apoptotic cells after that (6h after the inoculation) could be associated with cytokines produced by activated macrophages, which are capable of inducing neutrophiles' and lymphocytes' apoptosis, and they were eliminated by apoptosis like macrophages themselves.

Key words: macrophages, lymphocytes, neutrophiles, apoptosis, sepsis

INTRODUCTION

Multiple alterations in the inflammatory and immunologic function and the activation of various cellular systems (neutrophiles, endothelial cells, macrophages) have been demonstrated in clinical and experimental situations. The consequence of this activation process is synthesis and release of numerous mediators which may be produced in the situation of generalised inflammation and tissue damage. Many activators including bacterial as well as non-bacterial factors may exist inducing local and systemic inflammatory response. These mediators may be responsible for ongoing interactions of different cell types and finally lead to a sustained inflammation and multiple damage of organs throughout the body.

The phagocytic immune response is the first line of defence initiated. This response is activated by leukocytes. The mechanisms, by which extracellular signals are received and transduced across the

cell membrane, are being studied in macrophages as they play a significant role in the host's defence against microbes and tumours.

The granulocytes may also display a destroying effect on foreign invaders by using chemical mediators.

Apoptosis may allow the underregulation of intense inflammation of the body accompanied by cell death in sepsis [13]. During sepsis cytokines which are capable of inducing apoptosis, tumour necrosis factor (TNF) and interleukin-1 (IL-1) are produced intracellularly in different cells and may be released into the systemic circulation. Although lymphocytes are predominantly affected, sepsis induces apoptosis diffusely in parenhymal cells of selected organs [19].

In the present study our aim is to investigate the cells, which are placed under programmed cell death at different stages of sepsis in rats' liver, and whether the activity of macrophages is associated with programmed cell death.

MATERIAL AND METHODS.

Wistar rats (n=43) with the average weight of 241 g were inoculated intraperitoneally with viable *E. coli* cells (2×10^7/g of body weight) and were suspended in 1.5 ml of saline. *E. coli* were isolated from the blood of a septic patient. The rats had free access to standard laboratory chow and water ad libitum during the experiment. The studies performed were carried out in accordance with the requirements of the Ethics Committee of Animal Research of Tartu University. Thirteen rats died during the experiment. The remaining 30 survived rats (after inoculation) were analysed. The rats were anaesthetised with sodium-pentobarbital (50 mg/kg body weight) intraperitoneally and sacrificed with a cervical dislocation at different times after the inoculation — 2 hours (I group — 6 rats), 6 h (II group — 6 rats), 24 h (III group — 6 rats), 48 h (IV group — 6 rats), and 5 days (V group — 6 rats). 7 rats served as a control group and were intraperitoneally inoculated with 1.5 ml of saline. Before the surgical operation, the abdomen was scrubbed with 70% ethanol and shaved. In aseptic conditions the peritoneal cavity was opened, and the liver was removed. We used the same liver pieces for examination with the aid of a light microscope, immunohistochemical investigations and the detection of apoptotic cells. The liver pieces were fixed in 10% neutral phosphate buffered

formalin for 24h. After the fixation tissues were dehydrated (using graded alcohols and xylene) and embedded with paraffin wax.

For immunohistochemical examination thick slices (3–4 μm) were cut from paraffin embedded tissue sections, put on polysine™ (Menzel Glasses) or (Star Frost/Knittel Glasses) microscope slides, dewaxed and rehydrated.

The macrophage activity in liver was studied applying immunohistochemical staining by Avidin-Biotin Complex (ABC) method.

The slides were washed with Tris-Buffered Saline (TBS), pH 7.4, incubated with proteinase K (Sigma ST Louis, USA), treated with a solution of 5% bovine serum albumin (BSA) and incubated with Mouse Monoclonal Antibody ED1 (Nordic BioSite AB) as a primary antibody 1:50 in TBS and biotinylated with Goat Anti Mouse IgG(H+L) (Vector Laboratories) in TBS 1:200 as a secondary antibody, incubated with streptavidin-AP (Vector Laboratories) 1:1000 in TBS. The pieces of tissue were coloured with BCIP-NBT (Vector Laboratories) in the dark so that they could be distinguished after reaction. The marked macrophages were counted with the light microscope Zeiss Axiophot 2 Digital optical 3D (ocul. 10×, obj. 40×) in 168 squares (one side of the square is 23 μm and the whole area is 88.872 μm^2) in 10 viewing fields of the microscope.

For the detection of apoptotic cells in paraffin-embedded liver tissue sections, we cut 3–4 μm thick slices, put them on Star Frost/ Knittel Glasses microscope slides, dewaxed and rehydrated them.

"In Situ Cell Death Detection Kit" (Roche Molecular Biochemicals) was used for the detection of apoptotic cells, using reagents and protocols this kit was supplied with. The slices were incubated with proteinase K, PCR Grade (Roche Molecular Biochemicals) and washed with PBS, pH 7.4.

With this kit DNA labelled with deoxyuridine triphosphate (dUTP) fluorescein via action of terminal deoxynucleotidyl transferase (TdT), which attaches the dUTP to the 3'-OH DNA ends. Apoptotic nuclei have "nicks" (strand breaks) in their DNA, which are labelled with the fluorescein dUTP. Apoptotic nuclei appear to be green. Nuclei without strand breaks are not labelled. The apoptotic cells were counted with microscope AxioPhot 2 by fluorescent terminal.

Apoptotic cells were counted in 168 squares, one side of the square being 14.6 μm and the whole area 35 811 μm. Apoptotic cells were counted in 100 viewing fields of the microscope (ocul. 10×, obj. 63×) and recalculated by magnification (ocul. 10×, obj. 40×).

In order to compare different groups, the results were statistically analysed by unpaired t-test. The aim of the study is to evaluate how experimentally caused sepsis, based on intraperitoneal *E. coli* infection influences activation of macrophages and programmed cell death.

RESULTS

During the period of 0–6 h after the inoculation with *E. coli* there was no mortality. After 6–24 hours 18% of the infected rats died, after 24–48 h 8%, and 48 h to 120 h after inoculation 4%. The rats in the control group remained asymptomatic.

The results revealed that the number of activated macrophages increased by a certain degree in all experimental groups of rats. The number of activated macrophages showed the maximum level in group I at the end of the 2nd hour after the inoculation with *E. coli* (Fig. 1). At the end of 6th hour the number of macrophages decreased and showed a continuous decrease until 48 h had passed since the inoculation. Statistically significant differences between the groups were: group I versus group II ($p<0.04$), the control group versus groups III, IV and V ($p<0.05$), and the control group versus group I ($p<0.002$).

The number of apoptotic cells in liver of rats increased a little in group I but rose quickly after that and was the highest in group II (6h after the *E. coli* inoculation). At the same time the number of the activated macrophages decreased, and there was a negative correlation between the numbers of apoptotic cells and activated macrophages in group II ($r = -0.5$). The number of apoptotic cells started to decrease 24h after the inoculation and showed a decrease until the end of the experiment but stayed higher in groups III and IV compared to group I. 120 h after the inoculation (group V) it was approximately at the same level as in the case of group I (Fig. 2). Statistically significant differences in apoptotic cells between the groups were the following: group I versus group II ($p>0.02$), and the control group versus groups III and IV ($p<0.05$).

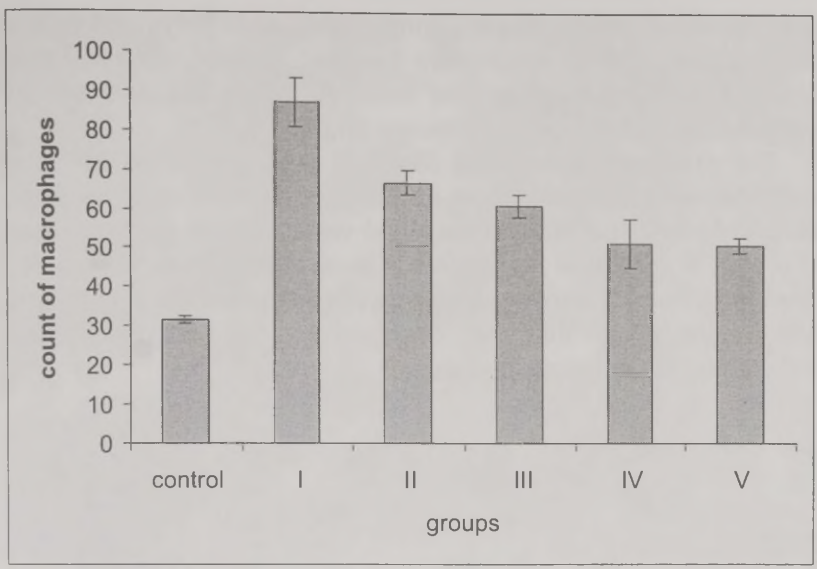

Figure 1. The numbers of active macrophages in the liver (range and median).

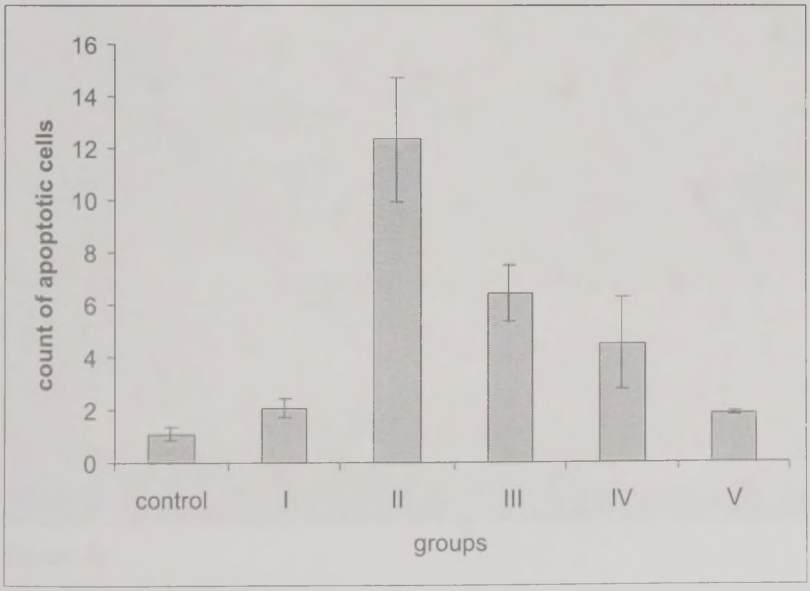

Figure 2. The numbers of apoptotic cells in the liver (range and median).

We identified macrophages, lymphocytes and polymorphnuclear neutrophiles (PMN), which were localised in liver sinusoids, near blood vessels and between liver cells by nuclear characteristics by examination with the light microscope (Fig. 3 a, b, c, d).

Our examinations with "In Situ Cell Death Detection Kit" also demonstrated green fluorescent nuclei of positively stained apoptotic cells in liver sinusoids, near the blood vessels and in the liver tissue (Fig. 4 a, b, c, d). The localisation of these apoptotic nuclei indicates that apoptotic cells were macrophages, polymorphnuclear neutrophiles and lymphocytes as they were determined by light microscopy. We did not find any apoptotic liver cells.

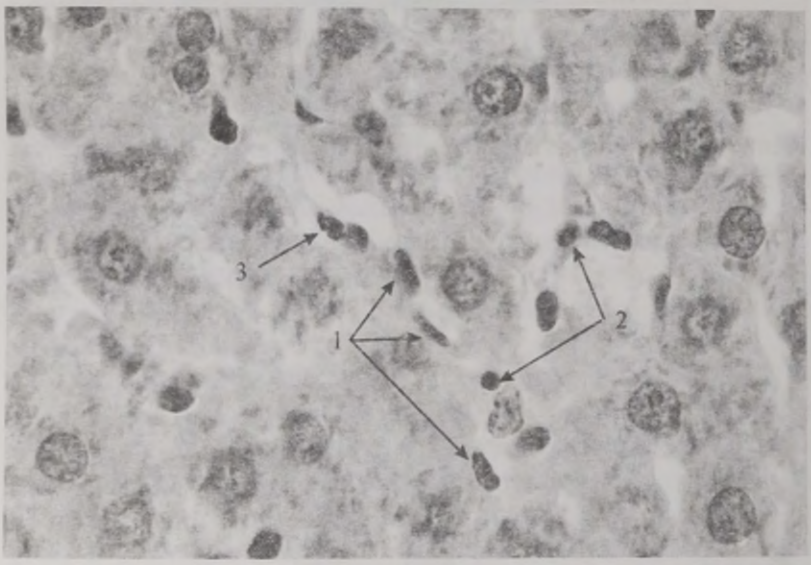

Figure 3a

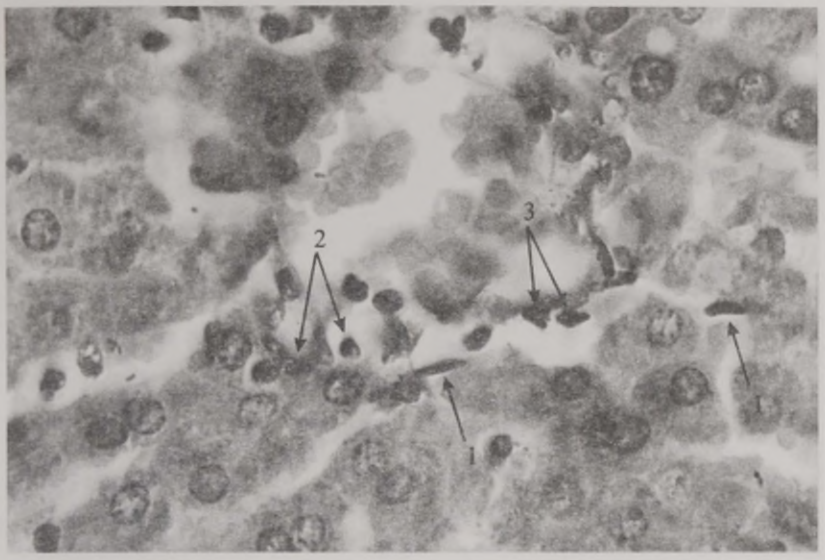

Figure 3b

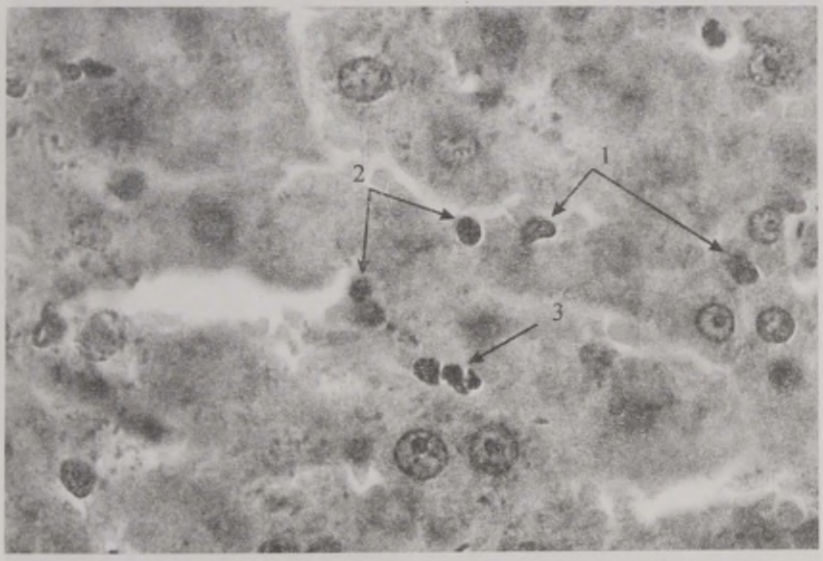

Figure 3c

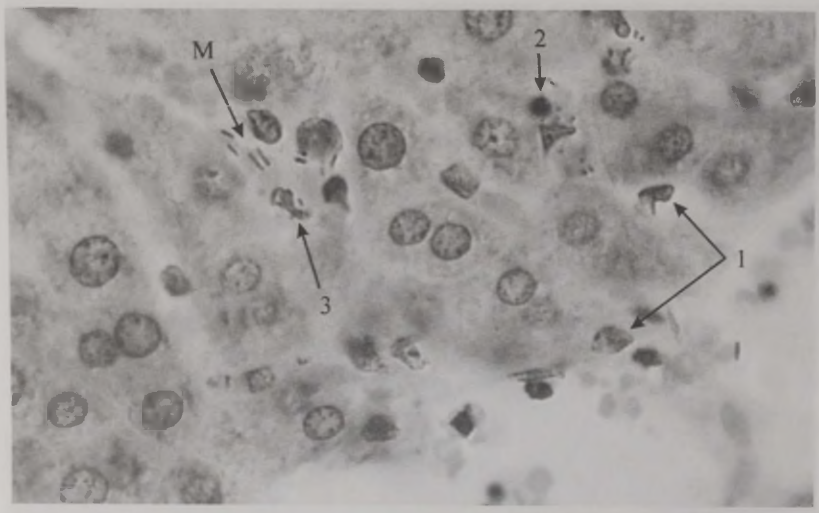

Figure 3d

Figure 3 a–d. Macrophages, lymphocytes, neutrophiles and microbes in liver tissue sections stained according to R. C. Brown and C. H. Hopps [11] and identified by light microscope. a) In liver sinusoids: 1 — macrophages, 2 — lymphocytes, 3 —neutrophiles. b) Near the blood vessel: 1 — macrophages, 2 — lymphocytes, 3 —neutrophiles. c, d) Between the liver cells: 1 — macrophages, 2 — lymphocytes, 3 — neutrophiles.

Figure 4a

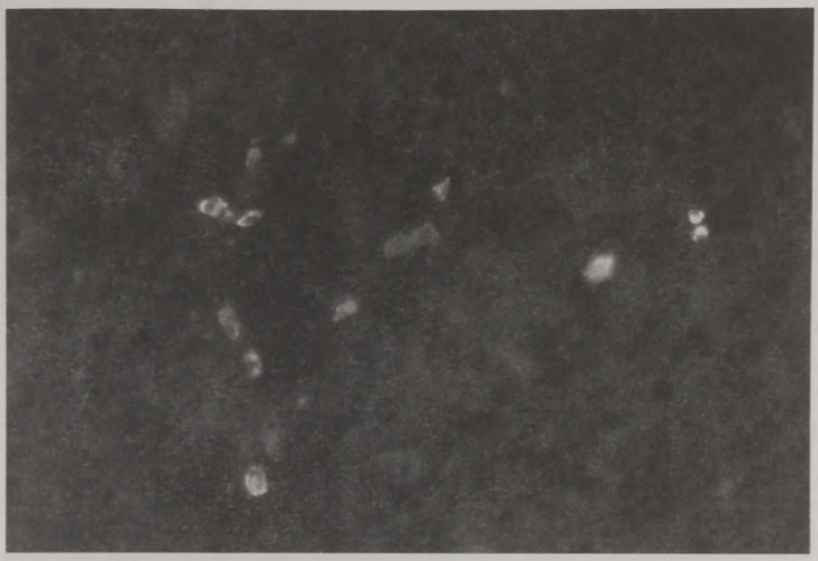

Figure 4b

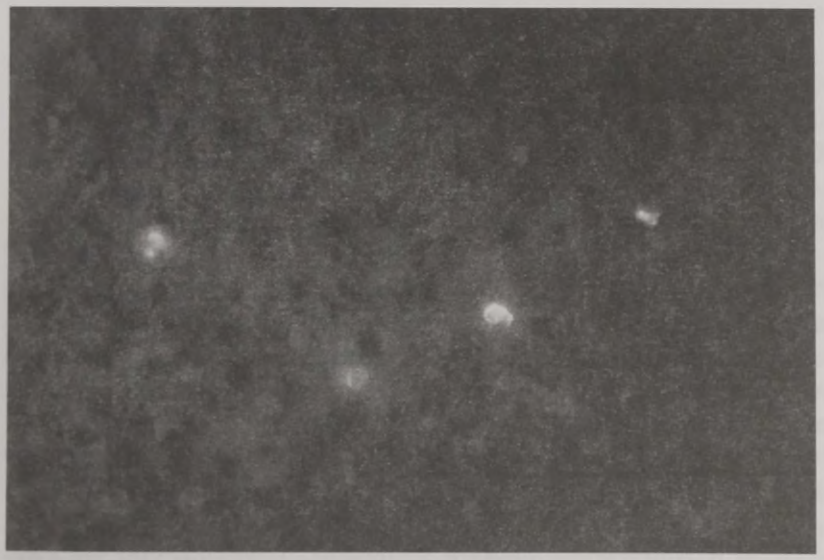

Figure 4c

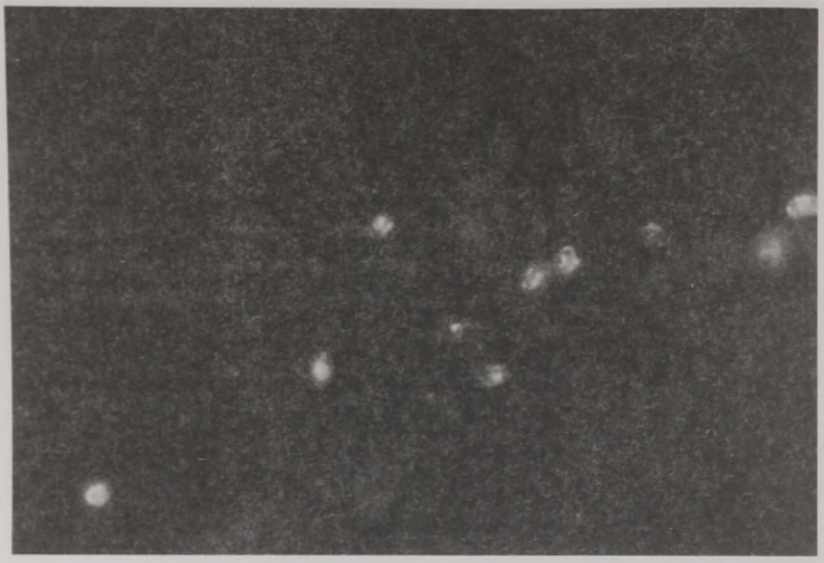

Figure 4d

Figure 4 a–d. Tissue sections of liver examined by the fluorescent terminal. Nuclei appearing bright green are positive for apoptosis. a) In liver sinusoids. b) Near the blood vessel. c, d) Between the liver cells.

DISCUSSION

When the host is threatened by an invading organism, the phagocyte immune response is the first line of the defence initiated. This response is activated by leukocytes, mainly neutrophiles. Monocytes or macrophages are also included. Macrophages have phagocytic abilities to eliminate the foreign invaders [18]. Kupffer cells, stimulated by bacteria, serve as an important cellular source at the later stage of sepsis [9].

The humoral or antibody response is the next form of the defence. Mature B-lymphocytes produce antibodies. T-lymphocytes are cytotoxic cells and attack the invaders themselves. The immune response is not simply cellular or humoral but it is a network of cells, chemical mediators and molecular elements. The interactions between these

various components serve as a basis of regulation and co-ordination of the inflammatory response.

Once inflammatory response is initiated, neutrophiles are the first cells to be recruited to the sites of infection. After the activation, polymorphnuclear neutrophiles generate and release numerous active substances (proteolytic enzymes, reactive oxygen species and vaso-active substances) [2, 28]. Normally PMN disappear in lungs, liver, oral cavity, gastrointestinal tract and spleen, where they may disappear from mucosal surfaces or die and become sequestered by macrophages [24, 21]. The survival of neutrophiles in tissues normally lasts from 6 hours to 2 days. Bacterial products [14] and cytokines (IL-6, IL-8 and IL-2) modulate the role of neutrophiles and eosinophils in the tissues [12, 16]. PMN incubated with IL-1β, TNF, granulocyte and macrophages colony stimulating factor (GM-CSF) and interferon χ (IFN-χ) showed a marked increase in survival [13]. Inflammation cytokines play an important role in neutrophiles phagocytoses. Once in circulation, endotoxin prompts the release of TNF-2, IL-6, IL-8 from mononuclear phagocytes and other cells. Cytokines stimulate neutrophiles' migration to the inflammation process or prepare them to elimination by macrophages [26].

Some authors confirm that IL-2 and TNF in vitro and in vivo induce lymphocyte apoptosis and activate lymphoid cells [1, 2, 15], and that IL-1 and IL-6 activate T cells to produce IFN-χ, IL-2 and GM-CSF [20]. Although lymphocytes are predominantly affected, sepsis induces apoptosis diffusely mainly in parenhymal cells in selected organs [17]. Rodgers et al. [25] have asserted that lymphocytes throughout the body are predisposed to undergo apoptosis and demonstrated apoptosis in the liver of mice infected with *Listeria monocytogenes*. Researchers have found that apoptosis, inducing the loss of lymphocytes, may be responsible for the immune depression that typifies the disorder [19, 27]. Ayala and colleagues [17] have found marked apoptosis in thymocytes during sepsis. Zhang et al. [29] have noted apoptosis in cells located in thymus, spleen and bone marrow but not in other organs. No apoptosis was detected in liver by Hotchkiss et al. [17], but examination of thymus and spleen revealed massive apoptotic death of lymphocytes in some regions of these organs.

Apoptosis is a process, by which cells undergo a form of nonnecrotic suicide. For certain cells in the immune system (T-lymphocytes, B-lymphocytes) this process can be induced [13, 15], but for the other

cells the process of apoptosis is constitutive. Studies indicate that inflammatory mediators lipopolysaccharide (LPS), nitric oxide (NO), TNF, IL-1β, IFN-χ have a different effect on the induction of apoptosis in monocytes or macrophages or both [5, 23], and that monocytes and macrophages do not appear to undergo the rapid spontaneous apoptosis that we can see in neutrophiles [22].

Studies of several laboratories indicate that inflammatory cytokines IL-1, IL-6, TNF may be the agents that initiate the development of cell and organ dysfunction associated with sepsis and multiple organ failure [10, 13]. Ayala et al. [6] demonstrated an early (0–4 hours) elevation in the blood levels of both TNF and IL-6 in a murine model of sepsis and its association with endogenous cytokine release by macrophages from the liver and peritoneum.

Our observations of rats whose liver was experimentally infected with *E. coli* showed that the level of activated macrophages rose 4 hours earlier (2h after the inoculation) than the number of apoptotic cells, which was the highest 6 h after the inoculation. After that the numbers of those cells fell synchronously. This is affirmed by the studies of Ayala et al. [3, 4]; they found that Kupffer cells showed a decreased frequency of apoptosis only at the later stage (24 hours) of sepsis and that 24 hours after cecal ligation and puncture of mice there was a significant reduction in lymphocytes.

Our results suggest that the high level of activated macrophages 2 h after the inoculation with *E. coli* may be caused by bacterial endotoxins capable of triggering the full sepsis cascade, which partially depends on the presence of activated macrophages and neutrophiles in the circulation.

The high level of apoptotic cells 4 hours later (6 h after the inoculation) could be associated with inflammatory cytokines produced by activated macrophages, which are capable of inducting neutrophiles and lymphocytes apoptosis, and they were eliminated as macrophages themselves. The loss of neutrophiles and lymphocytes because of apoptosis and their cytokine products can be one reason that limits macrophages activity in the later stage of sepsis and impairs the proper inflammatory response. Lymphocytes and neutrophiles act as harmful cells excreting cytotoxic enzymes or cytokines if they are activated, and programmed cell death may be useful in sepsis, excreting the harmful cells.

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Papers on Anthropology XI, 2002, pp. 253–282

AGE, BODY BUILD, PHYSICAL ABILITY, VOLLEYBALL TECHNICAL AND PSYCHOPHYSIOLOGICAL TESTS AND PROFICIENCY AT COMPETITIONS IN YOUNG FEMALE VOLLEYBALLERS (AGED 13–16 YEARS)

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ABSTRACT

The study examines correlations of body build characteristics with physical abilities, results of volleyball technical and psychophysiological tests in young female volleyballers (aged 13–16 years) and explains to which extent body build and tests determine the proficiency of performing volleyball elements. Anthropometric measurements and tests were performed on 46 girls; 50 body measurements, 9 physical ability tests, 9 volleyball technical tests and 21 computerised psycho-physiological tests were studied. The performance of game elements was measured by the original computer program *Game* in 32 volleyballers.

As a result we established that anthropometrically it was possible to predict the variability of physical ability tests within 42–89%, volleyball technical tests within 11–37%, psycho-physiologica tests within 28–43%.

Predicting proficiency in the game from anthropometric characteristics and test results showed that the models devised on the basis of anthropometric characteristics and test results were both essential for most elements of the game.

Key words: female volleyballers, physical ability tests, psycho-physiological tests, anthropometry, volleyball proficiency, game recording computer program

INTRODUCTION

A number of authors have studied the body build, physical fitness and motor skills of adult volleyballers [3, 4, 23]. Fewer studies have been carried out on adolescent volleyballers [18, 25]. Only very few authors have paid attention to the players' psychophysiological properties [12] or to assess them in combination with anthropometric measurements and technical skills [5].

In the literature we have not found any studies recording the technical abilities of players in competition situation. There is no clarity in the literature which anthropometric characteristics should be used in volleyball research. Thus, Malina [18] has studied mainly height and weight, Häkkinen [5] has analysed weight and proximal, mean and distal thigh circumferences, Thissen-Milder and Mayhew [27], Smith and co-authors [22] and Häkkinen [5] have assessed the total mass of adipose tissue by means of skinfolds. As yet, there is no clarity about the significance of other anthropometric characteristics [33] and the relations between individual anthropometric variables and the structure of the body as a whole. Therefore, the aim of the present study was to analyse the role of a possibly great amount of anthropometric characteristics, physical abilities, technical skill elements and psycho-physiological properties in the success of female volleyballers of the up to 16-year age group at competitions.

MATERIAL AND METHODS

Subjects

The sample consisted of 46 female volleyball players aged 13–16 years. All of them practised volleyball regularly and participated in young female volleyballers' championships in the age group of up to 16-year-olds. The players were informed about the essence of the studies planned, and they as well as their parents consented to voluntary testing. The study was approved by the Medical Ethics Committee of the University of Tartu.

The players were studied in teams (n=6). The anthropometric measuring as well as the testing of physical abilities, performance of volleyball technical elements and psychophysiological properties of a team were carried out at one and the same session. The same researchers participated in examining all the teams.

Measurement procedures

Anthropometric research

The girls were healthy, and their sexual development corresponded to Tanner's [26] stages III–IV. The methodology of the anthropometric study relied on the long-term research carried out on many populations at the Centre for Physical Anthropology, University of Tartu [8, 9, 10, 11, 21].

Anthropometric measurements were taken by a trained anthropometrist, who had previously shown test-retest reliability of $r>0.90$.

The girls were measured according to the classical method of Martin [Knussmann, 13]. For measuring the skinfolds, the methodology provided in Knussmann's handbook [13, p. 274] was followed. To measure lower extremity length, we applied the method of K. S. Jatsuta [7] that has been widely accepted in Russia and has been the principal method used in Estonia since J. Aul's work [1].

A total of 50 body measurements, including 11 skinfolds, were taken. From these basic measurements, 65 indices and body composition characteristics were calculated.

Physical fitness tests

All the subjects passed the following nine validated tests of physical fitness. Jumping ability was measured by two vertical jump performance tests [32]: standing vertical jump and reach (PA_1) and running vertical jump and reach (PA_2). As the highest reach of the player's outstretched arm had been measured, then subtracting from PA_1 the length of the outstretched arm, the height of standing vertical jump (PA_3) was obtained. By subtracting the length of the outstretched arm from PA_2, we obtained the height of running vertical jump (PA_4). Maximum aerobic endurance was measured by 20 m shuttle run (PA_5). The reliability and validity of this test have been checked by Leger et al. [17]. Trunk strength (PA_6) was measured using a sit-up test by Brewer and Davis [2]. The flexibility test (PA_7) measured the extent of bending forward from sitting position [15]. Deftness and speed of movement was measured by a zigzag run test (PA_8) [14]. Upper body and arms strength were measured by the medicine ball throwing test (PA_9) [30].

Volleyball technical tests

Mastery of volleyball skills was evaluated by nine tests compiled by the authors of the paper. The tests were based on the classical elements of volleyball. They included two overhead pass tests (T_1, T_2), a forearm pass test (T_3), two serve tests (T_7, T_8), a reception test (T_9), two spike tests (T_4, T_5) and a feint test (T_6).

Psycho-physiological tests

The girls' psycho-physiological abilities were assessed by the following four kinds of computerised tests (n = 21).

1. Perception of the speed of a moving object. In three series the subject had to assess the speed of an object moving on the computer screen (eight attempts in each series). Based on this, the program calculated the average value of speed assessment correctness in points, separately for each series (A_1, A_3, A_5), and the average time needed for assessment in seconds (A_2, A_4, A_6).

The test result was the better the more points the subject achieved and the less time was needed for giving the assessment.

2) Auditory reaction was studied by three different stimuli (eight attempts for each stimulus). The reaction time was recorded separately for the right and the left hand. The program calculated the average reaction time for the right (B_1–B_3) and the left hand (B_4–B_6).
3) Visual reaction was also studied by three different stimuli (eight attempts for each stimulus), separately with the right and the left hand. The program calculated the average visual reaction time for the right (C_1–C_3) and the left hand (C_4–C_6).
4) If auditory and visual tests were viewed as simple reactions, the speed perception test was evaluated as a complex reaction. Here the subjects had to assess objects moving at different speeds, adopt a decision and react only after that. Therefore, in order to compare individually the speed of processing different information, we calculated the difference in seconds between complex reaction time (A_2, A_4, A_6) and perception time of visual stimuli as a simple reaction ($C_1 - C_6$).

The respective test was called the test of anticipatory reflection of reality ($D_1 - D_3$), and its results were calculated in the following way:

$$D_1 = A_2 - \frac{C_1+C_2}{2}\ ;\ D_2 = A_4 - \frac{C_3+C_4}{2}\ ;\ D_3 = A_6 - \frac{C_5+C_6}{2}\ .$$

The methodology of psychophysiological tests for volleyballers was mostly based on the well-substantiated methodologies of Kioumountzoglou et al. [9] and Hascelik et al. [10]. The apparatus used by us for psychophysiological studies had been patented in Moscow on 8 June 1992 (No. 1766372) [29] and accepted for use by the IX World Congress of Sport Psychology in Israel in 1997 [28].

Players' proficiency

To assess players' proficiency at competitions, an original volleyball recording program, *Game*, devised by the authors was used [20]. This program has been applied by the Estonian Volleyball Federation and has been introduced in the journal of the American Volleyball Federation [24].

The results were recorded at Estonian Championship and Cup matches for up to 16-year-olds, in which the 32 players under study participated.

All the girls played in the teams where they practice. The games were recorded within three months in different cities of Estonia where the matches took place. All the players were assessed on the basis of at least four matches. Technically, the assessment of players' proficiency proceeded as follows: during the game a recording assistant (a volleyball expert) fixed the performance of each technical element by each player of one team by pressing, according to the program, three keys on the computer keyboard. This enabled us to record: (1) the element of the game that was performed; (2) grade for its performance on a five-point scale (1 — excellent ... 5 — failed); (3) the number of the player who performed the element.

Each player's proficiency in all the elements they performed was calculated after the following formula:

$$\text{Index of proficiency} = \frac{\text{number of performances} \times \text{maximum grade} - \text{sum of grades}}{(\text{maximum grade} - 1) \times \text{number of performances}}$$

Proficiency can range from 0 to 1, where 1 means that in all the cases the element was performed excellently, and 0 — a failure in all the cases.

Statistical analysis

Statistical analysis of the data by the method of multivariate statistical analysis was performed by one of the authors of the paper — Säde Koskel, M.Sc..

RESULTS

Results of anthropometric research

Basic statistics of single anthropometric variables in age classes and their correlation with age are presented in Table 1. As the table shows, significant differences could be noticed in the case of 14 variables.

Increase in age caused a significant increase in height, weight, suprasternal height, xiphoidal height, head-neck length, sternum length, upper limb length, horizontal arms spread, acromial breadth, pelvis breadth. As for circumferences, there was an increase in pelvis circumference, middle thigh, upper leg, forearm circumferences. Limb bones thicknesses — humerus, femur, ankle and wrist breadth, and lower leg and wrist circumference did not increase significantly. There was no significant difference in skinfolds.

In indices and body composition characteristics the age-related difference was even smaller. Only four indices out of 65 showed statistically significant difference. Thus, increase in age caused an increase in body surface area, humerus breadth / upper limb length and bone-muscle rate of the cross-sectional area of the arm. Relative head circumference decreased.

There were no significant differences in body mass index, Rohrer index, relative thickness of limb bones and all the characteristics of body fat content.

Although we did not conduct a longitudinal but a cross-sectional study, the assessment of proportions showed that despite individual variability of body characteristics in puberty, the general development still follows the established proportions.

Comparing the girls' height and weight with Estonian averages in respective age groups, we found that volleyballers surpassed their peers in all age groups.

In order to find which anthropometric characteristics should be used in volleyball studies and how they could by systematised, we carried out a special study of the anthropometric structure of the body as a whole. Correlation analysis showed that the body as a whole is formed of a complex of body measurements that are in mutual statistically significant correlation, and all of them have the strongest correlation with body height and weight. Thus, the leading characteristics of the system are height and weight, which determine an essential part of the variability of all the other characteristics.

Predicting the variability of all basic measurements from height, weight and age we managed to demonstrate that in 1/3 of cases height, weight and age determine the variability of other basic measurements with a precision of up to 50%, and in 2/3 of cases the precision reached 50–90%. Along with height and weight, the impact of age in regression models was essential in only four cases (lower limb length, humerus breadth, side and subscapular skinfold).

Table 1. Means and standard deviations of basic anthropometric measurements in age groups of young female volleyballers (n=46) and their correlations with age

No	Variable	$\bar{x}$	SD	13 years n=10		14 years n=14		15 years n=12		16 years n=10		Statistical significant correlation with age (r)
				$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	
2.	Weight (kg)	56.778	9.504	54.48	13.84	52.55	6.65	58.26	4.20	60.46	9.47	0.291
3.	Height (cm)	167.23	6.09	163.19	7.23	164.08	4.41	168.43	5.30	169.60	5.50	0.429
4.	Suprasternal height (cm)	135.26	5.50	132.83	6.78	133.31	3.94	137.14	5.12	138.14	4.97	0.395
5.	Xiphoidal height (cm)	120.46	5.07	118.95	5.96	118.64	3.74	122.50	5.02	122.08	5.10	0.295
6.	Head-neck length (cm)	30.99	0.96	30.36	1.20	30.76	1.05	31.29	0.64	31.46	0.75	0.413
7.	Sternum length (cm)	14.85	1.78	13.88	1.56	14.67	2.33	14.64	1.63	16.06	1.06	0.363
8.	Abdomen length (cm)	35.44	5.37	35.68	6.66	34.69	5.97	37.39	4.60	33.92	3.72	–
9.	Trunk length (cm)	50.24	5.52	49.56	7.29	49.36	5.81	52.03	5.23	49.98	3.31	–
10.	Upper body length (cm)	66.95	5.40	64.36	4.52	67.65	7.73	68.10	3.78	67.20	3.38	–
11.	Lower bodylength (cm)	99.27	7.25	98.83	6.63	96.43	10.00	100.33	5.80	102.40	2.97	–
12.	Upper limb length	72.69	4.09	71.63	5.83	70.74	2.29	73.77	3.83	75.21	2.87	0.375
13.	Lower limb length	87.60	5.62	87.50	3.72	85.76	6.56	88.68	6.36	88.99	4.88	–
14.	Horizontal arms spread (cm)	167.51	8.35	164.05	9.41	163.91	5.11	169.00	8.14	174.22	7.41	0.464
15.	Biacromial breadth (cm)	35.33	1.62	34.90	2.14	34.89	0.76	35.33	1.60	36.35	1.68	0.319
16.	Chest breadth (cm)	23.88	1.50	23.80	2.11	2.43	1.37	24.13	1.26	24.30	1.21	–
17.	Waist breadth (cm)	21.90	1.73	22.15	2.16	21.32	1.61	21.58	1.12	22.85	1.81	–
18.	Pelvis breadth (cm)	25.67	1.54	24.90	1.82	25.39	1.40	26.00	1.04	26.45	1.66	0.367
19.	Chest depth (cm)	16.23	1.25	16.40	2.12	15.79	0.96	16.38	0.93	16.50	0.71	–
20.	Abdomen depth (cm)	15.48	1.31	15.15	2.11	15.36	0.93	15.25	0.94	16.25	0.98	–

21.	Femur breadth (cm)	8.69	0.57	8.54	0.76	8.64	0.50	8.78	0.52	8.83	0.53	–
22.	Ankle breadth (cm)	6.86	0.46	6.84	0.64	6.76	0.32	6.90	0.43	6.96	0.50	–
23.	Humerus breadth (cm)	6.17	0.39	6.22	0.44	6.90	0.33	6.21	0.43	6.17	0.41	–
24.	Wrist breadth (cm)	5.07	0.29	4.91	0.40	5.13	0.27	5.08	0.23	5.13	0.25	–
25.	Head circumference (cm)	34.96	1.44	54.93	1.49	55.32	1.18	54.60	1.60	54.91	1.62	–
26.	Neck circumference (cm)	31.50	1.71	31.46	2.55	31.41	1.43	31.41	1.43	31.12	1.86	–
27.	Upper chest circumference (cm)	81.23	4.97	81.64	7.53	79.52	4.04	82.10	3.69	82.16	4.47	–
28.	Lower chest circumference (cm)	73.96	5.36	74.15	7.37	72.17	4.72	74.67	3.51	75.57	5.88	–
29.	Waist circumference (cm)	67.62	5.65	67.65	7.84	65.83	3.96	67.45	2.63	70.32	7.32	–
30.	Pelvis circumference (cm)	79.49	6.30	77.50	9.53	77.26	4.73	81.48	3.50	82.20	5.88	0.324
31.	Hip circumference (cm)	85.13	9.35	85.11	10.42	81.34	10.83	88.89	3.02	85.93	10.27	–
32.	Upper thigh circumference (cm)	55.09	5.94	54.20	8.16	52.94	5.50	56.80	1.99	57.12	6.65	–
33.	Middle thigh circumference (cm)	46.49	4.79	44.72	6.31	45.26	4.05	47.87	3.14	48.34	5.21	0.308
34.	Upper leg circumference (cm)	34.16	2.68	33.26	3.39	33.26	2.64	35.27	1.77	35.01	2.44	0.304
35.	Lower leg circumference (cm)	22.04	1.58	21.63	2.39	21.63	1.19	22.33	2.23	22.70	1.37	–
36.	Arm circumference (cm)	24.87	2.41	24.17	3.59	24.22	1.74	25.65	1.54	25.55	2.50	–
37.	Arm circumference flexed and tensed (cm)	26.84	2.57	26.25	3.91	26.28	1.85	27.51	1.60	27.40	2.79	–

No	Variable	$\bar{x}$	SD	13 years n=10		14 years n=14		15 years n=12		16 years n=10		Statistical significant correlation with age (r)
				$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	
38.	Forearm circumference (cm)	22.45	1.60	21.92	2.15	21.91	1.39	22.89	1.14	23.18	1.48	0.328
39.	Wrist circumference (cm)	15.73	0.94	15.58	1.54	15.58	0.69	15.73	0.75	16.08	0.71	–
40.	Chin skinfold (cm)	0.64	0.23	0.70	0.31	0.57	0.19	0.63	0.18	0.68	0.25	–
41.	Chest skinfold (cm)	0.67	0.27	0.76	0.35	0.56	0.18	0.71	0.21	0.70	0.35	–
42.	Side skinfold (cm)	0.82	0.40	0.94	0.49	0.74	0.42	0.82	0.22	0.84	0.45	–
43.	Waist skinfold (cm)	1.27	0.50	1.31	0.73	1.16	0.35	1.26	0.34	1.39	0.61	–
44.	Suprailiacal skinfold (cm)	0.83	0.39	0.89	0.59	0.79	0.37	0.88	0.29	0.77	0.28	–
45.	Umbilical skinfold (cm)	1.03	0.39	1.09	0.58	0.90	0.25	1.08	0.37	1.09	0.38	–
46.	Subscapular skinfold (cm)	1.03	0.41	1.19	0.60	0.93	0.39	1.08	0.23	0.95	0.37	–
47.	Biceps skinfold (cm)	0.81	0.31	0.91	0.39	0.71	0.25	0.86	0.25	0.78	0.35	–
48.	Triceps skinfold (cm)	1.27	0.40	1.31	0.53	1.18	0.37	1.42	0.27	1.16	0.43	–
49.	Thigh skinfold (cm)	2.14	0.56	2.01	0.56	1.91	0.50	2.42	0.33	2.26	0.73	–
50.	Calf skinfold (cm)	1.34	0.34	1.28	0.35	1.20	0.24	1.44	0.38	1.48	0.34	–

Table 2. Means and standard deviations of basic anthropometric measurements in a 5SD height-weight classification of young female volleyballers (n=46)

No	Variable	Small (n=8)		Medium (n=8)		Large (n=6)		Signifi-cance	Pycnomorphs (n=13)		Leptomorphs (n=11)		Signifi-cance
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	1–3	$\bar{x}$	SD	$\bar{x}$	SD	4–5
1.	Age	13.63	1.06	14.88	0.83	15.00	1.26	–	14.54	0.97	14.45	1.04	–
2.	Weight (kg)	44.56	4.02	54.22	2.63	68.58	7.16	+	60.87	7.41	53.75	5.20	+
3.	Height (cm)	158.39	3.31	166.96	1.15	174.52	3.62	+	163.75	3.15	169.77	4.86	+
4.	Surpasternal height (cm)	128.40	2.45	136.01	1.18	142.93	3.09	+	132.95	2.90	138.24	5.10	–
5.	Xiphoidal height (cm)	114.23	2.61	121.45	2.07	126.8	3.35	+	119.04	2.49	122.47	5.59	–
6.	Head-neck length (cm)	29.99	1.01	30.95	0.70	31.58	0.97	+	30.81	0.70	31.54	0.99	+
7.	Sternum length (cm)	14.18	2.28	14.56	1.21	16.07	1.25	–	13.91	2.16	15.76	1.12	+
8.	Abdomen length (cm)	31.15	2.52	35.05	1.73	36.10	2.91	+	38.26	6.39	35.15	6.67	–
9.	Trunk length (cm)	45.33	1.32	49.61	1.90	52.17	2.34	+	52.17	7.18	50.92	6.45	–
10.	Upper body length (cm)	66.15	11.92	67.23	2.09	68.98	2.98	–	66.01	4.30	67.35	3.19	–
11.	Lower body length (cm)	92.24	11.92	99.74	2.49	105.53	1.90	+	97.75	3.44	102.42	6.27	+
12.	Upper limb length (cm)	68.93	4.10	73.64	3.14	76.18	4.03	+	71.11	2.81	74.72	3.42	+
13.	Lower limb length (cm)	83.01	4.85	88.95	2.08	93.30	1.93	+	84.19	5.64	90.87	4.25	+
14.	Horizontal arms spread (cm)	162.19	11.48	169.23	4.05	175.50	5.66	+	163.32	6.38	170.74	6.89	+

No	Variable	Small (n=8)		Medium (n=8)		Large (n=6)		Signifi-cance	Pycnomorphs (n=13)		Leptomorphs (n=11)		Signifi-cance
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	1–3	$\bar{x}$	SD	$\bar{x}$	SD	4–5
15.	Biacromial breadth (cm)	33.81	1.56	35.44	0.98	36.33	2.34	+	35.61	1.45	35.45	1.25	–
16.	Chest breadth (cm)	22.56	1.45	23.25	0.89	25.50	0.71	+	24.77	1.24	23.36	1.16	+
17.	Waist breadth (cm)	20.69	1.51	21.31	1.13	24.08	1.59	+	22.73	1.47	21.05	1.06	+
18.	Pelvis breadth (cm)	24.19	1.62	25.94	0.78	27.00	2.05	+	25.69	1.38	25.82	1.05	–
19.	Chest depth (cm)	15.06	1.05	16.06	0.78	17.17	1.03	+	16.85	1.38	15.95	0.91	–
20.	Abdomen depth (cm)	14.31	1.67	15.63	1.03	16.75	0.69	+	15.96	1.23	14.95	0.57	+
21.	Femur breadth (cm)	8.05	0.49	8.66	0.39	9.05	0.68	+	8.90	0.49	8.75	0.44	–
22.	Ankle breadth (cm)	6.48	0.46	6.65	0.44	7.03	0.66	–	7.01	0.35	7.02	0.29	–
23.	Humerus breadth (cm)	5.88	0.28	6.18	0.30	6.57	0.37	+	6.10	0.41	6.23	0.36	–
24.	Wrist breadth (cm)	4.57	0.32	5.01	0.23	5.20	0.28	+	5.10	0.22	5.23	0.21	–
25.	Head circumf. (cm)	54.68	1.31	54.31	1.79	55.77	1.18	–	55.17	1.62	54.95	1.11	–
26.	Neck circumf. (cm)	29.80	0.98	30.95	1.08	33.83	1.50	+	32.31	1.47	30.91	0.94	+
27.	Upper chest circumf. (cm)	76.29	2.73	79.71	2.24	86.18	3.02	+	85.29	4.50	78.42	2.72	+
28.	Lower chest circumf. (cm)	70.10	4.29	72.09	2.95	79.50	5.48	+	77.62	5.05	71.26	3.07	+
29.	Waist circumf. (cm)	63.05	3.23	65.59	2.40	74.88	6.70	+	70.70	5.04	64.84	2.58	+
30.	Pelvis circumf. (cm)	71.79	4.46	79.55	4.13	87.45	4.99	+	82.71	4.41	76.89	3.23	+
31.	Hip circumf. (cm)	75.91	11.73	86.89	3.39	88.17	13.99	–	89.01	8.58	84.31	2.64	–
32.	Upper thigh circumf. (cm)	47.31	4.54	55.34	1.96	59.60	8.00	+	59.03	3.21	53.45	3.66	+

33.	Middle thigh circumf. (cm)	41.11	3.74	46.50	2.74	52.02	5.46	+	49.10	3.06	44.31	2.59	+
34.	Upper leg circumf. (cm)	30.88	1.03	33.79	1.84	37.20	2.34	+	35.61	2.12	33.46	1.90	+
35.	Lower leg circumf. (cm)	19.94	1.12	21.30	0.60	23.95	0.84	+	22.71	1.03	22.29	1.31	–
36.	Arm circumf. (cm)	22.10	1.77	24.34	1.09	27.13	2.09	+	26.88	1.52	23.67	1.35	+
37.	Arm circumf. flexed and tensed (cm)	23.84	1.53	26.43	1.09	27.13	2.09	+	28.88	1.94	25.52	1.27	+
38.	Forearm circumf. (cm)	20.44	0.99	21.69	0.70	24.05	1.49	+	23.67	1.07	22.14	0.87	+
39.	Wrist circumf. (cm)	14.64	0.64	15.33	0.70	16.58	0.78	+	16.22	0.80	15.77	0.68	–
40.	Chin skinfold (cm)	0.52	0.12	0.59	0.17	0.80	0.28	+	0.76	0.25	0.52	0.14	+
41.	Chest skinfold (cm)	0.51	0.15	0.63	0.18	0.92	0.29	+	0.83	0.28	0.51	0.19	+
42.	Side skinfold (cm)	0.56	0.15	0.73	0.18	1.20	0.48	+	1.10	0.40	0.55	0.16	+
43.	Waist skinfold (cm)	0.91	0.32	1.09	0.30	1.73	0.43	+	1.63	0.49	0.97	0.31	+
44.	Suprailiacal skinfold (cm)	0.54	0.14	0.83	0.31	1.10	0.32	+	1.13	0.39	0.55	0.20	+
45.	Umbilical skinfold (cm)	0.76	0.28	0.94	0.19	1.30	0.29	+	1.32	0.42	0.80	0.30	+
46.	Subscapular skinfold (cm)	0.80	0.15	1.00	0.24	1.25	0.35	+	1.35	0.51	0.77	0.28	+
47.	Biceps skinfold (cm)	0.64	0.22	0.75	0.24	1.07	0.36	+	0.98	0.21	0.62	0.29	+
48.	Triceps skinfold (cm)	0.98	0.30	1.15	0.27	1.45	0.31	+	1.65	0.26	1.00	0.33	+
49.	Thigh skinfold (cm)	1.79	0.49	1.96	0.50	2.67	0.52	+	2.42	0.44	1.90	0.48	+
50.	Calf skinfold (cm)	1.09	0.24	1.35	0.37	1.65	0.36	+	1.45	0.25	1.22	0.30	+

This implies that each basic characteristic can be used in studies, because, in addition to representing a concrete measurement of the body, it also essentially represents the body as a whole.

We also attempted to find an answer to the question, how and whether it is possible to classify basic anthropometric measurements. We used a scheme of 5 SD-classes devised by the Centre for Physical Anthropology (Table 2). The subjects were divided into three classes of concordance between height and weight (small height — small weight, medium height — medium weight, and big height — big weight) and two classes of disconcordance (pycnomorphous: big weight — small height, and leptomorphous: small weight — big height). Despite the relatively small number of subjects (n=46), we managed to demonstrate systematic changes in the height, breadth and depth measurements of the body. The impact of age on the division between classes proved to be insignificant.

Results of physical fitness tests

Basic statistics of physical fitness tests results and their correlation with age are presented in Table 3. The Table shows that two jump tests (PA_1, PA_2) and the highest reach of the player's outstretched arm are related to age. With the exclusion of the stomach muscle strength test (PA_6), all the other tests were in weaker or stronger mutual correlation.

The tests also showed significant correlation with anthropometric variables. The tests of vertical jump and reach (PA_1, PA_2) and the highest reach of the player's outstretched arm correlated very strongly (at the level of 0.7–0.9) with height, extremities length and horizontal arms spread; there was also an almost as strong correlation with biacromial and pelvic breadth. The jump tests also showed statistically significant correlations with nearly all the anthropometric variables, except skinfolds.

Analogously to the previous ones but somewhat more weakly, the medicine ball throwing test (the upper body and arms strength test, PA_9) correlated with practically all the anthropometric variables except skinfolds. The strongest correlations (at the level of 0.6) were not with height but with extremities circumferences.

Table 3. Basic statistics of young female volleyballers' physical fitness tests results and their correlation with age

No	Variable	$\bar{x}$	SD	Min	Max	Statistically significant correlation with age (r)
1.	Test of highest jump and reach standing (PA_1) (cm)	252.98	10.01	237.00	275.00	0.383
2.	Test of highest jump and reach running (PA_2) (cm)	256.98	10.08	243.00	284.00	0.373
3.	Highest reach of the players outstretched hand (cm)	217.20	8.25	201.00	236.00	0.370
4.	Vertical jump height standing (PA_3) (cm)	35.78	4.14	27.00	46.00	–
5.	Vertical jump height running (PA_4) (cm)	39.78	5.21	31.00	58.00	–
6.	Endurance test (Eurofit PA_5) (sec)	375.78	84.70	135.00	545.0	–
7.	Stomach muscle strength test (Eurofit PA_6) (sec)	169.68	59.56	85.00	300.0	–
8.	Test of flexibility (PA_7) (cm)	16.63	6.53	4.00	32.50	–
9.	Test of speed measuring (PA_8) (sec)	27.70	1.48	24.70	33.00	–
10.	Medicine ball throwing test (PA_9) (cm)	300.37	44.35	210.00	400.0	–

The tests of jump height (PA_3 and PA_4) showed significant negative correlations with all skinfolds. The same can be said about the speed test — the ticker the skinfolds, the worse the speed test results.

The endurance test correlated negatively not only with skinfolds but with a number of other anthropometric variables, which suggests that smaller players have greater endurance.

Flexibility and stomach muscles test showed practically no correlations with anthropometric variables.

Test results correlations with body build were also studied by regression analysis. We predicted the results of all physical fitness tests using two models: (1) age, height and weight; (2) single variab-

les, chosen by stepwise regression, which were in significant correlation with the result of the test studied (see Table 4).

Table 4. Linear regression formulae for predicting physical fitness tests results from young female volleyballers' (n=41) anthropometric measurements

No	Predicted variables	Explanatory variables	Coefficients	R2
1.	Test of highest jump and reach standing PA_1	Intercept	–1.31	
		Age	0.18	0.75
		Weight	–0.14	
		Height*	1.53	
2.	PA_1	Intercept	46.60	
		Lower limb length	0.72	0.89
		Horizontal arms spread	0.60	
		Upper leg circumference	1.52	
		Chest sinfold	–12.69	
3.	Test of highest jump and reach running PA_2	Intercept	37.37	
		Age	0.43	0.62
		Weight	–0.018	
		Height*	1.29	
4.	PA_2	Intercept	77.26	
		Horizontal arms spread	0.62	0.78
		Upper leg circumference	2.62	
		Umbilical skinfold	12.79	
5.	Highest reach of the players' outstretched hand	Intercept	13.80	
		Age	–0.30	0.90
		Weight	0.07	
		Height*	1.23	
6.	Highest reach of the players' outstretched hand	Intercept	29.05	0.95
		Trunk length	0.27	
		Lower limb length	0.65	
		Horizontal arms spread	0.51	
		Neck circumference	1.03	
7.	Vertical jump height standing PA_3	Intercept	–14.30	
		Weight	–0.21	0.16
		Height*	0.37	
8.	PA_3	Intercept	14.75	
		Upper leg circumference	1.02	0.61
		Chest skinfold	11.68	
		Biceps skinfold	7.13	
		Relat. mass of subcutaneous adipose tissue	–0.85	

No	Predicted variables	Explanatory variables	Coefficients	R2
9.	Vertical jump height running PA_4	Intercept Age Weight Height	 –	–
10.	PA_4	Intercept Ankle breadth Upper leg circumference Chin skinfold Relat. mass of cubcutaneous adipose tissue	37.28 –5.72 +1.84 +13.60 –2.14	0.63
11.	Endurance test PA_5	Intercept Age Weight* Height	617.36 14.98 4.14 1.36	0.26
12.	PA_5	Intercept Upper chest circumference Subscapular skinfold Relat. mass of subcut. adipose tissue	–6.06 22.84 –134.64 –38.19	0.42
13.	Test of speed measuring PA_8	Intercept Age Weight* Height*	45.51 –0.31 0.09 –0.11	0.24
14.	PA_8	Intercept Biacromial breadth Chest depth Ankle breadth Suprailiacal skinfold	34.70 –0.31 0.85 –1.53 1.11	0.63
15.	Medicine ball throwing test PA_9	Intercept Age Weight* Height	–11.08 5.20 1.86 0.80	0.29
16.	PA_9	Intercept Upper leg circumference Arm circumference Suprailiacal skinfold Mass of subcutaneous adipose tissue (kg)	–274.32 5.32 20.49 –41.51 –10.26	0.65

* statistically significant variables in the model.
All models are statistically significant (on level 0.05)

The study showed that age, height and weight determined the variability of PA_1, PA_2 and PA_3 results with in 60–90%. The predictions of PA_5, PA_8 and PA_9 had smaller value (16–29%). By comparing the two models used for prediction, we found that in all cases the model composed of single characteristics was more effective than the height-weight model.

The essential single characteristics in the models were: lower limb length, upper leg circumference, ankle breadth, arm circumference, biacromial breadth, upper chest circumference, horizontal arms spread. Relative mass of subcutaneous adipose tissue had a negative correlation with tests results.

Results of volleyball technical tests

Table 5 presents the results of three pass tests (T_1, T_2, T_3), two spike tests (T_4, T_5), feint test (T_6), two serve tests (T_7, T_8) and reception test (T_9). All results have been graded in points. These tests showed no statistically significant correlation with age.

Table 5. Main characteristics of young female volleyballers' (13–16, n=45) volleyball technical tests*

No	Variable	$\bar{x}$	SD	Min	Max	Statistically significant correlation with age (r)
1.	Overhead pass with a clap behind the back T_1	16.58	5.56	2.00	20.00	–
2.	Overhead pass with squat T_2	7.31	4.89	2.00	20.00	–
3.	Forearm pass into 1 m^2 T_3	21.40	11.69	1.00	30.00	–
4.	Spike along the sideline T_4	4.49	2.04	0.00	8.00	–
5.	Spike diagonally T_5	3.93	1.50	0.00	7.00	–
6.	Feint into the centre of the court T_6	4.11	1.82	0.00	8.00	–
7.	Serve straight T_7	5.33	1.85	0.00	8.00	–
8.	Serve diagonally T_8	5.20	1.63	2.00	8.00	–
9.	Reception into zone 2 or 3 T_9	5.02	1.71	2.00	8.00	–

* The tests measured the number of succesful repetitions

From the three pass tests, the forearm pass test (T_3) showed the closest correlations with body measurements. It had negative correlations with weight, circumferences and all the indicators of adiposity (skinfolds, mass of subcutaneous adipose tissue, body mass index, fat rate of the cross-sectional area of thigh and arm (r=0.3–0.4)). It revealed positive correlations with acromial breadth / pelvis breadth and arm cross-sectional bone and muscle area.

Table 6. Prediction volleyball technical tests results from basic anthropometric measurements, indices and body composition characteristics

No	Predicted variable	Explanatory variables	Coefficients	R2
1.	Overhead pass with squat T_2 (in points)	Intercept	–24.78	
		Biacromial breadth/pelvis breadth (%)	0.27	0.24
		Relat. mass of subcut. adipose tissue (%)	–0.40	
2.	Forearm pass into 1 m^2 T_3 (in points)	Intercept	–9.13	
		Femur breadth/lower limb length (%)	–3.94	0.29
		Biacromial breadth/pelvis breadth (%)	0.58	
		Mean skinfold (cm)	–9.106	
3.	Spike along the sideline T_4 (in points)	Intercept	–20.08	
		Horizontal arms spread (cm)	0.08	0.27
		Wrist breadth (cm)	2.08	
		Intercept	–21.08	
		Upper limb length (cm)	0.23	
		Horizontal arms spread (cm)	0.18	0.32
		Wrist breadth (cm)	2.54	
4.	Feint into the centre of the court T_6 (in points)	Intercept	–7.77	
		Ankle breadth (cm)	1.73	0.18
5.	Serve straight T_7 (in points)	Intercept	–16.75	
		Biacromial breadth/pelvis breadth (%)	0.10	0.22
		Bone muscle rate of the cross sectional area of thigh/total cross sectional area of thigh	10.62	

Spike test (T_4) correlated positively with length measurements (height, head-neck length, sternum length, upper limb length), biacromial breadth, horizontal arms spread, upper leg and lower leg circumferences and wrist circumference. Spike test T_5 demonstrated the essentiality of the relation of wrist circumference to wrist breadth and the relation of humerus breadth to upper limb length. All the correlations were at the level of r=0.3–0.4. This suggests that better results in spike are achieved by tall and slender players with greater extremities strength.

The results of the feint test (T_6) also depended on the breadth and strength of extremities bones. There were positive correlations (r=0.3–0.4) with wrist breadth, wrist circumference, relation of wrist circumference to body height, with humerus breadth, ankle breadth and with the relation of ankle breadth to body height.

Serve (T_7, T_8) had positive correlations with femur breadth / lower limb length, acromial breadth / pelvis breadth, and negative correlations with the proportion of adipose tissue thickness to the cross-sectional area of the thigh (r= –0.303).

In conclusion, our results showed that volleyball tests were better performed by slender girls with smaller body fat content, longer upper limb length, larger bicromial breadth and strong limb bones. The same was confirmed by regression analysis results, which revealed that most dependent on body build were the forearm pass (T_3) and spike (T_4) tests (R^2 =0.29 and 0.32).

Results of psycho-physiological tests

For the comparative study of adolescent female volleyballers psycho-physiological properties we applied 21 computerised tests on speed perception, auditory reaction, visual reaction and anticipatory reaction to reality (Table 7). As in the case of the previous test types, individual differences were great, but age had no influence on test results.

There were ten tests that showed stronger correlations with body build than the others (r=0.3–0.4).

The basic characteristics that correlated positively with psycho-physiological tests results were sternum length, trunk length, abdomen length, biacromial breadth, chest breadth and waist breadth.

Table 7. Basic statistics of young female volleyballers' psychophysiological tests results (n=46)

No	Variable n=32	$\bar{x}$	SD	Min	Max
1.	Average score of first- time speed perception tests (in points) A_1	4.341	4.072	–8.000	10.000
2.	Average reaction time in first-time speed perception tests (sec) A_2	0.697	0.240	0.210	1.880
3.	Average score of second-time speed perception tests (in points) A_3	6.049	2.881	0.000	12.000
4.	Average reaction time in second-time speed perception tests (sec) A_4	0.691	0.160	0.500	1.270
5.	Average score of third-time speed perception tests (in points) A_5	2.878	2.685	–2.000	12.000
6.	Average reaction time in third-time speed perception tests (sec) A_6	0.790	0.142	0.580	1.440
7.	Average reaction time in first-time auditory perception tests (right hand) (sec) B_1	0.235	0.064	0.169	0.447
8	Average reaction time in first-time auditory perception tests (left hand) (sec) B_2	0.229	0.061	0.175	0.452
9.	Average reaction time in second-time auditory perception tests (right hand) (sec) B_3	0.209	0.053	0.119	0.387
10.	Average reaction time in second-time auditory perception tests (left hand) (sec) B_4	0.213	0.057	0.125	0.429
11.	Average reaction time in third-time auditory perception tests (right hand) (sec) B_5	0.216	0.043	0.160	0.368
12.	Average reaction time in third-time auditory perception tests (left hand) (sec) B_6	0.212	0.047	0.110	0.374
13.	Average reaction time in first-time visual perception tests (right hand) (sec) C_1	0.199	0.060	0.129	0.364

No	Variable n=32	$\bar{x}$	SD	Min	Max
14.	Average reaction time in first-time visual perception tests (left hand) (sec) C_2	0.200	0.060	0.121	0.369
15.	Average reaction time in second-time visual perception tests (right hand) (sec) C_3	0.200	0.076	0.101	0.495
16.	Average reaction time in second-time visual perception tests (left hand) (sec) C_4	0.197	0.078	0.069	0.501
17.	Average reaction time in third-time visual perception tests (right hand) (sec) C_5	0.197	0.050	0.107	0.326
18.	Average reaction time in third-time visual perception tests (left hand) (sec) C_6	0.197	0.048	0.100	0.319
19.	Anticipatory reflection of reality, first attempt (sec) D_1	0.494	0.228	0.002	1.541
20.	Anticipatory reflection of reality, second attempt (sec) D_2	0.483	0.182	0.103	1.059
21.	Anticipatory reflection of reality, third attempt (sec) D_3	0.586	0.155	0.281	1.237

There were negative correlations with weight, chest depth, abdomen depth, femur breadth, ankle breadth, upper chest circumference, hip and upper thigh circumference, upper and lower leg circumference, arm, forearm and wrist circumference, umbilical and triceps skinfolds.

The indices that revealed positive correlations were relative trunk length, relative abdomen length, relative upper body length, relative upper limb length, relative biacromial breadth, relative waist breadth, arm circumference / upper limb length, relative wrist circumference, lower leg circumference / lower limb length, femur breadth / lower limb length, trunk length / upper chest circumference.

The negatively correlated indices were body mass index, relative lower body length, relative lower limb length, relative femur breadth, relative humerus breadth, relative hip and upper thigh circumference, relative upper leg circumference, relative arm circumference, forearm circumference / upper limb length, wrist circumference / upper limb length, wrist breadth / upper limb length.

We applied regression analysis (Table 8) in an attempt to predict the results of all the tests from significant anthropometric arguments, and five tests showed the most significant correlations (R^2=0.28–0.43). In conclusion, it might be said that these tests were performed better by slim girls with smaller extremities measurements.

Table 8. Predicting psychophysiological test results by basic anthropometric measurements, indices and body composition characteristics

No	Predicted variable	Explanatory variables	Coefficients	R^2
1.	Average reaction time in first-time speed perception tests A_2 (sec)	Intercept	0.45	
		Relat. trunk length (%)	0.05	0.37
		Arm circumference/upper limb length (%)	0.03	
2.	Average reaction time in second-time speed perception tests A_4 (sec)	Intercept	–2.09	
		Relat. trunk length (%)	–0.04	
		Relat. waist breadth (%)	0.11	0.40
		Lower leg circumf./lower limb length (%)	0.03	
		Trunk length/upper chest circumf. (%)	0.03	
3.	Average reaction time in third-time auditory perception tests (right hand) B_5 (sec)	Intercept	0.26	
		Relat. trunk length (%)	0.01	0.34
		Wrist circumf./upper limb length (%)	–0.01	
4.	Average reaction time in second-time visual perception tests (right hand) C_3 (sec)	Intercept	0.46	
		Sternum length (cm)	0.02	0.43
		Femur breadth (cm)	–0.06	
5.	Anticipatory reflection of reality, second attempt D_2 (sec)	Intercept	–2.02	
		Relat. abdomen length (%)	0.02	
		Relat. upper limb length (%)	0.05	0.28

Assessment of players' proficiency

Out of the 46 girls who were studied anthropometrically and by tests, 32 participated in competitions, where their performance was recorded by the computer program *Game*. For all players and all elements of the game we calculated the index of proficiency. For the whole group, the mean index of proficiency at serve was 0.545 (SD=0.279), at reception 0.513 (SD=0.183), at feint 0.657 (SD=0.246), at block

0.523 (SD=0.360) and at attack 0.563 (SD=0.226). The mean value of the proficiency index was 0.539 (SD=0.161).

All the anthropometric variables and test results of the girls who participated in competitions were correlated with the index of proficiency for all elements of the game. From the anthropometric variables and test results that were significantly correlated with proficiency in the game, we calculated by means of stepwise procedure the best models of linear regression for predicting proficiency in different elements of the game. To assess the independent impact of anthropometric variables and test results on proficiency, different models were formed for the basic anthropometric variables, indices and all the test results studied. The results are presented in Table 9.

All the elements of proficiency in the game could be predicted by a model that consisted only of basic anthropometric variables. Proficiency correlated significantly with 14 body measurements. These were height, weight, xiphoidal height, suprasternal height; trunk measurements: chest, waist and hip circumferences, limbs measurements: arm circumference (relaxed), arm circumference (flexed and tensed), upper thigh and lower leg circumference, wrist circumference and wrist breadth.

The efficiency of serve (32%) was facilitated by greater xiphoidal height and arm circumference. Efficiency of reception (50%) was linked to bigger weight, bigger suprasternal height and bigger wrist breadth.

Block was best performed (80%) by girls with bigger height and weight. For feint the most essential (83%) characteristics were bigger xiphoidal height, arm circumference and hip circumference. Attack was also more successful (71%) in girls with bigger weight and lower leg circumference.

For serve (17%), reception (33%), block (65%), feint (93%) and attack (41%) it was also possible to compile statistically significant regression models from anthropometric indices and body composition characteristics only. The most essential indices were Rohrer index, body mass index, relative chest breadth, relative waist breadth, relative pelvis breadth, relative humerus breadth, and the following relative circumferences: head, lower chest, upper leg, arm.

The physical ability model contained the results of four tests. Efficiency of reception depended on the result of the flexibility test (PA_7, 44%). Efficiency of feint was determined by the endurance test (PA_5, 18%) and the medicine ball throwing test (PA_9, 22%).

Table 9. The test models containing anthropometric measurements, results of tests of physical, psychophysiological and volleyball technical abilities

No	Predicted variable	Regression equations					
		Anthropometric models (basic measurements)	Anthropometric models (indices and body composition characteristics)	Physical ability models	Psychophysiological models	Volleyball technical models	Various test models
1.	Efficiency of serve	$-0.99-0.02X_2-0.03X_3+0.06X_5+0.09X_{36}$ $R^2=0.32$	$1.76-0.33X_{69}$ $R^2=0.17$	none	none	none	None
2.	Efficiency of reception	$3.36+0.03X_2-0.09X_5+0.08X_4+0.55X_{24}-0.02X_{27}-0.13X_{39}$ $R^2=0.50$	$0.23-1.84X_{64}+0.08X_{52}$ $R^2=0.33$	$2.10-0.0008PA_5+0.009PA_7-0.05PA_8$ $R^2=0.44$	$0.76+0.03A_3-2.24B_6$ $R^2=0.39$	$-0.24+0.01T_2+0.03T_6$ $R^2=0.39$	$-1.03+0.01PA_5+0.01T_2$ $R^2=0.36$
3.	Efficiency of block	$-3.48+0.07X_2+0.06X_3-0.16X_{32}$ $R^2=0.80$	$2.09-0.48X_{64}+0.13X_{73}$ $R^2=0.65$	none	$0.79+0.15A_3+0.08A_5-12.27B_3+4.94B_6$ $R^2=0.98$	none	None
4.	Efficiency of feint	$-3.22-0.05X_2-0.06X_3+0.11X_5-0.07X_{29}+0.03X_{31}+0.19X_{36}$ $R^2=0.83$	$8.80-0.25X_{62}-3.03X_{51}-0.10X_{99}-0.22X_{63}-0.15X_{71}+0.22X_{79}+0.01X_{97}$ $R^2=0.93$	$0.34+0.0009PA_5$ $R^2=0.18$	$1.33+0.04A_5-3.74B_6$ $R^2=0.60$	$0.20+0.09T_8$ $R^2=0.44$	$-0.19+0.03T_1-0.01T_2+0.01T_3+0.46D2$ $R^2=0.59$
5.	Efficiency of attack	$6.44+0.05X_2-0.03X_3-0.04X_{28}+0.12X_{35}-0.12X_{37}$ $R^2=0.71$	$1.26+0.06X_{78}-0.06X_{71}$ $R^2=0.41$	$0.06+0.002PA_9$ $R^2=0.22$	$1.07+1.61A_6-7.27B_4-0.68D_2$ $R^2=0.80$	none	$0.09+0.03T_6+0.01PA_9$ $R^2=0.31$

Exploratory variables of models:
X_2 – Weight (kg)
X_3 – Height (cm)
X_4 – Suprasternal height (cm)
X_5 – Xiphoidal height (cm)
X_{24} – Wrist breadth (cm)
X_{27} - Upper chest circumference (cm)
X_{28} – Lower chest circumference (cm)
X_{29} – Waist circumference (cm)
X_{31} – Hip circumference (cm)
X_{32}– Upper thigh circumference (cm)
X_{35} – Lower leg circumference (cm)
X_{36} – Arm circumference (cm)
X_{37} – Arm circumference flexed and tensed (cm)
X_{39} – Wrist circumference (cm)
X_{51} – Rohrer index
X_{52} – Body mass index
X_{62} – Relat. chest breadth (%)
X_{64} – Relat pelvis breadth (%)
X_{69} – Relat. humerus breadth (%)
X_{71} – Realt. head circumference (%)
X_{73} – Relat. lower chest circumference (%)
X_{78} – Relat. upper leg circumference (%)
X_{79} – Relat arm circumference (%)
X_{97} – Biocromial breadth/pelvis breadth (%)
X_{99} - Biocromial breadth/upper chest circumference (%)
PA_5 – Endurance shuttle run test (sec)
PA_7 – Flexibility test (sit and reach) (cm)
PA_8 – Speed shuttle run test (sec)
PA_9 – Medicine ball throwing test (cm)
A_3 – Average score of second-time speed perception tests (in points)
A_5 – Average score of third-time speed perception tests (in points)
A_6 – Average reaction time in third-time speed perception tests (sec)
B_3 – Average reaction time in second-time auditory perception tests (right hand) (sec)
B_4 – Average reaction time in second-time auditory perception tests (left hand) (sec)
B_6 – Average reaction time in third-time auditory perception tests (left hand) (sec)
D_2 - Anticipatory reflection of reality second attempt (sec)
T_1- Overhead pass with a clap behind the back (in points)
T_2 – Overhead pass with squat (in points)
T_3 – Forearm pass into 1 m^2 (in points)
T_6 – Feint into the centre of the court (in points)
T_8 – Serve diogonally (in points)

Out of the nine volleyball technical tests, five correlated with proficiency in the game. In the model where only volleyball technical tests were used as arguments, their number was three (T_2, T_6, T_8). In the model that consisted of different types of tests (see the last model), the following tests were essential: T_1, T_2, T_3 and T_6).

The model of volleyball technical tests was essential for reception (39%) and feint (44%). In the first case, the pass test T_2 was essential, and in the second case the serve test T_8.

Proficiency in the game correlated surprisingly closely seven psycho-physiological tests (A_3, A_5, A_6, B_3, B_4, B_6, D_2). They determined the efficiency in four elements of the game out of five within 39–98%. The only element where they did not have any significance was serve, for the performance of which the player has enough time and where the player is not dependent on the activity of other players. On the contrary, success in psycho-physiological tests was very essential for such elements as block (98%) and attack (80%), which, as a rule, are performed in the greatest deficit of time. Here, the player needs very quick reaction and correct assessment of the movement of the ball.

That several aspects are essential for proficiency in the game was shown by the model that included various tests. Here efficiency of reception (36%) was determined by greater endurance (PA_5) and pass technique (T_2). Efficiency of feint (59%) depended on better handling of the ball in pass (T_1, T_3) and better psychical reaction (D_2). Efficiency of attack (31%) depended on better performance of feint (T_6) and greater strength of arms and back muscles (PA_9).

DISCUSSION

Our results confirmed the data published in literature [6, 19, 27] that volleyball proficiency depends on players' very different abilities. As literature does not contain many data on the significance of adolescent female volleyballers' body build and different tests results for proficiency in the game, we hope that in our study we managed to present a somewhat more profound and integrated approach to the problem.

First of all, we managed to show which anthropometric measurements could be used to characterise volleyballers' body build and to assess tests results. We demonstrated that body characteristics form an

integrated system and each of them, in addition to a concrete measurement, also essentially represents the body as a whole. Therefore, all basic anthropometric measurements that are related to the problem under study can be used as arguments in regression analysis. Until now, researchers have confined themselves mostly to height and weight.

We also suggested a solution to the problem of classifying adolescent female volleyballers' body characteristics, being the first to use a height-weight classification (5 SD classes). Until now, authors have used only the Heath-Carter system [31] for typification. We suggest that the height-weight classification facilitates successful classification of length, breadth and depth measurements, circumferences as well as skinfolds and shows that the anthropometric structure of our sample of adolescent girls (aged 13–16) has the same regularities as found in other age groups [10, 21].

The physical ability tests results varied considerably, which was to a significant extent caused by peculiarities of body build. Thus, by linear regression analysis it proved possible to determine anthropometrically the variability of PA_1 (89%), PA_2 (78%), PA_3 (61%), PA_4 (63%), PA_5 (42%), PA_8 (63%) and PA_9 (65%).

The performance of volleyball technical tests did not depend on age, but the results of tests T_2–T_7 were dependent on body build (R^2=0.11–0.37). Body build was most essential for spike tests (T_4, T_5), while the most significant variables were upper limb length, horizontal arms spread, wrist breadth, relative wrist circumference and wrist circumference / upper limb length. The indicators of body fat content had a negative impact.

The results of psycho-physiological abilities tests were not in correlation with age, but tests A_2, A_4, B_5, C_3 and D_2 correlated with body build (R_2=0.28–0.43). The most significant characteristics were relative trunk length, relative upper limb length, relative waist breadth, femur breadth, arm circumference / upper limb length, wrist circumference / upper limb length.

We were not able to compare our results with anyone's because in literature we could not find any data on using such an extent of psycho-physiological tests on adolescent female volleyballers. Some studies, however, have shown that elite male volleyballers essentially surpassed physical culture students of the same age in psychological tests of reaction speed [12] and that an 8-week physical training period of a junior male volleyball team had a positive effect on their

physical fitness, and their auditory and visual reaction times shortened [6].

The study of the significance of female adolescent volleyballers' anthropometric characteristics and test results for proficiency in game was facilitated by the original volleyball recording program *Game* designed by the authors. We found that basic anthropometric measurements enabled us to predict proficiency in the game within 32–83%, anthropometric indices within 17–93%. Test results did not provide a statistically significant result in the case of serve. In reception the reliability of tests varied from 36 to 44%, in feint 18–60% and in attack 22–80%. In the case of block the only significant tests were the psycho-physiological ones (R^2=0.98).

As no analogous study of proficiency could be found in literature, we could compare only the significance of physical abilities for the proficiency in the game, where greater speed, endurance, arms and upper body strength and sit and reach flexibility [4, 5, 16, 19, 32] are the qualities necessary for a successful volleyballer.

In summary, we can conclude that application of our anthropometric methodology and testing programme helps to analyse the quality of coaching and assess each player's individual development.

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SIMILARITY ANALYSIS OF MULTIVARIATE PROFILES*

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ABSTRACT

A method of constructing multivariate profiles was presented together with an analysis of their similarity. Wingate test data (mean and terminal power outputs, times to attain and to maintain mean power, and time to run 2×25 m distance) from three sports (judo, 400 m race, handball) and a control group served as examples. Individual profiles for control group were compared with mean reduced profiles for three sports using similarity indices obtained from chi-square function. The profiles were computed from data standardised against means and SD for the control group (physical education students). Next, the data were reduced by subtracting averaged values (both group and individual) for all five variables. Several types of profiles for individual students were demonstrated, among them similar or significantly dissimilar to given sports. The method can be used as a screening aid in sport selection and/or classification.

Key words: multivariate analysis, profiles, similarity

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* The study was supported by project No. DS-40. A part of the paper was presented at the 23rd ICPAFR conference in Tartu, 5–8 September 2002.

INTRODUCTION

Multivariate profiles have been widely used in e.g. biological taxonomy, psychometrics, and many other fields. In most cases, the profiles are used to demonstrate differences between two or more groups with respect to a set of variables. As an example of such an application may serve the study on iron metabolism in athletes [3], in which an iron-deficient group was compared to that with normal iron stores. Such studies usually concentrate on identifying variables, or sets of them, which differ significantly between groups. This is related to MANOVA or factor analysis.

A different approach is needed when trying to assign an individual case to given category, like in taxonomy. Then the objective is to determine to which predefined set of values ("species") the individual case is the most similar. Determining the degree of similarity of profiles has been done by applying a generalised correlation approach [2], by computing a correlation-based similarity index [1], etc.

The aim of this study was to employ the chi-square function [4] to determine the similarity of multivariate profiles in order find to which group (represented by a set of data) a subject is most likely to belong.

MATERIAL AND METHODS

The data used in this paper were taken from a larger study of one of us (H. N.) and were recorded for the following groups of subjects: judoists (n=19), middle-distance runners (n=10), handball players (n=35) and physical education students (n=40). The athletes were in the age range of 20–30 years and had reached a high level in sport. All individuals were subjected to the standard 30 s Wingate test and to maximal 2×25 m shuttle run. The following Wingate test variables were used: mean power output (P_a), terminal power output — at the end of the test (P_t), time to attain maximum power output (T_{att}), time to maintain maximum power output (T_{sust}) and running time (T_r). In order to orientate all variables identically (the higher value of the variable the better), T_{att} and T_r were converted to their reciprocals, i.e. velocities (V_{att} and V_r, respectively). All data were standardised against respective means and standard deviations for the control

group, then mean standardised values were computed for every group, and multivariate profiles were prepared.

RESULTS AND DISCUSSION

Mean values and SD's of studied variables obtained for the four groups of subjects are presented in Table 1. Mean values were standardised vs. the respective means and SD's for students, as shown in the last line of the table.

Since multivariate profiles may be of the same shape but at a different level, i.e. shifted vertically, standardised values were not used directly in the analysis. All profiles were first reduced by mean values of all variables for individual profiles. The deviations from the mean formed a "reduced profile". For example, the reduced judo profile was obtained by subtracting 0.45 (mean standardised value for judo group; cf. Table 1) from all standardised values for that group. The reduced values are shown in Table 2. For every individual reduced profile, 4 chi-square functions were computed, namely for each of the mean group profiles, i.e. judo, 400 m, handball and students (Fig. 1). The following formula was used:

$\chi_k^2 = \Sigma\ (z_{ij} - Z_{jk})^2$, where z_{ij} is the standardised, reduced value of variable j for subject i, and Z_{jk} is the mean standardised, reduced value of variable j for group k. Example data for computations are shown below.

The measure of similarity of subject's profile to the mean judo profile equals to:

$\chi^2 = (1.00 - 0.18)^2 + (2.06 - 1.26)^2 + (-1.49 - 0.19)^2 + (-0.55 + 0.85)^2 + (-1.02 + 0.78)^2 = 4.26$

based on $m-1$ degrees of freedom, where m is the number of variables. Since there are five variables, df = 4.

The computations were analogously repeated for other groups.

Chi-square values for nine students are presented in Table 3.

Table 1. Mean values (±SD) of studied variables for 4 groups of subjects

Variable / Group	P_a/kg	P_t/kg	V_{att}	T_{sust}	V_r
Judo	**8.99**±0.54	7.77±0.53	0.192±0.043	2.17±0.93	0.116±0.005
400 m race	9.53±0.44	8.31±0.75	0.149±0.016	2.89±0.96	0.123±0.002
Handball	8.83±0.90	6.79±0.56	0.185±0.029	2.39±0.79	0.120±0.005
Students	**8.67±0.50**	6.72±0.62	0.172±0.035	2.53±0.90	0.117±0.004
Judo, standardised values	0.63	1.70	0.64	–0.40	–0.34

Legend: P_a/kg — Mean relative power output; P_t/kg — Mean end power output; V_{att} — Reciprocal of time to attain maximum power output; T_{sust} — Time to sustain maximum power output; V_r — Reciprocal of 2×25 m running time.
Standardised values for judo: 0.63 = (8.99–8.67) / 0.50, etc.; the respective values are bolded. Mean standardised value for judo equals to 0.45.

Table 2. Mean standardised, reduced values for 4 groups studied and standardised values for Subject No. 56 (raw and reduced)

Variable / Group	P_m/kg	P_t/kg	$V_{att\ Pm}$	$T_{sust\ Pm}$	V_{run}	χ^2
Judo (n = 19)	0.18	1.26	0.19	–0.85	–0.78	4.26
400 m race (n = 10)	0.61	1.49	–1.79	–0.69	0.38	2.57
Handball (n = 37)	0.01	-0.20	0.26	–0.47	0.40	11.16
Students (n = 45)	0	0	0	0	0	8.79
Subject No. 56						Mean
Raw standardised values	2.51	3.57	0.02	0.96	0.49	1.51
Reduced values	1.00	2.06	–1.49	–0.55	–1.02	

χ^2 — Chi-square values obtained by comparing the reduced profile of subject No. 56 with the respective group profiles. For explanation of other symbols see Table 1.

Table 3. Wingate test variables measured in 9 physical education students and the resulting chi-square values reflecting the degree of similarity to specific sport profiles

Subject No.	Measured values					Values of χ^2 (df = 4)			
	P_m/kg	P_t/kg	$V_{att\ Pm}$	$T_{sust\ Pm}$	V_{run}	Judo	400 m	Hand-ball	Students
78	8.96	7.20	0.172	2.84	0.117	2.92	2.77	2.82	1.33
87	9.00	7.00	0.148	2.06	0.122	7.24	**2.07**	3.90	4.07
64	8.25	6.80	0.211	0.60	0.113	**1.48**	*9.93*	3.15	3.93
56	9.93	8.93	0.200	3.40	0.119	4.26	**2.57**	*11.16*	8.79
66	9.23	6.50	0.213	2.91	0.113	5.16	*11.60*	**4.25**	2.84
73	8.32	6.10	0.231	1.84	0.116	5.84	*14.29*	**1.20**	2.05
74	8.63	6.00	0.216	2.51	0.122	*10.98*	*13.70*	**1.95**	3.20
86	8.10	5.90	0.174	2.56	0.122	*13.21*	*12.90*	**3.64**	4.28
65	7.93	5.80	0.312	0.95	0.108	*16.93*	*39.43*	*15.90*	*17.30*

Values exceeding the χ^2 for df = 4 (significant difference from given profile; $p<0.05$) are printed *in italics*. Lowest χ^2 values, indicating maximum similarity to given sport profile, are **bolded**.
For explanation of symbols see Table 1

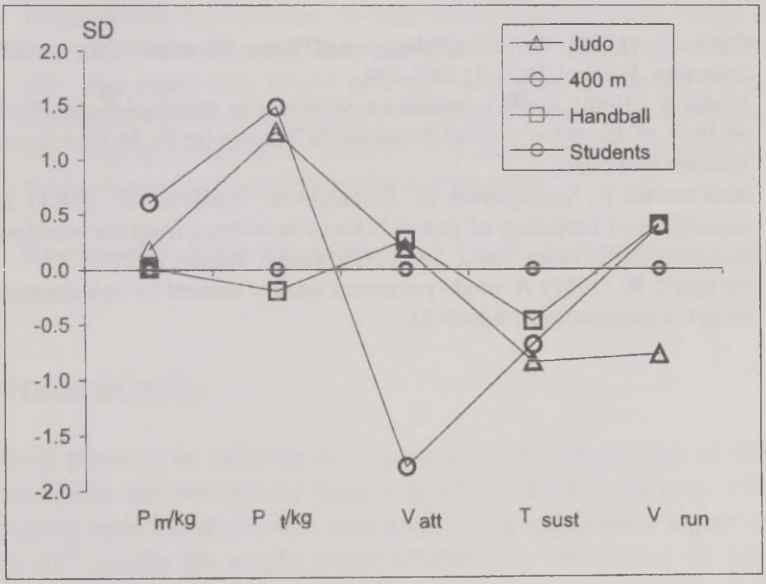

Figure 1. Reduced mean profiles for various sports. Data were standardised against those for physical education students.
For explanation of symbols see Table 1

Various types of profiles can be seen. The profile of the first subject (No. 78) may be regarded as similar to any group profile. In contrast, that of the last subject (No. 65) is significantly unlike any of the group profiles studied. The profile of subject No. 87 resembles most that of a runner, although exhibits no significant dissimilarity with any other group profile. Other subjects show significant dissimilarities to one or two group profiles and high degrees of similarity (low chi-square) to another one. Possible maximum similarity to the mean student profile was not considered.

Although no definite identification of the type of the profile is possible, the magnitude of the chi-square function provides an objective measure of similarity. That function was used in an earlier study [4] for determining the reliability and performance of an analytical method; the problem could thus be reduced to assessing similarity. It should be emphasised that the presented procedure may be useful in comparing profiles in other areas of research, and sport data presented in this study served only as an illustration.

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AMBULATORY BLOOD PRESSURE MONITORING IN ADOLESCENTS

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ABSTRACT

Ambulatory blood pressure monitoring (ABPM) is a well-established method for measuring blood pressure in adults and becoming common in children and adolescents. [1]. ABPM is particularly suitable for estimating the 24-hour blood pressure profile in adolescents with casual hypertension.

This paper will summarise the diagnostic relevance of a number of parameters from 24-hour ambulatory blood pressure recordings. These parameters include: 24-hour mean blood pressure values and their 95% Confidential Intervals (95% CI), difference between day- and night-time blood pressure, and data on blood pressure load in different gender groups, correlation between blood pressure and anthropometric data. 24-hour ambulatory blood pressure monitoring found good acceptance by adolescents.

Key words: adolescents, ambulatory blood pressure monitoring

INTRODUCTION

Blood pressure in children is very variable. Measurements of blood pressure in the community have suggested that at most only 1% of children have blood pressure consistently and appreciably higher than the 95th centile for single measurements [2]. Prevalence of hypertension in school-children in different regions of Estonia varies: systolic hypertension from 0% to 18.2%, diastolic hypertension from

0% to 17.0% and high rate of both blood pressures — from 0% to 5.9% [3]. Ambulatory blood pressure monitoring (ABPM) is a well-established method for measuring blood pressure in adults and becoming common in children and adolescents. ABPM is particularly suitable for estimating the 24-hour blood pressure profile in adolescents with casual hypertension. ABPM reduces measurement error, is relatively easy to use and yields many more blood pressure parameters than clinic blood pressure measurements do. Researchers have used ABPM to study normal blood pressure patterns, "white coat effect" on blood pressure, and attempted to quantify the contributions of heritability and environmental components to hypertension [4]. To the author's knowledge, no studies of ABPM among children and adolescents had been done in Estonia before.

The **objective** of the present study was (1) to establish the method of ambulatory blood pressure monitoring in adolescents; (2) to analyse the data and the experience gained from the use this technique in Estonia; (3) to assess reference values of ambulatory blood pressure in hypertensive adolescents.

MATERIAL AND METHODS

The sample included fifty two 11–18-year-old adolescents In all of them high blood pressure had previously been detected by a family doctor, a school physician or by a pediatrician. The family history of cardiovascular diseases was studied. The anthropometric examination included measurement of height and weight, assessment of body fat percentage by the method of bioelectrical impedance with body fat analyser BF-905 (MALTRON®, UK) and calculation of body mass index by the formula: BMI = body mass (kg) / height (m^2). Ambulatory blood pressure (ABP) was recorded over a 24-hour period using a MOBILOGRAPH® recorder (manufactured by I.E.M. GmbH, Germany) and appropriate cuff size. Blood pressure was measured in every 20 minutes from 06.00 to 24.00 hours, and thereafter in every 30 minutes. The data were recorded while the patients went about their usual daily activities. A subject-kept activity diary facilitated data interpretation. The upper limits of "normality" for the mean of 24-hour SBP and DBP were estimated as the 95^{th} percentile of blood pressure (P95) according to the person's age, gender and height [5].

Blood pressure series measurements report enabled us to make different statistical statements regarding systolic and diastolic blood pressure (SBP, DBP) and pulse pressure (PP): day- and night-interval mean SBP and DBP values and variation (standard deviation), the percentage of decrease of blood pressure mean values between day- and night-interval. The adolescents whose nocturnal blood pressure fall for SBP and DBP was more than 15% were classified as dippers and those whose nocturnal BP fall was less than 15% as non-dippers. Blood pressure load at day-time was determined as readings >30% higher than the 95th percentile of BP by person's gender, age and height and showed in percentage. Blood pressure load at night-time was accounted as readings of SBP over 120 mm Hg and DBP over 75 mmHg . It was possible to analyse the number of succeeded blood pressure measurements too.

The SPSS 8.0 for Windows statistic package was used. All the data underwent statistical processing with determination of the mean, 95% Confidence Interval for mean (95% CI), standard deviation (SD), standard error (SE), correlation coefficient and t-test for comparison of means. In all cases the significance level $p<0.05$ was used.

RESULTS

All adolescents except for two (3.8%) accepted ABPM, provided it was clearly explained in advance. The data of 50 patients — 33 boys (66.0%) and 17 girls (34.0%) were analysed. Positive family history — prevalence of heart disease and/or hypertension in I and II degrees relatives was found in 24 patients (48.0%). The characteristics of the subjects of the study are presented in Table 1. The studied boys were older, heavier and taller than girls ($p<0.05$). Girls had higher body fat content than boys ($p<0.05$). No difference between boys and girls was found in BMI. From all 24-hour blood pressure measurements 91.8±10.7% were successfully completed. The number of day-time measurements (M±SD) was 49±11 and night-time measurements — 22±6. The results of ABPM are presented in Table 2. Day-time SBP, DBP and pulse pressure readings were higher than night-time ones in both sexes. There were small gender differences in blood pressure readings: boys had somewhat higher day-time systolic blood pressure and day- and night-time pulse pressure ($p<0.05$). Independent sample

test did not reveal any differences in mean day- and night-time SBP and DBP data according to family history.

Seventy two percent of the subjects (36/50) had an elevated BP load. Data on the mean BP load are presented in Table 3. The mean prevalence of day-time SBP load was almost the same in boys and girls (41.1% and 41.8% accordingly). In night-time mean SBP load a difference was found between boys and girls ($p<0.05$): boys had 43.3 % of all readings over 120 mmHg and girls 29.2 %. The frequency of blood pressure load by gender is shown in Table 4. More than half of all the surveyed adolescents had day- and night-time systolic blood pressure load over 30% of measurements without gender differences. Boys had day-time DBP load statistically more often than girls (9.1% versus 5.9%) and night-time DBP load too (6.1% versus 5.9%). Among girls there were 35.3% of dippers and 64.7% of non-dippers as compared to 24.2% and 75.8% among boys, but the difference was not significant ($p>0.05$). Comparison of differences in blood pressure load over individual reference data at day-time and over fixed BP data at night-time (SBP>120 mmHg and DBP>75 mmHg) in dippers and non-dippers is shown in Table 5. Among dippers there were 17.9% of adolescents with night-time SBP>120 mmHg and 3.6% with DBP>75 mm Hg in contrast to non-dippers data (46.6% and 16.6% accordingly) ($p<0.05$).

Table 1. Characteristics of study subjects

Variable		Mean	SD	95% CI
Age (years)	Boys	15.36**	1.85	14.71– 16.02
	Girls	13.88	4.52	12.74– 15.01
Weight (kg)	Boys	70.39**	12.93	65.81 – 74.98
	Girls	57.31	13.09	50.34 – 64.29
Height (cm)	Boys	166.33**	10.28	160.43 – 176.24
	Girls	162.33	8.08	142.25 – 182.41
BMI (kg/m²)	Boys	22.47	4.93	20.73 – 24.22
	Girls	21.99	5.20	19.22 – 24.76
Body Fat (%)	Boys	24.65 **	7.89	21.85 – 27.44
	Girls	31.46	12.92	24.57 – 38.34

*BMI — body mass index ; ** $p < 0.05$ between boys and girls

Table 2. Data of ambulatory blood pressure monitoring

Variable		Mean	SD	95%CI
Day-time SBP	Boys	130.5**	8.9	127.4 – 133.7
	Girls	124.8	7.6	120.9 – 128.7
Day-time DBP	Boys	71.0	7.2	68.4 – 73.5
	Girls	71.4	5.6	68.5 – 74.2
Day-time PP	Boys	59.6**	7.7	56.8 – 62.3
	Girls	53.5	5.3	50.7 – 56.2
Night- time SBP	Boys	117.7	10.4	114.0 – 121.4
	Girls	112.4	8.9	107.8 – 117.0
Night- time DBP	Boys	61.6	6.2	59.4 – 63.7
	Girls	61.5	6.4	58.2 – 64.8
Night- time PP	Boys	56.2**	7.4	53.6 – 58.3
	Girls	51.0	5.7	48.1 – 53.9

SBP — systolic blood pressure; DBP — diastolic blood pressure; PP — pulse pressure
** $p < 0.05$ between boys and girls

Table 3. Mean blood pressure load over individul reference readings in adolescents

Variable		Mean (%)	SD	95%CI
Day-time SBP load (%):	Boys	41.1	24.1	32.6 – 49.6
	Girls	41.8	23.5	29.7 – 53.9
Day-time DBP load (%):	Boys	11.6	15.6	6.1 – 17.2
	Girls	13.5	15.6	6.1 – 17.2
Night-time SBP load (%) :	Boys	43.3**	28.8	33.1 – 53.5
	Girls	29.2	28.9	14.4 – 44.1
Night-time DBP load (%) :				
	Boys	13.6	15.1	8.3 – 19.0
	Girls	11.7	16.8	3.1 – 20.3

SBP — systolic blood pressure; DBP — diastolic blood pressure
** $p < 0.05$ between boys and girls

Table 4. Frequency of blood pressure load in adolescence

Gender	Day-time SBP load over 30%	Day-time DBP load over 30%	Night-time SBP load over 30%	Night-time DBP load over 30%
Boys	63.6%	9.1%**	63.6%	6.1%**
Girls	58.8%	5.9%	41.2%	5.9%

SBP — systolic blood pressure; DBP — diastolic blood pressue
** $p < 0.05$ between boys and girls

Table 5. Comparison of differences in mean blood pressure load between dippers and non-dippers

Variable	Results of BP dipping	N	Mean (%)	SD	SE
Day-time SBP load over individual reference data	Dipper	14	45.4	16.5	4.4
	Non-Dipper	36	39.8	25.9	4.3
Day-time DBP load over individual reference data	Dipper	14	12.2	9.4	2.5
	Non-Dipper	36	12.3	16.9	2.8
Night-time SBP over 120 mmHg	Dipper	14	17.9**	12.6	3.4
	Non-Dipper	36	46.6	30.1	5.0
Night-time DBP over 75 mm Hg	Dipper	14	3.6**	3.5	0.9
	Non-Dipper	36	16.6	16.9	2.8

SPB – systolic blood pressure; DBP – diastolic blood pressure
** $p < 0.05$ between dipper and non-dipper groups

Pearson test showed significant correlation ($p<0.05$) between age and height ($r=0.79$), BF% and BMI ($r=0.66$). Blood pressure did not correlate with adolescents' anthropometric data, BMI or BF %. The mean data of day-time SBP correlated with day-time pulse pressure ($r=0.65$), SBP load ($r=0.62$) and DBP load ($r=0.85$). Mean night-time SBP correlated with night-time pulse pressure ($r=0.86$), night-time DBP load ($r=0.97$) and day-night decrease of SBP $r= -0.81$).

DISCUSSION

Among the studied adolescents boys were older, heavier and taller than girls, but girls had higher body fat percentage than boys. No significant difference between boys and girls was found in body mass index.

Ambulatory blood pressure monitoring as a new method for assessing of blood pressure variables was successfully completed in almost all adolescents. The mean day-time BP in girls (124.8 / 71.4 mmHg) was almost similar to literature data — 125/75 mm Hg [6]. In this study 15–years boys had somewhat higher mean day-time SBP (130.5 mmHg) than boys of same age in Lurbe E et al. (123 mmHg) [6]. The mean day-time SBP load over individual reference readings (41.1% in boys and 41.8% in girls) was higher than in literature (39%) where normotensive children were studied [6]. The day-time DBP load over individual reference readings (95% CI 6.1%–17.2% in boys and girls) and night-time DBP load over individual reference readings (95% CI 8.3%–19.0% in boys and 3.1%–20.3% in girls) in this study were lower than in the study of Lurbe et al. (26%) [6]. This study confirmed that adolescents with earlier found casual hypertension more often had systolic hypertension by ABPM . The circadian rhythm was disturbed in 64.7% of girls and 75.8% of boys who were non-dippers. Independent samples test showed statistical differences in day-night SBP and DBP fall between dippers and non-dippers. There were found no differences in night-time blood pressure fall between children with positive family history and without it.

ABPM is feasible in adolescents and the values obtained are useful in everyday practice.

The study was supported by the Estonian Science Foundation grant project No. 4683.

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Papers on Anthropology XI, 2002, pp. 297–312

PARENTAL BODY LINEARITY AND SKINFOLDS IN THE OFFSPRING

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ABSTRACT

Parents of excess weight often have fat children. The purpose of the study was to examine the possible influence of parental body linearity estimated by the height-to-weight ratio (HWR) on the skinfold thicknesses developed by their school-age children.
The problems studied were:

a) skinfold differences attributable to parental HWR grouping;
b) skinfold differences during growth linked to gender and/or to homologous parent;
c) comparison of skinfold development on the limbs and the trunk.

Skinfolds were expected to follow the parental groups of HWR, following better the homologous parent's category. Dimorphism in skinfold patterning and a dissimilar age course at the studied sites were also assumed.

A cross-sectional sample of 1997 schoolgirls and 1585 schoolboys (aged 7 to 18) was measured in two counties of Middle Hungary in the eighties and the nineties. Skinfolds (triceps, subscapular, suprailiac and calf) were measured by the same observer using a Lange calliper. Parental heights and weights were obtained by a questionnaire. The categories of HWR (cm stature over the cube root of kg body mass) for the fathers were: below 40.0 (stout), 40.0–41.5 (medium), and above 41.5 (lean). For the mothers the respective cut-off points were 40.5 and 42.0.
The observations were as follows:

a) The sons of the low-HWR parental groups had thicker skinfolds than peer-age boys of the other categories. In the girls this difference was present but less marked.
b) The female series of mean skinfolds increased with advancing age whereas in the boys this steady growth ended at age 12 to decrease or level off in the older ones, in particular in the parental groups with low HWR. Differences between the children of the corresponding paternal and maternal groups of HWR were slight and decreased with age in both genders.
c) While the age series of mean skinfold thickness on the trunk of the boys and on both the trunk and limbs of the girls showed a tendency to grow, the series of means for the male children's limbs consistently decreased after age 12.

It has been inferred that 1) the offspring of parents either of whom has a low HWR is likely to accumulate more subcutaneous fat; 2) by the age of 18 parental HWR does not separate skinfold patterns well; and 3) the skinfolds of the limbs and the trunk have dissimilar growth patterns in school-age children depending on age and gender.

Key words: parental height-to-weight ratio (HWR), child's skinfold thickness.

INTRODUCTION

Overweight and fatness in the developed world have been recognised as risk factors to health, as civilisation pathology. They arise mainly from lack of sufficiently intense habitual physical exercise, and usually associate with dietary habits wrong both quantitatively and qualitatively. The latter depend essentially on the family's way of life and, in particular, nutrition [3, 4, 7]. When dealing with these problems in school-age children, it is, therefore, advisable to study parents and children concurrently [9, 12, 20].

Three closely related factors interact in shaping the physique of our children: the genetic background of the hereditary characteristics most of which show a polygenic origin; the series of events usually referred to as growth, development and maturation, which is again geneticaly determined; and the agents of environment that interact with these

genetic factors [23, 16, 24, 2, 19]. The mechanisms of interaction are very intricate, so the separation of the respective causes and effects is extremely difficult [18, 13]. So we often feel satisfaction when the part of one or other factor in a given attribute of physique can be evidenced or else when differences in it can be retraced to associations with age and gender [10].

General experience is that fat parents often have children suffering from excess weight. In addition, fat children are very likely to become overweight as adults [11, 26]. The main goal of our study was to examine the association between parental body linearity — estimated by their height to weight ratio (HWR) — and the nutritional status of their children — estimated by the series of skinfold thicknesses between 7 and 18 years of age. The problems studied concerning this possible association were as follows.

a) Age- and gender-linked differences in skinfold means attributable to parental HWR grouping, and, if such existed, which of the parents was more involved.
b) Parental HWR influence on the age series of the sum of skinfold thicknesses on the limbs and the trunk during growth.
c) Age series of the limb and trunk skinfolds in the offspring of parents belonging to the same (lowest, respectively highest) HWR category.

Skinfolds were expected to follow the parental groups of HWR and to follow the parent's category of the homologous gender better. Dimorphism in skinfold patterning and a dissimilar age course at the studied sites were also assumed.

MATERIAL AND METHODS

A cross-sectional sample of a total of 1997 schoolgirls and 1585 schoolboys living in two counties (Fejér and Veszprém) of Middle Hungary was measured in the eighties and nineties [5, 6].

Parental data for height and weight were obtained by a questionnaire. HWR was chosen to describe parental body linearity because it is dimensionally correct in that the power terms of its numerator and denominator agree, further because it has been extensively studied as the basis of ectomorphy, the third component of the somatotype [22, 14, 8, 17].

Table 1. Distribution of the children by age group, gender and parental HWR

Parent	Father stout: HWR<40.0		Mother stout: HWR<40.5	
Age group (yr.)	Sons	Daughters	Sons	Daughters
7	19	18	17	16
8	32	27	39	35
9	26	38	34	37
10	43	31	45	42
11	33	35	35	35
12	38	41	47	44
13	38	45	53	43
14	29	34	37	51
15	58	108	93	126
16	67	93	65	116
17	71	89	76	113
18	31	65	44	86
Parent	Father lean: HWR>41.5		Mother lean: HWR>42.0	
Age group (yr.)	Sons	Daughters	Sons	Daughters
7	25	30	44	36
8	40	41	54	49
9	32	47	43	64
10	44	58	51	71
11	42	45	56	45
12	42	45	52	46
13	44	55	38	45
14	43	37	35	30
15	71	78	54	87
16	48	74	53	86
17	52	71	53	72
18	31	56	31	56
Totals	999	1261	1149	1431

Abbreviations: HWR: Height to Weight Ratio [$cm \cdot kg^{-1/3}$ (cm stature over the cube root of kg body mass)]. The categories of HWR for the fathers: below 40.0 (stout), above 41.5 (lean). For the mothers the respective cut-off points were 40.5 and 42.0.

The more linear body build is, the higher its HWR. Conversely, stout people have a low HWR. Body linearity depends considerably on subcutaneous fat, a fact justifying the assumption that parental body build may be related to the child's skinfold thickness. We assumed that parental HWR is an indirect reflection of the nutritional status and, thus, also of the lifestyle of the parents. The latter is regarded by the

children as a paradigm to be followed, particularly by the younger ones. The categories of parental HWR were stout, medium and lean.

Table 1 contains the HWR grouping limits chosen for the parents and the sample sizes of the children belonging to the respective parental categories of HWR Cut-off points for HWR were selected to match sexual dimorphism and yield acceptable subsample sizes. However, the present paper does not discuss the medium category, although their data were also processed. Table 2 shows the distribution of the parents by HWR categories. Not all of the questionnaires returned contained both the paternal and maternal data on height and weight, but drop-out due to this reason was slight.

Table 2. Number of parents by HWR categories

HWR	Fathers	Category	HWR	Mothers
<40.0	1109	Stout	< 40.5	1329
40.0...41.5	1163	Medium	40.5...42.0	1002
>41.5	1151	Lean	>42.0	1251
Total	3323			3582

Abbr.: as in Table 1.

Body fat is an important component of body mass. The estimation of body fat by using skinfold thicknesses is a recognised technique [25]. In the children limb (triceps and calf) and trunk (subscapular and suprailiac) skinfolds were measured to the nearest half mm by the same observer using a Lange calliper. Skinfold means were calculated for every full ±0.5 year of age for ages 7–18.

RESULTS AND DISCUSSION

Figure 1 shows the means and standard errors of the triceps and calf skinfolds of the sons of the stout and lean parental groups. These were not different in the first grades of school, but remarkable differences were noted between 10 and 12 years of age, with a larger dissimilarity between the maternal groups. Boys tend to lose their childhood fat only after this age interval. Absolute and relative fat loss during adolescent growth was found to have taken place earlier in the sons of

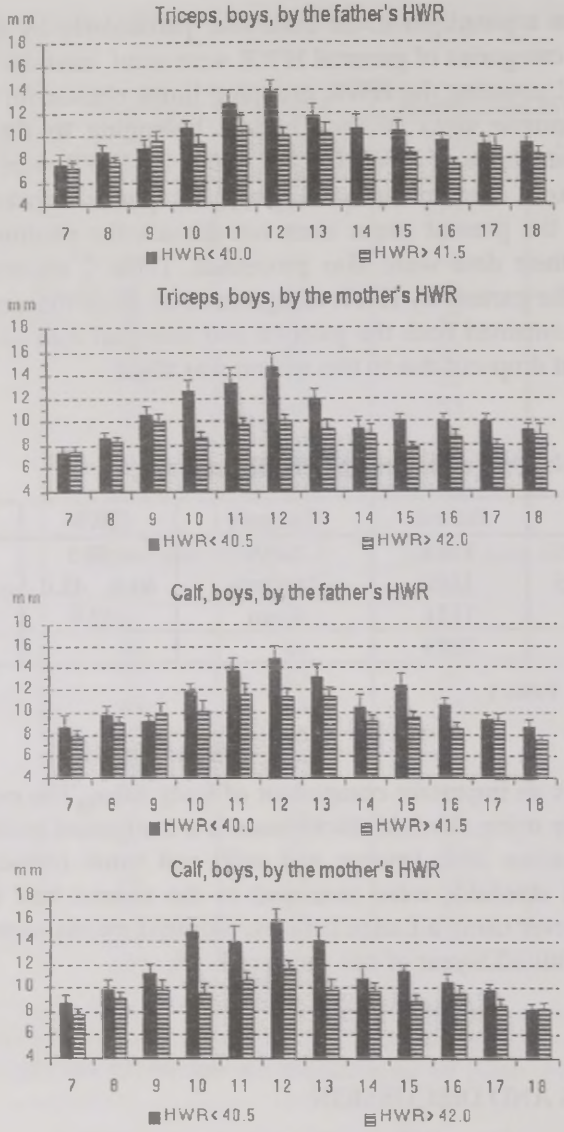

Figure 1. Means and standard errors of the triceps and calf skinfolds of the sons of the stout and lean parental groups. Full bars: sons of the stout parental group; horizontally hatched bars: sons of the lean parental group. Abbreviations: HWR: Height to Weight Ratio [cm·kg$^{-1/3}$ (cm stature over the cube root of kg body mass)]. The categories of HWR for the fathers: below 40.0 (stout), above 41.5 (lean). For the mothers the respective cut-off points were 40.5 and 42.0

stouter parents and later, at ages 13 to 14, in those of leaner ones. This may indicate that the latter were late maturers as well. After age 14 these differences diminished. One may speculate whether school sports and other environmental influences had any role in that.

Figure 2 refers to the series of the triceps and calf skinfolds in the girls. Here again it was the mother's HWR that consistently had greater discriminative power. Paternal groups were not different before age 13, but more so in the older children, in particular on the calf. The quite large skinfolds at age 7 are likely due the small sample size. Relative fat loss occurs earlier in girls because of their earlier puberty, but is characteristically more moderate, and is followed by a steady accumulation of more fat than in boys. Thus, sexual dimorphism is demonstrable in the age series of the skinfolds as well. Differences between the HWR groups were also smaller in the girls but did not disappear completely.

Figure 3 demonstrates the age series of skinfolds at the subscapular and suprailiac sites in the boys. HWR group differences were large again between ages 10 and 13, with greater contrasts in the maternal groupings. The two studied trunk skinfolds followed a dissimilar age course. The so-called fat wave of prepuberty and early puberty [1, 15, 21] was more expressed in the sons of stouter parents, especially for the iliac skinfold. The age series of mean subscapular skinfold showed a steadily rising tendency in the lean parental groups. After age 17 there were no longer differences between the HWR groups.

As shown in Figure 4, the subscapular and iliac skinfolds of the girls differed more consistently between the maternal groups than between those of the fathers, particularly before the age of 14. Beyond the age of 15 years there were few real differences.

As it could be noted, the tendency of the age series of skinfold means displayed site, gender and subgroup similarities. This fact led us to combine the skinfolds on the limbs, respectively on the trunk.

Figure 5 shows the age series for the limb skinfolds in the two genders Two observations are worth attention. In the boys the contrasted parental groups had definitely different courses, in particular between 10 and 12 years of age, further it was maternal influence that appeared to be more marked. In the girls the state of affairs was not that clear, and even less so in respect of the paternal groups. Adding up the trunk skinfolds gave a similar but more pregnant impression (Figure 6). Intergroup differences were larger, and the discrimination of the maternal HWR excelled the one seen for the groups of the fathers.

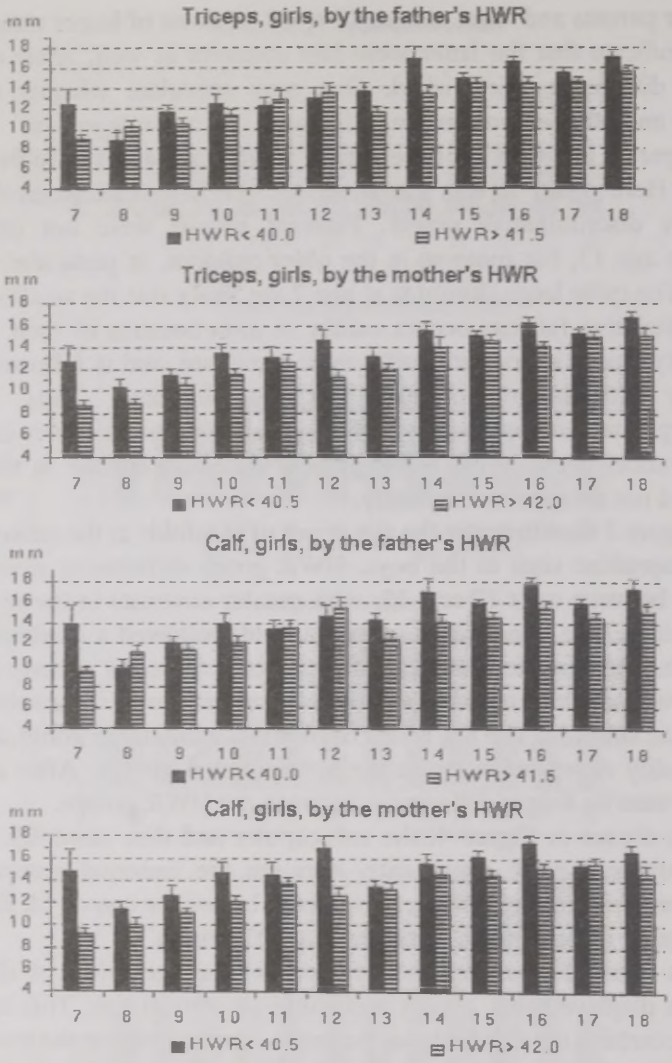

Figure 2. Means and standard errors of the triceps and calf skinfolds of the daughters of the stout and lean parental groups. Abbreviations as in Fig. 1

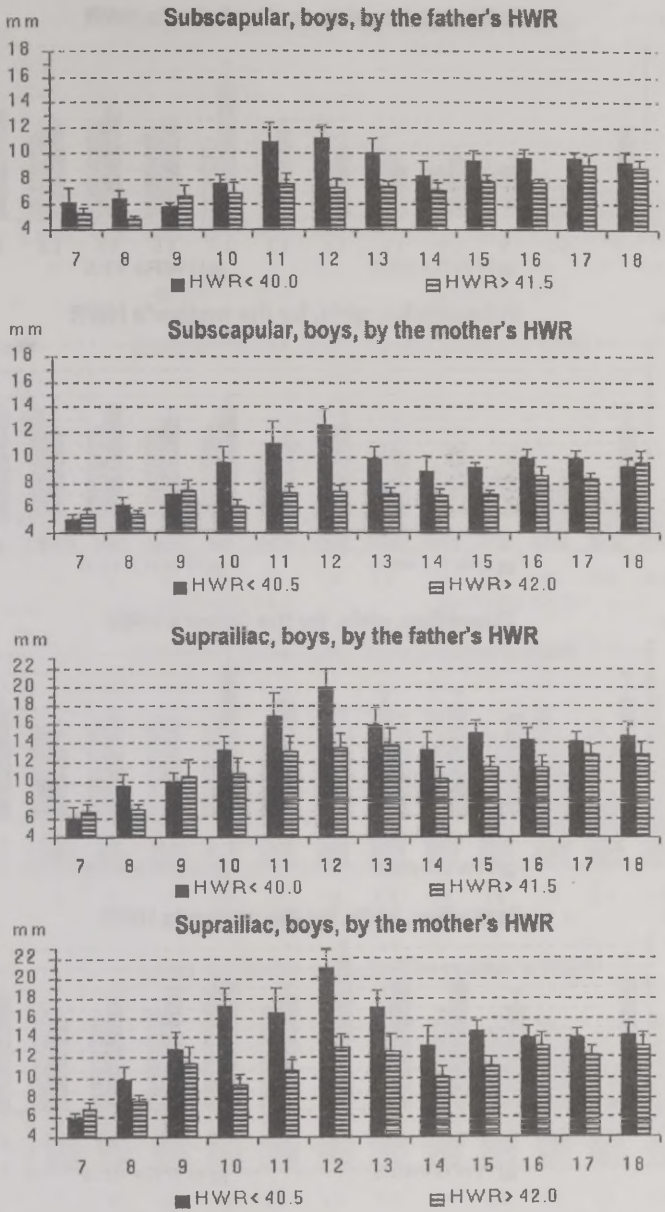

Figure 3. Means and standard errors of the subscapular and suprailiac skinfolds of the sons of the stout and lean parental groups. Abbr. as in Fig. 1.

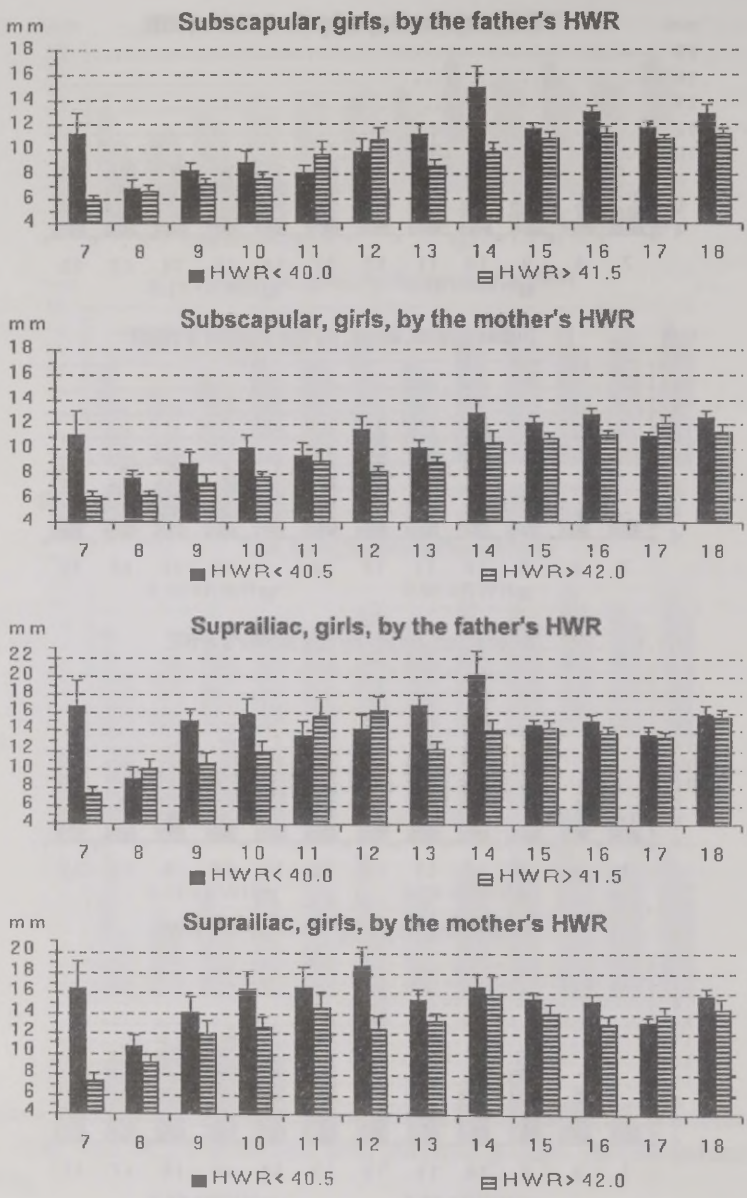

Figure 4. Means and standard errors of the subscapular and suprailiac skinfolds of the daughters of the stout and lean parental groups. Abbr. as in Fig. 1.

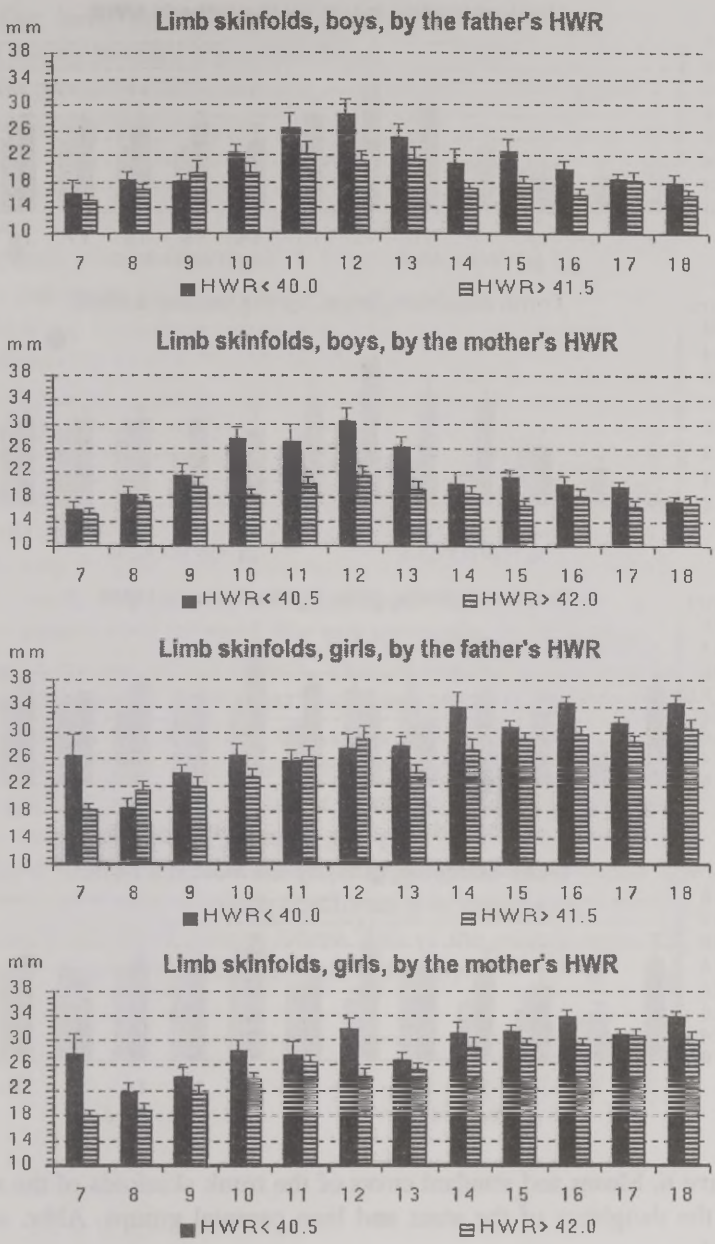

Figure 5. Means and standard errors of the limb skinfolds of the sons and the daughters of the stout and lean parental groups. Abbr.as in Fig. 1.

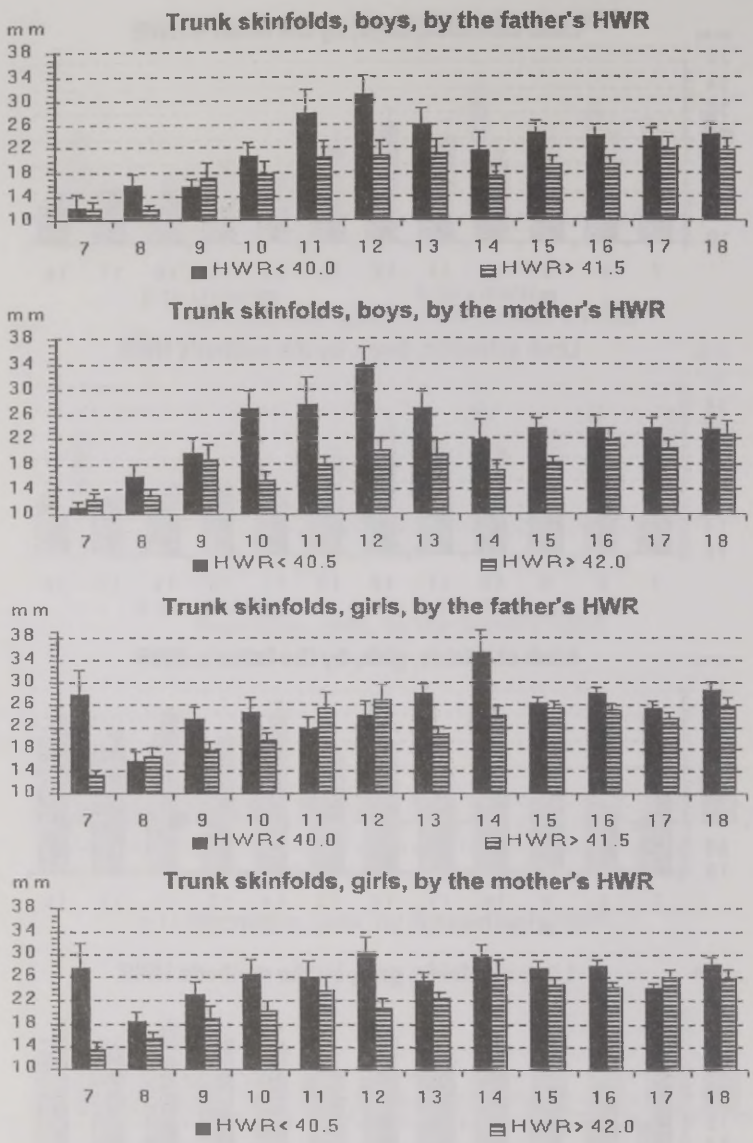

Figure 6. Means and standard errors of the trunk skinfolds of the sons and the daughters of the stout and lean parental groups. Abbr. as in Fig. 1.

Our basic assumption concerning children of either gender was that during primary school the mother's influence on the dietary habits of the group would be stronger. This would be later gradually replaced by the (perhaps more genetically controlled) effect of the parent that is of the same gender as the child. The observations corroborated this assumption, although one should express some reservations. At the time of the data collection the dominant family model in Hungary was that both parents had a job. This means that the children had at least two and at most three meals at school and spent most of their wake-up time away from their home. Since recently more mothers have again preferred to stay at home, and so their children may return for the midday meal, it seems likely that a repetition of the study would show stronger maternal effects.

The fact that after the growth spurt the studied parental intergroup differences diminished suggests that the reference model group to which the child would adhere is likely to change with advancing age. This may include such environmental effects that have strong, though not easily demonstrable impact on body weight and so on subcutaneous fat as well. We had no means to trace down the more general environmental effects. Thus, it seemed reasonable to study at least whether the results just discussed would also hold when both of the parents belonged to the same HWR category. This kind of grouping (Figure 7) resulted naturally in a further reduction of sample sizes, consequentially, in larger standard errors. Here the assumption was that this kind of parental grouping would be reflected by more marked intergroup differences at every age. The combined age series of limb and trunk skinfolds confirmed this hypothesis. The differences between the HWR groups where both of the parents were either lean or stout were particularly marked in the boys.

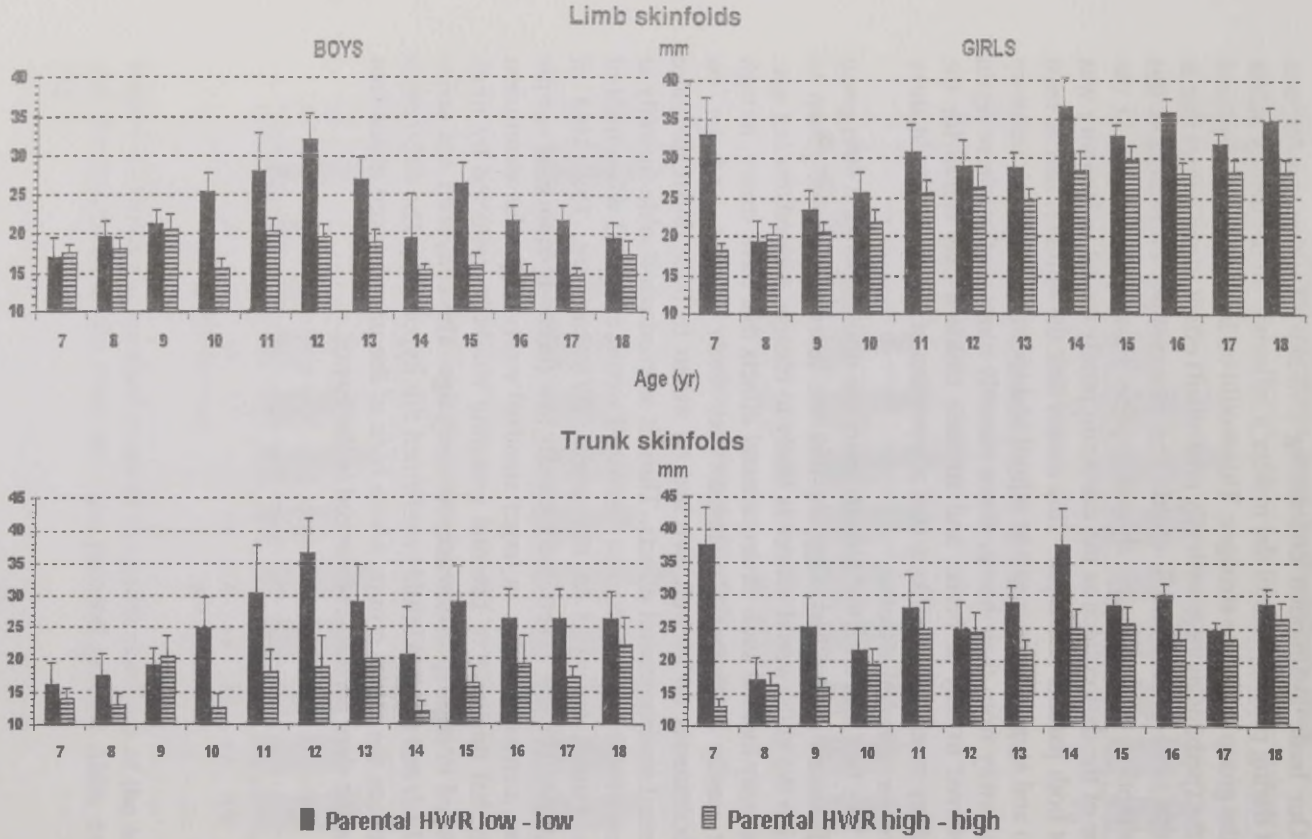

Figure 7. Means and standard errors of the limbs and trunk skinfolds of the sons and the daughters of identical parental HWR groups. Abbr. as in Fig. 1

Our summary conclusions are therefore:

1. In this sample the grouping of skinfolds means by parental body linearity could discriminate between the developmental change of skinfold thickness in the offspring; irrespective of whether one deals with the respective skinfold sites separately or in combination. The differences were not restricted to the absolute thickness of the skinfolds, that is, to total body fat content, but parental HWR also influenced the rate and course of subcutaneous fat layer development. This relationship was strongest between 10 and 13 years of age, a period when the rapid changes occurring in both mind and body seem to be associated with more marked responses to slight modifications of the environment, in particular in boys who are therefore regarded as being more ecosensitive.
2. The strength of this influence was found to depend on the child's age and gender to a larger extent than on the gender of the parent. Nevertheless, maternal influence was found to be stronger, in particular in early school-age children. When both parents belonged to the same (lean or stout) HWR category, the effect on the offspring was more conspicuous.

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Papers on Anthropology XI, 2002, pp. 313–323

KARL ERNST VON BAER AS AN ANTHROPOLOGIST[1]

Erki Tammiksaar

INTRODUCTION

Karl Ernst von Baer (1792–1876) is known as one of the most versatile naturalists of the nineteenth century. His works contributed greatly to the development of several branches of science, including embryology, zoology, geography, geocryology, ethnography, ichthyology. He discovered the mammalian ovum and with his treatise *Über Entwickelungsgeschichte der Thiere. Beobachtung und Reflexion* (Königsberg 1828, 1837, 2 vols.) laid the foundations of modern embryology. With the name of Baer is associated a law in embryology stating that the embryological development of organisms proceeds from simpler to more complicated forms, as well as a law in physical geography concerning the effect of the force of the rotation of the Earth on the formation of river beds. The principal method, which Baer also applied in anthropological studies, consisted in 'observation' and 'reflection'. He contributed greatly to the development of anthropology. Referring to Baer's anthropological work *Ueber Papuas and Alfuren* [7], Charles Darwin considered Baer his predecessor. On the other hand, anthropological investigations made Baer one of the opponents of Darwin.

Much has been written about Baer as an anthropologist in Russian [26, 33], even more in German [28, 20, 29, 23, 27, 24, 25], as he made a great contribution to the development of anthropology in both cultural regions. Few papers, however, have been written about him in Estonian [30] and English [21]. I hope that this short review will be an addition to them.

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[1] In this article the term anthropology means physical anthropology and the term ethnography — social anthropology.

BAER AS AN ANTHROPOLOGIST IN KÖNIGSBERG

In the years 1810–14, when studying medicine at the University of Tartu (then Dorpat), Baer began to take interest in comparative anatomy of man. The lack of opportunity for more profound anatomical training at the University of Tartu at that time made Baer go to Vienna, and then to Würzburg, where he met the anatomist Ignaz Döllinger. Under the supervision of Döllinger Baer acquired perfectly the art of dissection and sufficient knowledge of the anatomy of different animal species. In 1817, Baer as an anatomist was offered a post at the University of Königsberg. In 1821 he was elected professor of zoology and comparative anatomy of the University of Königsberg, which post he occupied until 1834 [24]. In parallel with lectures on zoology, Baer also lectured on human anatomy (professor of anatomy in 1826–34), and from 1818 on anthropology to the students of non-medical faculties. To meet the wishes of the audience, Baer published the first volume of his lectures under the title *Vorlesungen über Anthropologie* (1824) [1] in which he treated, in a detailed and comprehensible manner, human anatomy, or as he called it — anthropography (today physical anthropology). The second volume, in which Baer intended to treat the history of mankind (culture, archaeology, ethnography)[2] and anthroponomy, i.e., the relationship of man-nature, was never published. In papers written later, alongside physical anthropology, Baer often treated the problems of social anthropology and archaeology [2, 3, 4, 9, 12, 14, 18]. However, he did not draw fundamental generalisations in the field of social anthropology.

BAER AND ANTHROPOLOGY IN RUSSIA

In 1834, having been elected full member of the St Petersburg Academy of Sciences in zoology, Baer moved to St Petersburg. In the first years in Russia his zoological and anthropological interests receded into the background because of his third love — physical geography. Although in the years 1836–45 his main sphere of activity was geographical exploration, and organising and directing of physical

[2] In today's interpretation it is social anthropology.

geographical investigations in Russia, he did not forget anthropology and ethnography (especially archaeology).

In January 1841, Baer as the second zoologist in the St Petersburg Academy of Sciences addressed the first academician in zoology, Johann Friedrich Brandt, who simultaneously acted as director of the zoological museum of the Academy, and suggested that he could take responsibility for part of the collections of the museum, in the first place the craniological collections. Brandt agreed and in 1842 Baer began to systematise the craniological collections of the Academy of Sciences. From 1842 Baer's interests returned to anthropology, although he could not devote himself to it wholly. One of the reasons was the expedition to Siberia of Alexander Theodor von Middendorff (1842–45), which was initiated by him and for the organisation of which he was personally responsible. On the other hand, Baer decided to use geographical expeditions (the initiator of which he often was) organised by the St Petersburg Academy of Sciences and later also by the Russian Geographical Society to collect ethnographical-anthropological material on the nations of the Russian Empire. That was the reason why in 1844 Baer personally initiated the collection of ethnographical and craniological materials on different nations living in the Russian Empire, sending respective instructions to Middendorff in eastern Siberia and to the Hungarian linguist Antal Reguly [22: 13–14], Finnish linguists and ethnographers Johann Matthias Castrén and Andreas Johan Sjögren, ethnographer Yegor Kovalevski and geologist Ernst Hofmann. As soon as in 1843 Baer picked the first results of his efforts — namely, the bones of a giant were sent to the St Petersburg Academy of Sciences from the Caucasus. Baer made the first report and published a short article on the skeleton of the giant [2].

Baer also began to take interest in the origin of human races. He hoped to find a solution to the question by comparative analysis of skull specimens of different nations. Baer considered that kind of studies very important (the more that several of the nations were on the verge of extinction) and supported the publication of respective materials. It was Baer's idea that the materials of Ferdinand von Wrangell, the leader of the north-east Siberian expedition and later Russian-American Governor, on the ethnography of the Russian-American natives were published in the first volume of the serial publication founded and edited by Baer himself, *Beiträge zur Kenntniss des Russischen Reiches und der angränzenden Länder Asiens* (1839). According to Baer ethnography belonged to the

research sphere of anthropology. In 1844 he even intended to set up a Russian ethnographical society [31]. This idea was not realised. His growing interest in anthropology was demonstrated again by the foundation and acting as chairman of the ethnography section of the Russian Geographical Society, in the establishment of which in 1845 he had been instrumental. In 1846 he delivered an extensive programmatic speech about the goals and organisation of ethnographical expeditions in Russia. Baer initiated the ethnographical study of the Livonians and suggested the foundation of an ethnographical collection, or museum, at the Russian Geographical Society. This programme was not carried into effect as in 1848 the German-speaking members of the Society were voted down from the leading positions.

After the death of Academician Petr Zagorsky in 1846, Baer, as he had wished, was elected Head of the Chair of Comparative Anatomy and Physiology of the St Petersburg Academy of Sciences [27: 261]. Having accepted the new post, Baer continued his work on the craniological collection [5, 6]. Now he had more time for that as the expedition of Middendorff, which had taken so much effort, was over. Baer's main concern was craniology. At the sessions of the Academy of Sciences he often reported on the tasks facing the anthropological museum [25]. Gradually Baer concentrated the whole research in the field of anthropology, and anthropological collections to the Chair of Anatomy and Physiology, which he headed until 1862. In 1858 Baer put forward a plan for the foundation of the museum of anthropology and ethnography at the St Petersburg Academy of Sciences. It was realised in 1878 when ethnographical and anthropological collections were joined. The first curator of the museum was Leopold von Schrenck, ethnographer and a close friend of Baer.

Thus, Baer was a witness to the birth of social anthropology in Russia. It was his initiative that social anthropological investigation of the nations living in Russia was started; he laid the basis of the first ethnographical collections in Russia. He systematised and considerably extended the craniological collection of the St Petersburg Academy of Sciences and contributed greatly to archaeological research in Russia, as he considered that kind of fieldwork very important for the establishment of the age of mankind.

BAER AND THE DEVELOPMENT OF ANTHROPOLOGY IN GERMANY

In the middle of the nineteenth century, only a few European universities could boast of good collections of skulls. No standard method of skull measurement had been accepted and, for that reason, it was impossible to compare different collections. Baer as a systemiser and morphologist understood the importance of establishing a standard method of skull measurement for the development of anthropology. In 1858, at a meeting of German naturalists in Karlsruhe, he made a respective suggestion to several anthropologists individually and called them to meet again in 1859 in Göttingen, the town where ethnographical anthropology (a term created by Blumenbach) was born. The first meeting of German anthropologists was convened by Baer and Rudolf Wagner, a German anthropologist, as late as in 1861 [19]. Baer's idea was to assemble German-speaking anthropologists, so that the meeting would not be very numerous and would be able to pass resolutions. He believed that German anthropologists would adopt a method of skull measurement which the others would accept later [22: 33]. This is how it actually happened.

Another important aim of the meeting was to establish an anthropological society and found an anthropological journal [19: 28–29]. In 1861, these ideas of Baer were not realised. The first anthropological society in the world was established in Paris in 1859 by Paul Broca, the founder of modern anthropology and a colleague of Baer. However, the meeting of German anthropologists in 1861 led to the foundation of the German Anthropological Society in Berlin in 1869 and the first anthropological journal in the world, *Archiv für Anthropologie*, in 1870. Alexander Ecker, the editor and publisher of *Archiv für Anthropologie*, followed the principles put forward by Baer; thus the journal covered materials on anthropology, ethnography (psychical anthropology) and archaeology (historical anthropology) [20].

Baer, who was highly respected by the anthropologists of Europe, had close contacts with many renowned scholars in this field: Retzius, Wagner, Broca, Ecker, Johann Christian Lucae, Hermann Schaafhausen, Armand de Quatrefages de Breau, and others [32].

BAER AND ANTHROPOLOGY AT THE UNIVERSITY OF TARTU

Baer indirectly also influenced the development of the science of anthropology at the University of Tartu where anatomist Ludwig Stieda, professor of embryology, the author of the first scholarly biography of Baer and the keeper of the personal archival documents of Baer, worked for a long time (1862–85). He published several manuscripts of Baer and many papers on anthropology. Through the Chair of Embryology, Histology and Comparative Anatomy (established in 1877) Stieda put several ideas of Baer into practice. Owing to Stieda, systematic anthropological research was started at the University of Tartu. When working on Baer's biography, he became so much inspired with his anthropological writings that, together with students, he began to study the anthropological features of the Estonians, Latvians, Livonians and Jews [22: 7].

BAER'S VIEWS ON ANTHROPOLOGY

The theoretical problems Baer was interested in concerned, in the first place, the relationships between man and man, man and nature, and the role of man in nature. Baer considered the problems concerning the age, origin and human types of mankind very important.

Baer interpreted anthropology more widely than contemporary anthropologists of East-European countries do. He regarded under anthropology the following fields of science: comparative anthropology or anthropography (i.e., human anatomy, physiology and pathology, racial problems); anthroponomy or the relationship between man and living nature (today — ecology), and the relationship between man and man or the history of mankind (*Anthropohistorie* — the history of culture, ethnography, pre-historian anthropology, archaeology, state sciences and juridical philosophy) [1: 5–7]. His first scientific treatise, the doctoral thesis *Dissertatio inauguralis medica de morbis inther Esthonos endemicis* (Dorpati 1814), Baer also classified as an anthropological study.

Baer considered mankind a relatively new phenomenon on the Earth as compared with other living beings, and in his opinion mankind probably did not exist much earlier than indicated in the Bible

[29]. Baer did not agree that man had evolved from the ape and tried to prove the invalidity of Darwin's theory [15, 17]. He defended his point of view relying on the anatomy, intellect and differences of man as compared with other representatives of living nature [15]. But at the same time he admitted that man was an investigation object of zoology, emphasising the similarity between the organism of man and other vertebrates. In his metaphysical philosophy Baer associates the evolution of man and the whole nature with the teleological principle of goal-directedness in nature (*Zielstrebigkeit in der Natur*) and the special role of man in nature. Baer's contemporaries did not pay much attention to these points of view. Only lately more attention has been devoted to Baer's views on developmental biology.

The extensive collection of skulls gathered to the anthropological museum in the course of many years had sparked Baer's interest in the study and differentiation of human races. These problems, probably, had attracted Baer's attention in his first years at Königsberg already. Being influenced by the founder of ethnographical anthropology Johann Friedrich Blumenbach, Baer tried to avoid the use of the word "race" as he considered it offensive. He used the terms „Stamm" and „Type" (stock) instead [29: 389]. Baer called the science of human races comparative anthropology. Although for a very long time Baer did not give any answer to the question whether mankind had originated from one or several stocks, at the older age (proceeding from the classification of Blumenbach) he admitted that mankind had originated from a single stock from which five different varieties had developed [29: 393]. Baer did not deny the possibility of development of different varieties even nowadays. Although he was interested in the differentiation of natural races of mankind and in studies in their origin, his main concern was mankind's ethnological-historical culture [26]. According to his point of view the anthropology, the multiplicity of languages and cultures of mankind were determined by the living environment and geographical conditions. That is why Baer, who considered physical geography very important in the interpretation of different features of nations, arranged the craniological-ethnographical collection of the anthropological museum on the geographical principle [6: 3–4]. In Baer's interpretation ethnography and anthropology were closely connected with each other, and a thorough knowledge of ethnography was expedient in the study of different nations [4].

Baer was interested not only in anthropology but also in the role of man in changes in nature. In 1838, Baer read a paper, *Ueber die Verbreitung des organischen Lebens* (on the development of organic life in the world), in the St Petersburg Academy of Sciences in which he emphasised the great responsibility of mankind for the preservation of the diversity of the flora and the fauna [14, 10]. This indicates that Baer was not an armchair scientist but had become practician. The need to participate in the solution of practical research problems was one of the main reasons why Baer left very safe Königsberg and settled down in the metropol of the Russian Empire in the mouth of the Neva River. That also explains why Baer, in 1851, himself applied for the position of the leader of the expedition, the goal of which was to discover the causes of the decline of fish stocks in Lake Peipsi and the Baltic Sea [27]. As a result of the expedition the commission headed by Baer presented a draft of the proposed law to the emperor. It contained regulations of fishing in Lake Peipsi. The Czar ratified the first law of nature protection in Russia in 1859 [8].

With his expeditions to Lake Peipsi and the Baltic Sea in 1851–52, and the four important expeditions to the Caspian Sea (1853–56), with the aim of studying the fisheries, Baer proved that with casual activities (e.g., fishing) man can considerably disturb natural balance in a water body and change its species content and diversity. Baer stressed the important role of man in disturbing the balance and in its restoration. In the above-discussed context it meant the breeding of fish of endangered species in fish nurseries in order to prevent their becoming extinct. As a matter of fact, Baer himself made several attempts to introduce the trout in Lake Peipsi. Alongside the studies in fisheries Baer also considered the possibility of breeding oysters, which were in great demand among the gourmands of St Petersburg, in the Baltic Sea. However, he found the salinity level of the water not to be suitable for breeding oysters and suggested the Black or the White Sea instead [11].

CONCLUSION

A very broad interpretation of the term anthropology led Baer to the study of the ethnography and history of mankind in addition to the questions of modern anthropology. Baer is rightly considered the

founder of anthropology and ethnography in Russia and a very important figure in the organisation, standardisation and development of anthropological research in Europe, particularly in Germany, in the nineteenth century. His views exerted a considerable influence on the development of anthropology in the second half of the nineteenth century and at the beginning of the twentieth century.

With his studies into Russian fisheries, Baer confirmed that man had an important role in maintaining natural balance in water bodies, which consists not only in the use of natural resources to guarantee his own sustenance but also in taking measures to protect and increase these resources. Consequently, Baer can be considered the founder of the ecological way of thought in Russia.

ACKNOWLEDGEMENTS

I would like to express my gratitude to the Wellcome Trust for the support which made the writing of the article possible and to Mrs. M. Roos of the Karl Ernst von Baer Museum for her valuable help in the preparation of this paper.

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KARL FRIEDRICH BURDACH

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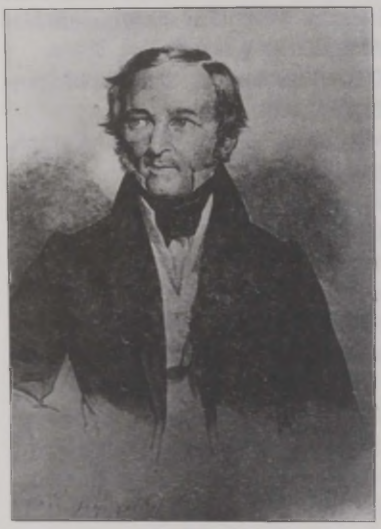

Karl Friedrich Burdach was born in Leipzig on 12 June 1776. From 1785 to 1793 he studied at Nikolai Gymnasium in his hometown. He spent a great deal of time reading literature. At school the main subject was Latin; no modern languages or natural sciences were taught. From 1793 to 1797 Burdach was a student at Leipzig University, where he took a whole encyclopaedia of courses: history of literature, philosophy, anthropology, history of philosophy, general history, zoology, something resembling comparative anatomy, history of the human race, mineralogy, botany, chemistry, pharmacy, mathematics, anatomy under Gaase and Chr. F. Ludwig, physiology, dispensing, mineral waters and midwifery. At the time there was no clinic in Leipzig yet, and students got their clinical training under Candidate Chr. G. K. Braune, who worked as an assistant to Dr. Geier and was a doctor at Jakob hospital. Burdach acquainted himself with surgery under Dr. Eckhold.

In 1798 Burdach defended the dissertation *Apoplexie per epilepsiam solutae observatio* (On Apoplexy in the Case of Epilepsy) and obtained the degree of Doctor of Medicine. In 1798 he also defended a dissertation to obtain the Doctor of Philosophy degree, *Commentarii in Hippocratis librum primum de morbis epidemicis specimen* (Commentary on Hippocrates' Book *On Epidemic Diseases*), and acquired

the right to deliver lectures as a *Privatdozent*. He continued his education in Vienna, where he was attracted by the well-known clinician Peter Frank. Having returned to Leipzig, he was mostly engaged in writing and teaching, which left him little time for medical practice. He published a number of articles and monographs, including reference books and translations of medical papers. He lectured on propaedeutics, anthropochemistry, physiology, pathology, pharmacology and nosology. In 1805 he completed the first part of his study of the brain, *Beiträge zur näheren Kenntnis des Gehirns*; the second part followed soon. He studied the structure and functioning of the brain. In 1807 he was appointed professor extraordinary of Leipzig University. P. Diepgen has written in his history of medicine, *Geschichte der Medizin*, that in 1800 Burdach introduced in his works the terms "biology" and "morphology" (Diepgen 1959: 15–16). In 1810 he visited Vienna for the second time. In 1811 Burdach was called to work in Tartu, where he arrived with his family and assistant Pietsch in August of the same year. The University Council elected Burdach Professor of Anatomy, Physiology and Forensic Medicine on 25 April 1811. The minister of education confirmed Burdach's appointment on 31 July 1811.

Broad scope of research interests and extraordinary organisational skills singled K. Fr. Burdach out among the early 19th-century professors at the University of Tartu.

In Tartu Burdach's main subject was anatomy that he taught during two terms. Along with that he lectured on physiology (in the 2nd term of 1813), embryology, medical propaedeutics and taught a course called *Geschichte des Lebens* (history of life). It consisted in an introduction to general biology, included evolutionary ideas and attracted a wide audience. Burdach himself has written, "I was popular: my lectures on life history were attended by 60 listeners from several faculties. This, considering the total number of students (225, out of them 123 medical students) was not a small number. At the lectures of anatomy and physiology I had 23–26 listeners. Among the medical students, excluding those who were financed by the state and were usually poorly educated, there were lots of young men who were talented or at least well suited to academic training. They had a favourable attitude towards me and proved a very grateful audience. Some of them saw me home from lectures daily, and I, on my part, no matter how deep the snow, always enjoyed ascending Toome Hill to the Anatomical Theatre. Not only lectures but also climbing the hill,

which my predecessor had complained about most, was a pleasure for me, because of the broad view that opened up from there, and it seemed to me as if I were breathing the air of mountains. I devoted myself entirely to preparation for the lectures, and as economic security had freed me from the fetters that had inhibited me earlier, my lectures could become more lively and attractive. Neither philosophy nor natural science at Tartu University were to the smallest extent influenced by Schelling and his school yet, and so my attempt to give empiricism a deeper meaning found massive support among young men capable of higher education. This was the brightest period in my academic life." (Issakov p. 91–92).

K. E. v. Baer has recollected that Burdach's lectures, particularly these on more general themes, e.g. lectures on general anatomy had real substance. They attracted lively interest because they were thought-provoking even in the case of most ordinary topics, although sometimes a little schematic, with an inkling of natural philosophy. But this was what was needed in Tartu. Most other lectures were uninspired and suffered from excessive academicism by which the professors tried to create an air of ostentation. The students were warned against natural philosophy like a phantom, without ever explaining its harmfulness in detail because it was not known. As a natural result, the students developed a desire to become acquainted with the phantom the professors feared without knowing it. Burdach lectured mostly on general anatomy, not like now, at a microscope, but according to Bichat (Marie Francois Xavier Bichat, 1771–1802, French physician, anatomist and physiologist, the founder of scientific histology and pathological anatomy). Still, the students got a general understanding of the organic structure of organisms, which was very valuable for them. Most of all, the students were fascinated by Burdach's "history of life", a history of evolution in a certain sense (Baer, p. 118, Issakov, p. 74).

In his autobiography Burdach has written (Issakov, p. 91), "My main course of lectures was anatomy. Until got adapted to this subject again, I presented a few principles from notes prepared earlier and exemplified them. As in those times the academic courses were in harmony with the social arrangement of life so that each term included a summer and a winter quarter, I arranged my work so that during the second term of the year (from 1 August to the end of December) I began with general anatomy, osteology (study of bones) and syndesmology (study of connections between bones — joints, sym-

physes, tendons) and finished with myology (study of muscles). In the first term of the following year (from 1 February to the end of June) I lectured first on splanchnology (branch of anatomy that studies the internal organs), then neurology and angiology (part of anatomy that deals with blood and lymph vessels and the heart)." There were no exercises in dissection yet. Burdach's assistant was Pietsch and prosector until 1814 was L. E. v. Cichorius, who, however, was of absolutely no use for Burdach (S. Issakov, p. 91). Assistant Pietsch, on the contrary, was skilful, diligent and loyal to Burdach. He prepared organs of cadavers, which were used to illustrate lectures, added a number of valuable specimens to the remarkable collection that Isenflamm had purchased and created by his own work, was engaged in research and helped Burdach. When Pietsch was working for Burdach, Burdach also kept a detailed diary on the administration of the Anatomical Theatre. The annual number of anatomisations reached thirty. The specimens collection was put into perfect order, it was complemented and a catalogue was compiled.

To be of greater benefit for his audience, Burdach came up with the idea of founding a conversation and writing club for them. By this he wanted to develop their mental alertness so that they could keep it up in their later career as practitioners and benefit from it. So the local medical society was founded, its primary aim being promotion of medical education but also development of health care and science in general. Membership of the society was to be a matter of honour, and members were expected to have scientific interests and diligence, decent manners and humane behaviour towards their fellows. Along with twenty full and eleven associate members, the society also had five extraordinary members: Professor Styx, high priest Lenz, secondary school teacher and lecturer Rosenberger, Doctor Lehmann and surgeon Löffler. However, the society wound up its activities at its 25th session as the authorities had not approved its statutes.

During his stay in Tartu, Burdach participated in research and publishing. He published the four-part *Enzyklopädie der Heilwissenschaft* (Leipzig, 1810–1814), *Anatomische Untersuchungen* (Leipzig, 1814), and articles in the local press. His philosophical views found expression in the article *Über die Ansichten der Natur*. He delivered reports on the same theme at the local medical society on 22 September 1811 and 4 February 1812. Although an ardent supporter of Schelling's views, Burdach still denied Schelling's teaching about the universal absolute and did not share the standpoint of transcendental

philosophy, which negated the independent existence of the ideal and the material. Burdach's interpretation of the evolutionary idea of progressive development and unity of nature in the spirit of Schelling's natural philosophy allows us to consider him an evolutionistic biologist of the pre-Darwin period. Influenced by the factual research material, which did not fit Schelling's scheme, Burdach abandoned the metaphysics of natural philosophy; this became apparent both in his public presentations and publications. In 1820 a handbook of experimental physiology edited by Burdach was published, with J. Müller, K. Wagner, K. E. v. Baer and M. H. Rathke acting as co-authors.

The method of nerve tissue staining is also related to the name of Burdach. He used alcohol and potassium solution (first he placed the nerve tissue under study into alcohol, in which the nerve fibres strengthened so that they could be precisely studied; then the cross-section area was stained with potassium solution, upon which the grey gel-like substance turned brown and the white nerve substance remained unchanged). The method of staining with silver nitrate devised by the Italian histologist C. Golgi dates from 1870. It can be supposed that the development of this method was started by Burdach in Tartu (Käbin, p. 34).

In summer 1813 Burdach visited St. Petersburg, where he acquainted himself with the activities of scientific institutions (Surgical Medical Academy, Fine Art Repository, etc.) and established personal contacts with Prof. P. Zagorski from the Medical Academy, professor of Vilnius University, embryologist L. Bojanus, professor of the surgical academy, one of the earliest Russian evolutionists Y. Kaidanov, the future Decembrist N. Turgenev. Burdach also met Minister of Education A. Razumovski, who offered him a professorship in St. Petersburg or Moscow. This project, however, did not materialise.

While living in Tartu, Burdach made friends with Professor of Russian Language and Literature A. Kaisarov, a public figure from the times of the Patriotic War of 1812. Among the professors of the medical faculty, Burdach had particularly friendly relations with Styx and Deutsch.

Burdach has written in his memoirs: "Definitely I had every reason to be satisfied with my situation in Tartu, and I really was; yes, I admit that as far as professional activities and social life are concerned, my stay in Tartu was the happiest period in my life. Warm reception by a great number of talented listeners, general respect by the public,

friendship of a number of wonderful people, although quite different in their social status, education, character and convictions, who left nothing to be desired, when, in my prime, I was in perfect health, pursuing my aim free of all sorrows (in Leipzig, because of financial straits, Burdach was not able to devote himself fully to research; in Tartu his annual wages were 625 roubles in silver plus pay for conferments of degrees and earnings from his small practice), being able to fulfil my earlier plans and enjoy happiness in family life." (Issakov, p. 98).

Still, the negative sides were not lacking either, and K. Fr. Burdach left Tartu because of a conflict with Vice-rector F. M. Klinger and the University Council over organising students' scientific society. The conflict was partly aggravated by Burdach's natural-philosophical views, which were in sharp dissonance with the pietism and kantian agnosticism of some professors. On 17 November 1813 he resigned and left Tartu on 14 February 1814. Burdach died in Königsberg on 16 June 1847.

A special place in Burdach's legacy belongs to his groundbreaking works on the anatomy and physiology of the nervous system. His studies in this area served as a basis for the monumental treatises *Vom Bau and Leben des Gehirns* (2 volumes, 1819–1822) and *Umrisse einer Physiologie des Nervensystems* (1844). Vladimir Alexandrovich Betz (Russian anatomist, 1834–1894), one of the creators of the cytoarchitectonics of the cerebral cortex has emphasised, "The real and solid basis for modern anatomy of the brain was laid in the works of Burdach (Professor of Tartu University)." (Betz, p. 15).

K. Fr. Burdach himself has reminisced, "For lack of opportunities, my earlier research activities were limited to processing the facts provided by others. Only now I was in a situation that enabled me to undertake empirical studies, and this made me happy. I set myself two main tasks, which seemed to me up to date and particularly suitable for my mental character: development of theories on the brain and procreation.

"I divided the brain precisely into parts; while doing this I tried to register individual peculiarities and relate them to the collected materials on living conditions. I studied the changes that various chemical reagents produced in the substance of the brain, as namely these facilitate the study of its texture, and I even observed different kinds of mould, the number of which depends on the impact of objective

circumstances; I also began to study the brains of embryos and certain animals.

This is how I prepared for the treatment of evolution; I dissected embryos, studied earlier observations, particularly those by Harvey (English physician and anatomist, 1578–1657, discoverer of blood circulation) and Autenrieth (Johann Heinrich Ferdinand Autenrieth, German medical scientist, professor of Tübingen University, published works on physiology). My students included Pander (Christian Heinrich Pander, 1794–1865, Russian naturalist of Baltic German origin, one of the founders of micropaleonthology, worked also in embryology, geology and comparative anatomy; studied at the Medical Faculty of Tartu University from 1812–1814, academician of St. Petersburg Academy of Sciences, 1823) and von Baer (Karl Ernst von Baer, 1792–1876, naturalist, founder of modern embryology, studied at Tartu University from 1810–1814), both of whom have, with their excellent studies, created the foundation for this theory in its present form" (Issakov, p. 94).

Burdach was one of the pioneers of applying the ontophylogenetic method of studying the brain. By the method of splitting he established the structure of the white and grey matter of the brain, brain's connections with the cerebellum; he described in detail the ontogenesis of the internal capsule and the *corpus striatum*. He proposed the method of dividing the brain into lobes that has been accepted in science. He established the ontogenetic and morphological difference between *sulci* and *gyri*. Burdach's special merit was the discovery of crossing between the projection, commissural and associative systems of the brain; a wedge-shaped funiculus in the spinal cord bears his name (*fasciculus Burdachi*), and so do some other elements of the central nervous system.

The anatomico-physiological orientation of Burdach's works exerted special influence on the neurological studies of the Czech physiologist Johannes Evangelista Purkinjé (1787–1869), the German naturalist, professor of anatomy and physiology at the Universities of Bonn and Berlin Peter Johannes Müller (1801–1858), the German neurologist Robert Remack (1815–1865), and the physiologist Georg Friedrich Karl Heinrich Bidder (1810–1894) who studied medicine at the University of Tartu from 1828–1834, was professor of anatomy at the University of Tartu from 1836–1842 and physiology and pathology from 1843–1869, from 1858–1865 also Rector of Tartu

University, corresponding member (1857) and honorary member (1884) of St. Petersburg Academy of Sciences.

Burdach's legacy also includes papers on anthropology. His *Anthropologie für das gebildete Publikum* (Stuttgart 1837), also published under the title *Der Mensch nach den verschiedenen Seiten seiner Natur*, was published even twice, for the second time after Burdach's death by his son in 1849.

Burdach also had special merits in the development of medical periodicals. After leaving for Königsberg, he maintained close contacts with Russian science. From 1815–1817 he published in Riga and Leipzig, together with Alexander Crichton (1763–1856, of Scottish origin, doctor of medicine, physician in St. Petersburg 1804–1819, occupied many important positions in the health service of the Russian Empire) and Joseph Rehmann (1779–1831, doctor of medicine, lived and worked in St. Petersburg), the journal *Russische Sammlung für Naturwissenschaft und Heilkunst*. Eight issues, making a total of two volumes, appeared. Its preface expressed hope that the publication would contribute to the development of contacts and fraternal cooperation between Russian and foreign doctors for the sake of progress. The principal aims of the journal were refreshment of Russian and foreign doctors' knowledge in natural sciences and medicine, and contribution to the studies of nature and people's everyday life in Russia and neighbouring countries. For this purpose the journal was meant to publish materials on the natural features of the provinces, climate and agricultural produce, people's health status, customs, dwellings, nutrition, etc.; peculiarities of epidemic diseases, the course of epidemics and epizootics, remedies in folk medicine, developments in medical science, etc. The journal's programme was extensive and forward-looking. Although the journal came out for only a few years, all these topics were dealt with to a greater or smaller extent. All the issues of the journal contained an extensive bibliography and information on medical and educational institutions, including the medical faculties at the universities of Tartu and Vilnius.

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Lebens; ein Beitrag zur Erregungstheorie. 2) Handbuch der praktischen Symptomatologie in alphabetischer Ordnung oder der Lehre von den Symptomen in inneren und äusseren Krankheiten nach ihren Ursachen, Wirkungen und Heilarten.

Asklepiades und John Brown. Eine Parallele von K. F. Burdach, der Philosphie Doktor und Privatdocenten auf der Universität Leipzig. Leipzig 1800 bei Meisner. 170 S.

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Beiträge zur näheren Kenntnis des Gehirns in Hinsicht auf Physiologie, Medicin und Chirurgie. Leipzig bei Breikopf und Härtel 1806. I. Teil, XX u. 292 S.; II. Teil, VIII u. 295 S.

Handbuch der neuesten Entdeckungen in der Heilmittelehre. Nebst einer Abhandlung über die Principien dieser Disciplin. Leipzig bei Hinrichs, 1806. 372 S.

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Die Physiologie. Leipzig in der Weidmannschen Buchhandlung. 1810. XX u. 867 S.

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Der Organismus menschlicher Wissenschaft u. Kunst. Zum 400jährigen Stiftungsfest der Universität Leipzig (4. Dez. 1809). Leipzig bei Mitzky u. Comp. 1809. XII u. 70 S.

Die Literatur der Heilwissenschaft; Gotha bei J. Perthes. I bd. XIV und 662 S.; II. Bd. VIII und 972 S.

Anatomische Untersuchungen, bezogen auf Naturwissenschaft und Heilkunst. Erstes Heft, mit 4 Kupfern. Leipzig 1817 bei Hartmann. IV u. 81 S.

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Ueber die Aufgabe der Morphologie. Rede zur Eröffnung des neuen Anatomicums in Königsberg. Leipzig bei Dyk 1817, 64 S.

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System der Arzneimittellehre. Zweite, umgearbeitete Ausgabe; Leipzig bei Dyk. 3 Bde; 1817, 1818, 1819.

Handbuch der neuesten in— und ausländischen Literatur der gesamten Naturwissenschaften und der Medicin und Chirurgie. Gotha bei Perhes 1828. XVI u. 392 S.

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Einige Superarbitrien in Hitzig's Zeitschrift für die Criminal-Rechtspflege. Bd. II, S. 129–143; Bd. VI. S. 409–428; Bd. XX S. 370–379; Bd. XXIV. S. 1–35.

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Papers on Anthropology XI, 2002, pp. 337–341

ALEXANDER FRIEDRICH VON HUECK

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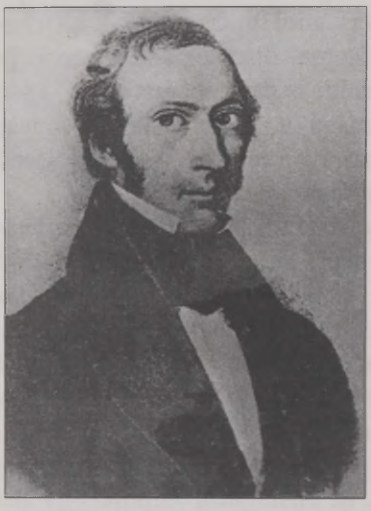

Alexander Friedrich von Hueck was born in Tallinn on 19/7 December 1802 as the son of Tallinn mayor Adam Johann v. Hueck. From 1821–1825 he was a student at the Faculty of Medicine, University of Tartu. In 1824 he received a gold medal for his prize essay written on a subject proposed by the Faculty. On 17 December 1826 he defended his dissertation *De mutationibus oculi internis respectu distantiae rerum* and obtained the degree of Doctor of Medicine. From 1827–1830 he continued his education at the universities of Berlin, Munich, Göttingen, Paris and Heidelberg. In 1830 A. v. Hueck was appointed prosector and professor extraordinary at the Department of Anatomy. From 1833 he was Professor of Anatomy at the University of Tartu, from 1833–1842 also Head of the Department of Anatomy and Forensic Medicine. In the proposal to appoint him to the post of prosector we can read that already as a student he had studied anatomy with great diligence and was outstanding in his skills of preparation.

In the autumn term of 1835 A. v. Hueck began to lecture on forensic medicine, initially for two, later three hours a week. For his lectures he first used the textbook by Henke, thereafter that by the Englishman Thomson and finally the textbook by Nicolai. Hueck suffered from slowly developing tuberculosis, which made him look for ways to ease his workload. When working as the Dean of the

Faculty of Medicine, he proposed in 1835 and again in 1840 that forensic medicine should be separated from the Department of Anatomy and, together with medical police, converged into a special Department of Public Health. (Such a department was formally founded on 19 October 1842 when Nicholas I approved the increased budget of the Faculty of Medicine for 1843 and the following years, which amounted to 23,370 roubles in silver. This should have also financed the foundation of the Department of Public Health, which would have included forensic medicine, medical police and hygiene, medical legislation, veterinary police together with teaching of epizootic diseases, pharmacy, which was until then united with chemistry, and parallel departments of internal diseases and surgery. In reality, the Department of Public Health became operative in 1845 when a suitable lecturer — G. Samson v. Himmelstiern — was found.) A. v. Hueck concentrated on his main subject — anatomy, and was the first to give it a solid scientific foundation.

Prof. A. F. von Hueck became renowned for his studies on the anatomy and physiology of the eye. His paper *Das Sehen* found experts' approval. In 1833–1835 Hueck's *Lehrbuch der Anatomie des Menschen* was published, which was the first textbook of anatomy issued in Tartu. The results of his anatomical and physiological research were published in Tartu in the paper *Die Achsendrehung des Auges* (1838) and in Leipzig as *Die Bewegung der Kristallinse* (1840). He was the first to describe the convexation of the first third of the lens in the case of accommodation. In anatomical terminology the ligament between the retina and the cornea (*ligamentum pectinatum anguli iridocornealis*) bears the name of the Hueck ligament.

A. v. Hueck also took an interest in anthropology and archaeology. In 1838 he travelled through Livonia in order to find and study skeletons of prehistoric animals. In 1838 he also published an anthropological paper on Estonians' skulls.

A. v. Hueck was among the nineteen founding members of the academic club (*Wissenschaftlicher Unterhaltungs-Cirkel*), which formed in the 1830s and in 1838 developed into the Learned Estonian Society (*Gelehrte Estnische Gesellschaft*). The first president of the Society was the pastor K. G. Hewe. A. v. Hueck was the president of the Learned Estonian Society in 1841. The Society published a great number of studies on the history of Estonia and the Baltic countries, the Estonian language, literature, folklore, ethnography, etc. and founded an excellent library of *Baltica*.

In 1841 Privatdozent H. M. Asmuss, a zoologist, resigned as assistant director of the zoology study room, and Alexander Friedrich v. Hueck took over, although, because of his early death, he was able to fill the post only for a year.

To the students of cameralistics Professor of Political Economy J. T. Grass lectured on statistics (i.e. economic geography) of the Baltic countries using, along with the works of Rathlef and Bornhaupt, also the works of Hueck.

A. v. Hueck was the Dean of the Faculty of Medicine in 1835 and 1840.

A. v. Hueck's special interest was agriculture, and his posthumously published book *Darstellung der landwirtschaftlichen Verhältnisse in Est-, Liv- und Kurland mit einer Karte* (Leipzig, 1845) is one of the most comprehensive collections of data on the agriculture of Estonia, Livonia and Courland in the first half of the 19th century.

A. Hueck died in Tartu in 1842.

A. Fr. v. Hueck's brother Carl Ferdinand August v. Hueck studied medicine and agriculture at Tartu University in 1830 and at Jena University from 1832–1833. He acquired a doctoral degree in agriculture and worked as an associate professor of agriculture at Jena University from 1833–1834 and Eldena Agricultural Academy in Pommern from 1834–1837. From 1838–1876 he was lord of Munalaskme manor in Harju county, Estonia, and developed it into an exemplary farm. For a year it even had a school for young farmers. He supported the abolition of corvée, modernisation of agriculture and promoted breeding of merino sheep, on which he wrote a book.

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CHANGES IN CARDIOVASCULAR RISK FACTORS IN OFFSPRING OF PARENTS WITH CORONARY ARTERY DISEASE DURING CHILDHOOD AND ADOLESCENCE

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ABSTRACT

Although the association between parental history of CHD and its risk factors in offspring is well documented in cross-sectional studies of pediatric and young adult population, no data are available concerning the timing and course of the development of risk factors from childhood to young adulthood. In high risk strategy this is of particular interest in terms of prevention and intervention.

We evaluated the trends and prognostic value of risk factors levels in offspring of parents with premature myocardial infarction (MI).

A total of 129 boys and girls aged 9–21 years from high risk families were examined twice with an interval of 4–5 years. The examination included a questionnaire on smoking, physical activity, socio-demographic data, dietary habits; measurements of height, weight, blood pressure, total cholesterol (TC), high density lipoprotein (HDL-C), low density lipoprotein (LDL-C) and triglycerides (TG). The criterion for overweight was the body mass index (BMI).

The correlation between CHD risk factors values at two testings was the highest for body mass index (r=0.69), total cholesterol (r=0.53) and systolic blood pressure (r=0.53). Persistence in the highest quintile between surveys for body mass index was seen in 82%, for LDL-C levels in 43% and for blood pressure in 25–38% of subjects.

The most stable CHD risk factors in offspring of parents with premature myocardial infarction (MI) after 4–5 years of follow-up were body mass index, total cholesterol and systolic blood pressure. This demands regular observation of children at high risk. emphasizing regular measuring of weight, not only cholesterol but also LDL-C levels, and blood pressure, and management of high risk individuals in early life.

Key words: risk factors trend, prevention of coronary heart disease, high risk families.

INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of death in Estonia [8]. Therefore primary prevention of atherosclerosis is an important part of governmental health policy. Several studies have shown that risk factors levels in childhood predict adult values. There is also a strong association between risk factors levels measured early in adult life and occurrence of CVD in mid-life [14].

A positive family history of premature CHD is recognized as an independent predictor for cardiovascular death in first degree relatives [2]. The association between parental history of CHD and its risk factors in offspring has been well documented in cross-sectional studies of pediatric and young adult population [12]. Both genetic predisposition and environmental determinants are important in this regard. In Estonia 17–25% of children aged 7–15 have a family history of premature CVD [13]. Since CHD aggregates in families, the parental history of CHD is considered as a useful marker for screening and education young offspring who may be at higher risk of developing CHD [21]. Our previous studies also showed the high prevalence of CVD risk factors in children and adolescents from high risk families [22].

Although the association between parental history of CHD and its risk factors in the offspring is known, the development of risk factors from childhood to young adulthood and its prognostic value in offspring of parents with CHD are not known. In high risk strategy this is of particular interest in terms of prevention and intervention.

MATERIAL AND METHODS

The sample for this study consisted of the original group of 156 participants with a positive family history of premature myocardial infarction or significant coronary artery atherosclerosis documented by angiography in parents or grandparents (men <50 yrs, women <55 yrs) entering the study at baseline. From this sample 129 youngsters aged 9–21 years were reexamined with an interval of 4–5 years from baseline examination. The boys-to-girls distribution was 48.1% to 51.8%. The examination included a questionnaire on smoking, physical activity, socio-demographic data, dietary habits; measurements of height (measured to ±0.1 cm), weight (measured to ±0.1 kg), blood pressure, total cholesterol (TC), high density lipoprotein (HDL-C), low density lipoprotein (LDL-C) and triglycerides (TG).

All examinations followed the same protocol. Subjects were instructed to fast for 12 hours before the screening and compliance was determined by interview on the morning of examination. In analyses involving serum-plasma variables, only fasting subjects were included. TC, HDL-C and TG were determined enzymatically, using commercial reagents in the Laboratory of Biochemistry of the Tallinn Diagnostic Centre. LDL-C was calculated by the Friedewald equation. Blood pressure levels were measured twice on the right arm in a relaxed sitting position using a standard mercury sphygmomanometer. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were recorded as the first and the fifth Korotkoff phases, respectively. As a measure of overweight, the body mass index (BMI), a measure of weight in kilograms divided by the square of the height in meters, was used.

Data were analyzed by SPSS for Windows 8.0.

RESULTS

Comparison of baseline data (age, sex, ethnic origin, age of MI in parents and grandparents, anthropometry, blood pressure data and lipids levels) between participants and non-participants (N=66) did not show any significant differences.

CHD risk factors trends and the magnitude of tracking coefficient (i.e. stability coefficient and tracking for subjects at risk) can be examined by noting the correlation coefficients between risk factors levels at different time points or the percentage of children persisting in high or low percentiles over a follow-up period.

In our study tracking analyzed with correlation coefficients between risk factors levels at the baseline examination and after follow-up period (Table 1) show that highest correlation was for BMI, r=0.69 ($p<0.01$). It was also strong for TC and SBP, both r=0.53 ($p<0.001$), and also significant for other lipoproteins except triglyceride.

Table 1. Spearman correlation coefficients for BMI, blood pressure and lipids between baseline and follow-up surveys

	BMI	SBP	DBP	TC	HDL-C	LDL-C	TG
r	0.69	0.53	0.35	0.53	0.23	0.28	0.11
P	0.01	0.001	0.01	0.001	0.05	0.05	ns

Another way to assess tracking is to determine the proportion of children who are persistently in the highest quartile or above the 90th percentile during follow-up period. The percentage of children whose risk factors levels were above the 90th or 75th percentile at the baseline and remained above the 75th or the 90th percentile after 4–5 years are shown in Table 2 and illustrated in Figures 1, 2, 3, 4, 5, 6. Of the children who had cholesterol levels exceeding the 90th percentile at the baseline examination 37% had levels above the 90th percentile and 64% above the 75th percentile after follow-up period (Fig. 1, 2). In 43% of the offspring whose LDL-C levels were above the 90th percentile at the baseline examination the levels had been placed similarly after follow-up period and in 57% they were above the 75th percentile. Correspondingly for TG levels it was 25% and 38%.

Table 2. Percentage of children whose risk factors levels were above the 90th or the 75th percentile at baseline examination and after follow-up period

Risk factors	The percentage of children whose risk factors levels were above the 75th percentile at baseline examination and after follow-up period	The percentage of children whose risk factors levels were above the 90th percentile at baseline examination and after follow-up period
BMI	78%	82%
TC	64%	37%
LDL-C	57%	43%
TG	37%	25%
SBP	51%	25%
DBP	55%	38%

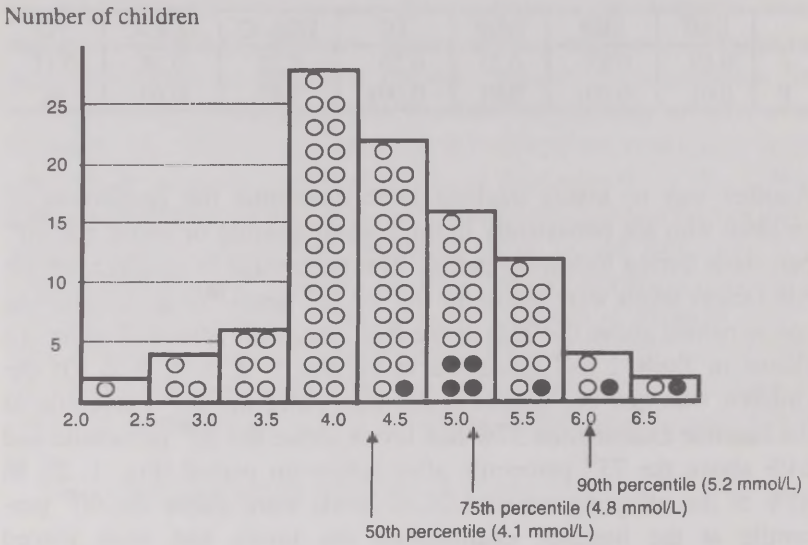

Figure 1. The frequency distribution of serum cholesterol at the follow-up survey. The black dots indicate children whose levels were above the 90th percentile at the baseline examination

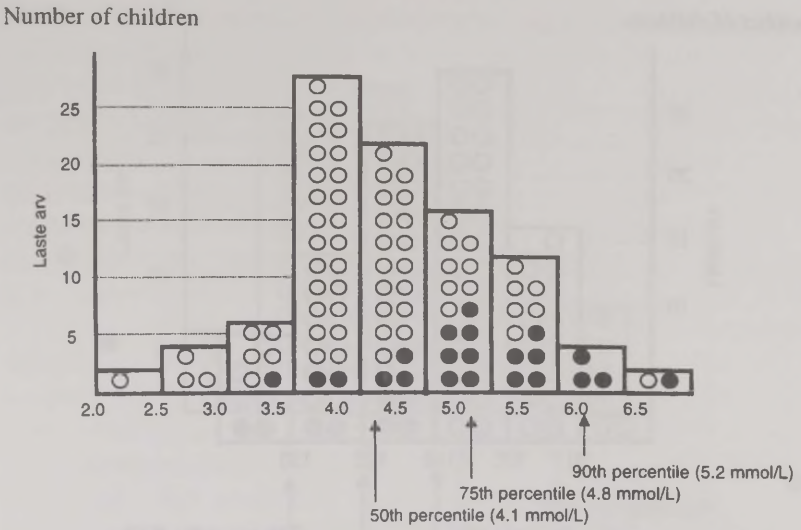

Figure 2. The frequency distribution of serum cholesterol at the follow-up survey. The black dots indicate children whose levels were above the 75th percentile at the baseline examination

Persistence above the 90th percentile for SBP and DBP between two surveys was observed in 25–37% of subjects and in the highest quartile correspondingly 50%–63% (Fig. 3, 4).

In 80% of the children whose BMI levels were above the 90th percentile at baseline these levels were still above this percentile after repeated survey and in 78% of the children correspondingly in the highest quartile (Fig. 5, 6).

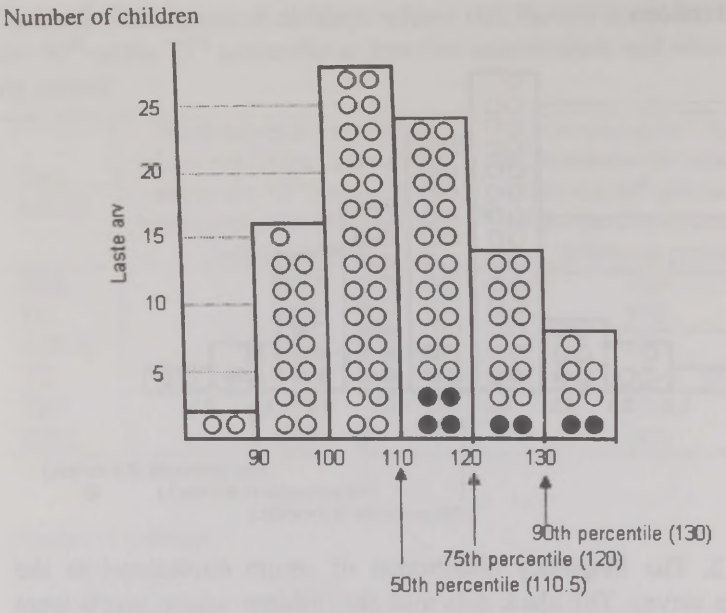

Figure 3. The frequency distribution of systolic blood pressure at the follow-up survey. The black dots indicate children whose levels were above the 90th percentile at the baseline examination

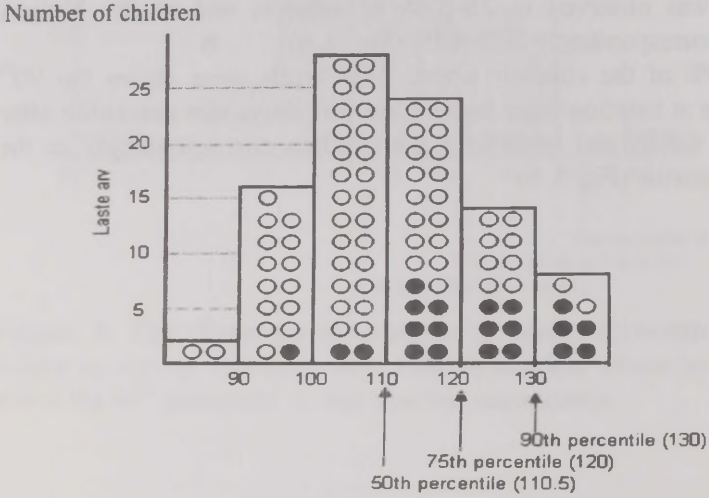

Figure 4. The frequency distribution of systolic blood pressure at the follow-up survey. The black dots indicate children whose levels were above the 75th percentile at the baseline examination

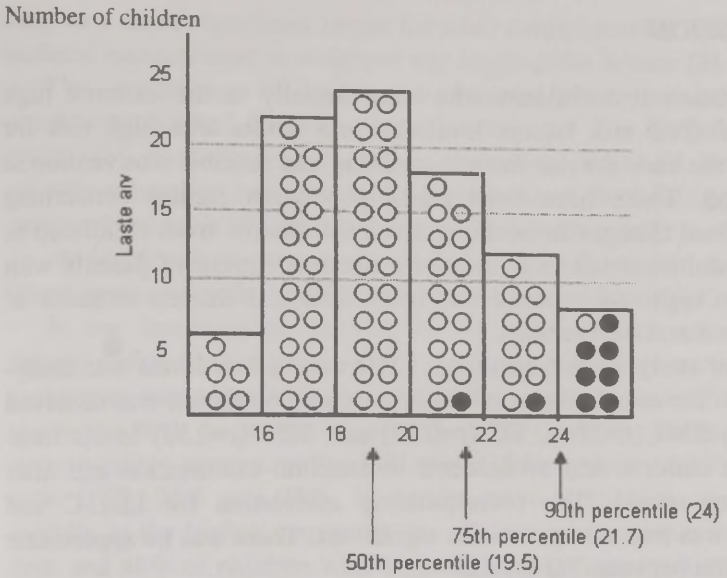

Figure 5. The frequency distribution of body mass index at the follow-up survey. The black dots indicate children whose levels were above the 90th percentile at the baseline examination

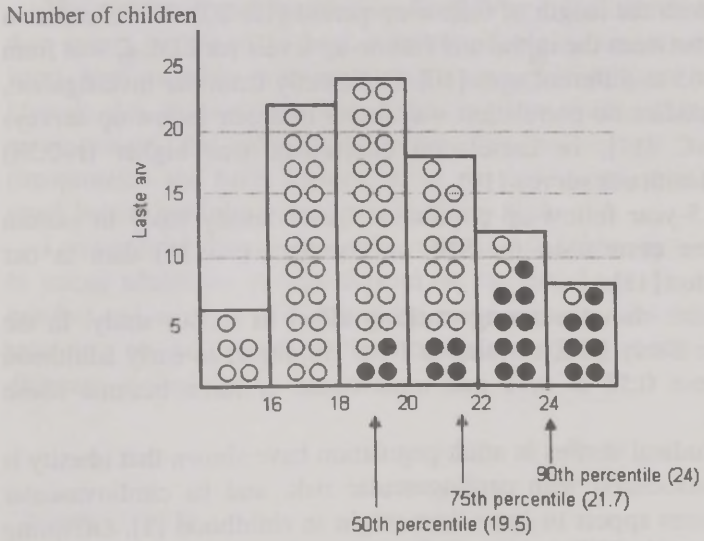

Figure 6. The frequency distribution of body mass index at the follow-up survey. The black dots indicate children whose levels were above the 75th percentile at the baseline examination

DISCUSSION

Confirmation that children who were initially in the extreme high range of CVD risk factors levels become adults with high risk for CVD is the basis for risk factors screening and possible intervention in childhood. There have been many population studies concerning longitudinal changes in cardiovascular risk factors from childhood to young adulthood but little is known about offspring of parents with CHD. In high risk strategy this is of particular interest in terms of prevention and intervention.

In our study when tracking of CHD risk factors levels was analyzed from the correlation coefficient a strong correlation was observed between BMI (r=0.69), TC (r=0.53) and SBP (r=0.53) levels measured in children and adolescents in baseline examination and after follow-up period. The corresponding correlation for LDL-C and HDL-C was less strong but also significant. There was no appreciable correlation between TG levels.

In many studies concerning tracking of lipid levels measured from the correlation coefficient for children initially at 3–18 years of age with different follow-up periods (from 2 to 9 years) the correlation between TC levels was also high (r=0.56–0.64) and decreased with increase with the length of follow-up period [18, 20]. The correlation observed between the initial and follow-up levels for LDL-C was from 0.33 to 0.65 at different ages [10]. Differently from our investigation, in some studies no correlation was found between follow-up surveys for HDL-C [17], or correlation coefficient was higher (r=0.58) compared with our survey [19].

In a 15-year follow-up population based family study in eastern Finland the correlation for SBP was weaker (r=0.35) than in our investigation [11].

BMI also shows a strong tracking effect as in our study. In the Muscatine Study BMI correlation from childhood to early adulthood ranged from 0.58 to 0.91 and most obese children became obese adults [6].

Longitudinal studies in adult population have shown that obesity is strongly associated with cardiovascular risk, and its cardiovascular consequences appear to have their origin in childhood [1]. Offspring of parents with CHD are generally overweight from their childhood and tend to have higher levels of lipids and fasting insulin as adults [7]. It has been suggested that the rate of weight gain during childhood

may be a more significant factor for adult cardiovascular risk than an isolated measurement of weight at any single point in time [3].

The importance of initial risk factors values for subsequent arteriosclerosis and CHD has been investigated in a long follow-up study [15]. Participants with serum cholesterol levels in the highest quartile at baseline had a markedly higher risk of death during follow-up than those with cholesterol levels in the lowest quartile.

A significant percentage of children and adolescents with high blood pressure develop stable hypertension in adulthood [16].

In our investigation stability of high risk factors values (lipid values) defined as the proportion of children persisting in the highest percentiles show that 82% of children who initially had BMI values above the 90th percentile, were still above the 90th percentile. The corresponding percentage for LDL-C, TC levels, SBP and DBP were 43%, 37%, 25% and 38%. In earlier surveys 44–46% of children initially in the highest percentile for cholesterol remained there over time and 48% of children with high LDL-cholesterol persisted in the highest quintile for several years [9, 24].

A prospective study (follow-up 9 year) of Australian children 9 years old at baseline shows that persistence in the highest quartile for BP between surveys was seen in 34–48% of subjects [5].

The results of the Amsterdam Growth and Health Study indicate that, over a period of 14 ears covering adolescence and young adulthood, both stability coefficient and tracking of subjects at risk for lifestyle risk factors were low, indicating low predictability of early measurements for value in later life. For the biologic risk factors (lipoproteins and body fatness) as in our investigation tracking was much better, indicating good predictability [23].

Longitudinal changes in cardiovascular risk factors from childhood to young adulthood greatly depend on the initial age of subject, the number and spacing of longitudinal measurements, and the length of total time period. It is difficult to compare tracking coefficients from different studies with each other.

CONCLUSION

The most stable CHD risk factors in offspring of parents with premature myocardial infarction after 4–5 years of follow-up were

body mass index, lipid levels and blood pressure. This demands regular observation of children at high risk emphasizing regular control of weight, not only cholesterol but also LDL-C levels, and blood pressure, and management of high risk individuals in early life.

This article is a part of the research project supported by grant 3753 of the Estonian Science Foundation.

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Papers on Anthropology XI, 2002, pp. 354–362

CONTRIBUTION OF SKELETAL AGE IN IMPROVEMENT OF MOTOR FITNESS IN PUBERTAL GIRLS

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ABSTRACT

The study was aimed to establish the contribution of chronological and skeletal age (TW-2), sexual maturation and growth to improvement of performance in 12-min run, shuttle runs, 20m dash, standing long jump and trunk forward flexion. Significant correlations were found between age, height, body mass and sexual maturation. Only standing long jump was related to growth ($r=0.332$, $p=0.031$). No other correlation between developmental/ maturation indices and fitness indices were significant. MANOVA failed to show any main effect of age or sexual maturation on motor abilities. A significant main effect appeared for interaction of skeletal age and growth. In conclusion, skeletal maturation influences improvement of motor abilities only in interaction with growth.

Key words: growth, motor abilities, sexual maturation, skeletal maturation

INTRODUCTION

Results of several studies indicate the relationship between skeletal maturation and improvement of motor abilities in adolescents. In 1949 Jones [4] showed that boys with advanced maturity tend to be stronger and perform better in motor tasks. However, similar correlations were found between chronological age and performance. The motor

performance in girls correlated neither with skeletal nor chronological age [4]. In 6 to 9-year-old children correlations with skeletal age were higher than with chronological age for the results of 40-yard dash, throw for distance, agility and ball catching for both sexes, in standing long jump for girls and in ball striking for boys [11]. Again various measures of muscle strength were in similar correlation with chronological and skeletal age [10,11]. In 10- to 16-year old girls skeletal age was correlated with static strength but not with explosive strength, running speed and flexibility [3]. When the effects of chronological age, stature, mass, and skeletal age are statistically controlled, correlations between the skeletal age and performance were reduced [1]. Although skeletal age explained for a longer part of most body dimensions than the chronological age did in regard to motor performance tests, the highest predictive value belongs to the interaction between the chronological and skeletal ages as such or in the combination with stature and/or mass [1].

A longitudinal study showed that when arm isometric strength or results of Cooper test were plotted against skeletal age, the highest annual increments were in boys from 16 to 17, and in girls from 14 to 15 years of age. For explosive leg strength and flexibility annual increments vs. chronological age were stable in boys and girls. However, a pronounced acceleration of the gain of explosive strength vs. skeletal age was detected (in boys from 14 to 16 and in girls from 11 to 12 years). Flexibility vs. skeletal age improved most from 15 to 16 years in boys and from 13 to 14 years of age in girls [5].

Skeletal maturation is causally related to increasing production of sex hormones, most of all of testosterone, as well as of growth hormone and insulin-like growth factors [9]. Therefore, a factor influencing skeletal maturation arises as a result of gonadal development. Sexual maturation has been shown to have a statistically significant main effect on improvement of standing long jump, trunk forward flexion and performance in 4×9 m shuttle run [17]. Accordingly, the question arises whether the improvement of motor abilities is directly related to skeletal maturation, or this influence is a manifestation of sexual maturation.

In this study, the contribution of developmental/maturation indices (chronological and skeletal age, sexual maturation, growth) to improvement of performance in Cooper test, 4×9 m shuttle run, 20 m dash, standing long jump and trunk forward flexion were statistically assessed against the background of results obtained in girls of 11 to 14 years of age.

MATERIAL AND METHODS

Subjects

The subjects of the study were 43 healthy girls aged from 11 to 14 years. All of them and their parents gave informed consent for participation in the study. The study design was approved by the Ethics Committee of the Medical Faculty of Tartu University.

Methods

X-ray pictures of the left hand and wrist were made at Tartu children's policlinics. The size of 20 bones was measured independently by two technicians. They were informed neither about the aim of the study nor about other characteristics of the subject. The skeletal age was calculated by the scoring system TW-2 [13]. Sexual maturation was assessed according to the scale proposed by Tanner [12] for evaluation of breast development. Growth was characterised by height and body mass.

Subjects performed the following motor fitness tests: 20m dash (standing start), 4×9 m shuttle run, standing long jump (three attempts, the best result was considered), Cooper 12-min running test and trunk forward flexion (subjects tried to reach with their fingertips the points possibly below the support level of feet).

Data analysis

The groups formed by chronological and skeletal age, as well as by breast development stage, were compared using one way ANOVA together with *post hoc* Tukey multiple comparison test. Pearson product-moment correlation coefficients were completed between each of the regarded indices. The relationships between motor abilities, body size, sexual maturation and chronological and skeletal age were analysed with the aid of MANOVA and ANCOVA.

Two-tail significance was evaluated designating the 0.05 probability level as significant.

RESULTS

General analysis

Comparison of groups of chronological age showed significant difference ($p<0.05$) between 12- and 13-year-old girls in skeletal age, height, body mass, and sexual maturation (Table 1). Skeletal age groups differed significantly in chronological age and height between skeletal ages of 11 and 12 years. Significant differences were also found in sexual maturation between skeletal ages of 13 and 14 years. Comparison of sexual maturation groups showed that reaching breast development stage 3, skeletal age, height and body mass increased significantly. Reaching breast development stage 4 associated with a significant increase in chronological age and again in skeletal age.

Table 1. Development indices in relation to chronological and skeletal age and to sexual maturation (mean ± SD)

Chrono-logical age (years)	Skeletal age (years)	Stage of sexual maturation*	Height (cm)	Body mass (kg)	n
11	10.3±3.3	2.7±0.5	151±6	39±6	10
12	11.7±0.9	2.7±0.6	154±9	37±11	15
13	13.2±1.1**	3.4±1.0**	161±3	47±7**	9
14	13.5±1.6	3.9±0.9	162±4	53±13	9
Sign of F	***0.018***	**0.001**	**0.001**	**0.003**	
11.6±0.5	**10**	2.5±0.5	149±5	37.5	8
11.6±0.9	**11**	2.6±0.5	152±7	36.11	11
12.6±0.9**	**12**	3.0±0.6	161±6**	44±7	11
13.3±0.8	**13**	3.3±1.0	161±7	47±9	6
13.3±0.6	**14**	4.7±0.6**	162±4	51±8	4
13.7±0.9	**15**	4.7±0.7	158±2	60±10	3
Sign of F <0.001		<0.001	0.001	0.022	0.986
11.9±0.7	10.4±3.2	**II**	150±7	35±4	11
12.1±11	11.9±0.8**	**III**	158±7**	42±10**	21
13.1±0.7**	13.7±1.0**	**IV**	161±4	53±16	7
13.8±0.5	14.4±1.0	**V**	162±5	54±5	4
Sign of F 0.002	0.001		0.002	0.002	

* The mean of breast development stage number in girls of the group
** Statistically significant ($p<0.05$) difference from the previous group.
The nominates of group are indicated in bold.

There were no significant differences between chronological and skeletal age as well as between sexual maturation stages in results of motor ability tests except the increase in standing long jump in 12-year-old girls (Table 2).

Table 2. Results of motor tests in relation to developmental indices (mean ± SD)

Groups	n	Cooper test (m)	Shuttle run (s)	20 m dash (s)	Standing long jump (cm)	Forward flexion (cm)*
Chronological age (years)						
11	10	2197±292	11.9±1.3	4.2±0.4	153±21	11±4
12	15	2301±164	11.8±0.9	4.3±0.8	169±14**	16±9
13	9	2263±288	12.2±0.9	4.2±3.7	160±24	12±7
14	9	2282±313	12.2±1.0	4.5±4.9	172±15	13±7
Sign of F		0.803	0.680	0.499	0.094	0.423
Skeletal age (years)						
10	8	2186±285	11.4±1.3	4.1±0.3	164±16	13.5
11	11	2269±203	12.2±1.0	4.2±0.4	159±17	14.11
12	11	2344±259	12.1±1.0	4.4±0.8	166±21	13.7
13	6	2335±227	11.5±0.9	4.1±0.3	164±29	12.7
14	4	2200±419	12.2±1.1	4.5±0.6	164±29	15.5
15	3	2111±276	12.6±0.6	4.7±0.7	171±19	15.11
Sign of F		0.772	0.450	0.653	0.691	0.986
Sexual maturation stage						
2	11	2264±254	118±1.3	4.2±0.3	160±9	14±12
3	21	2210±280	11.9±0.8	4.3±0.7	164±24	13±5
4	7	2310±227	12.4±1.1	4.3±0.6	165±17	12±8
5	4	2129±245	12.3±1.1	4.8±0.2	175±17	14±7
Sign of F		0.506	0.6112	0.328	0.679	0.931

* Difference between feet support level and persist reached by fingers in forward flexion in cm

** Statistically significant ($p<0.05$) difference from the previous group

Correlation analysis

Significant correlations were found between chronological and skeletal ages, height, body mass and sexual maturation (Table 3). Results in standing long jump correlated with height ($r=0.3332$, $p=0.031$), while performance in shuttle run was significantly related to the time of 20 m dash ($r= -0.369$, $p=0.016$) and the result of standing long jump ($r= -0.492$, $p=0.001$).

Table 3. Correlations between chronological and skeletal ages, height, body mass and sexual maturation

	Chrono-logical age	Skeletal age	Sexual maturation	Height	Body mass
Chronological age	xxx				
Skeletal age	0.546 p<0.001	xxx			
Sexual maturation	0.532 p<0.001	0.585 p<0.001	xxx		
Height	0.581 p<0.001	0.326 p<0.033	0.585 p<0.001	xxx	
Body mass	0.494 p=0.001	0.4821 p=0.002	0.559 p<0.001	0.499 p=0.001	xxx

MANOVA

Multivariate analysis was used for testing the main effects of chronological and skeletal age as well as sexual maturation on the variance of results of motor ability tests. None of these developmental indices had a main effect on the variance of motor abilities tested. Univariate analysis showed that 15% of variance of results of standing long jump were attributable to chronological age and 12% of variance in results of shuttle run to skeletal age. However, in both cases the statistical power was too low (0.53 and 0.30 respectively) to make conclusions. The contributions of other developmental indices on the variance of results of motor tests were negligible.

Interactions

The effects of chronological and skeletal age, sexual maturation and growth were tested in conditions of any combination of these four factors. The significant main effect on tested motor abilities appeared only in the case of interaction of skeletal age and growth (Wilks lambda =0.59, t=0.04, observed statistical power 0.93). The univariate test of significance showed significant F values for shuttle run (F(1;36) =10.68, p=0.002, power 0.89) and for 20 m dash (F(1;36)=6,76, p=0.013, power 0.71).

DISCUSSION

All four developmental indices: skeletal age, stage of breast development, height and body mass increased in the studied girls in good correlation between themselves and with chronological age. However, comparison of groups composed by these indices showed nonlinear development. Significant differences were established in body measures between girls of chronological age of 12 and 13 years, as well as between girls of sexual maturation stages II and III. According to generalisations of great bodies of investigations, the peak height velocity appears as a rule in 12-years-old girls [2, 7] and in sexual maturation stage III [8]. However, skeletal age groups differed only by height between skeletal ages 11 and 12 years, although significant correlations were found between skeletal age, chronological age, height, body mass, and sexual maturation stage. Thus, a divergence should exist in factors determining or modifying growth rate and skeletal maturation. Since skeletal age differed between sexual maturation groups, the divergence may be related to some differences in the action of sex hormones on growth vs. skeletal maturation.

The lack of significant differences between groups in results of motor tests was surprising because several other studies contain results showing corresponding differences between girls of chronological age of 11–15 years, although not between all groups and in all fitness indices [6, 7, 14]. We also failed to find significant correlation between chronological age and tested motor abilities. Obviously, there exists a pronounced variability in factors influencing the improvement of motor ability. Chronological age is only one of these factors and not the dominant factor.

Our previous cross-sectional investigation showed improved performance in shuttle run, reaching sexual maturation stage II and in standing long jump and trunk forward flexion, reaching stage III [16,17]. A five-month longitudinal experiment demonstrated improvements in standing long jump and trunk forward flexion in girls of stage III, and in 20 m dash in girls of stage IV [15]. The present results failed to show these differences. The obvious reason for the discrepancy is related to the lesser number of girls in the present sample. Due to several other influencing factors, the sexual maturation effect appears convincingly only in a great sample.

In agreement with data obtained both in prepubertal [4] and pubertal [3] girls we failed to found correlation between skeletal age and fitness indices. It has been shown, that skeletal age action on fitness improvement appears when interaction with chronological age or stature were computed [1]. The multivariate analysis of our results indicated a significant main effect on variance of fitness parameters for interaction of skeletal age and growth but not for interaction of ages or sexual maturation computed separately.

In conclusion, skeletal maturation influences the improvement of motor abilities in interaction with growth. The latter, in its turn, is dependent on sexual maturation

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ISSN 1406–0140