Papers on Anthropology

XII

PAPERS ON ANTHROPOLOGY
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UNIVERSITY OF TARTU
CENTRE FOR PHYSICAL ANTHROPOLOGY

PAPERS ON ANTHROPOLOGY

XII

TARTU 2003

Editor:
Prof. Helje Kaarma

The English text revised by
Mall Tamm and Ilmar Anvelt

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

ISSN 1406–0140

Printed by Tartu University Press
www.tyk.ut.ee
Order No 599

PREFACE

The present collection serves to mark that ten years have passed from the foundation of the Centre for Physical Anthropology at the University of Tartu (18 July 1993). Regular anthropometric research in Estonia has definitely lasted much longer, dating back to the beginning of the activities of Juhan Aul.

Thanks to the cooperation with the biologists and medical scientists of the University of Tartu and medical experts elsewhere in Estonia, and financing by the Estonian Ministry of Social Affairs to keep the Anthropometric Register, we have been able to continue to pursue our main aim — research of constitutional peculiarities of both sick and healthy persons.

The contributions by numerous authors in many areas of anthropology are the best birthday present for all of us.

Helje Kaarma

Prof. Helje Kaarma

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PHYSICAL ACTIVITY AND BIOLOGICAL RISK FACTORS OF CORONARY HEART DISEASE (CHD): THE STUDY OF PREMATURE MYOCARDIAL INFARCTION

Katrin Aasvee[1], Elvira Kurvinen[1], Inna Tur[1], Matti Jauhiainen[2], Jouko Sundvall[3]

[1] Estonian Institute of Cardiology, Ravi str. 18, 10138, Tallinn, Estonia
[2] National Public Health Institute, Department of Molecular Medicine, Biomedicum, Haartmaninkatu 8, 00290, Helsinki, Finland
[3] National Public Health Institute, Department of Health and Functional Capacity, Mannerheimintie 166, 00300, Helsinki, Finland.

ABSTRACT

The aim of the study was to evaluate the associations of physical activity (PA) and the biological risk factors of atherosclerosis in the male survivors of premature myocardial infarction (PMI; n=71) and in the corresponding control group (n=85). A self-administered six-graded scale by Grimby was used to estimate physical activity, the special interest was to determine whether biological cardiovascular risk factors demonstrate gradual changes by degrees of physical activity habits' scale. Serum lipids, apo B and Lp(a) levels were measured, blood pressure, BMI and waist-to-hip ratio were determined. In the males who suffered from PMI certain gradual decreases of serum TC, LDL-C, apo B and TC/HDL-C ratio by the PA grade were revealed, while the HDL-C concentration was increased from the 2nd up to the 6th grade of PA. The trends were not significant in the control group. The only significant difference in anthropometrical risk factors by degrees of PA was significantly lower BMI value in the control men at the 5th grade of PA as compared to those at the 2nd grade of PA. The used classification system of physical activity was quite sensitive first of all for the evaluation of relationships between physical activity and blood lipoprotein parameters.

Keywords: CHD risk factors; physical activity; lipids; lipoprotein(a); premature myocardial infarction

INTRODUCTION

The low level of physical activity has been considered a relevant risk factor in the development of coronary atherosclerosis. Because CHD is the leading cause of death and disability in Estonia [2], the potential role of physical activity in the prevention of CHD and its complications is of particular importance. It is well known that physical activity is inversely associated with CHD morbidity and mortality [1, 25, 31]. The impact of physical activity index on CHD is mediated through its beneficial effects on obesity, lipoprotein metabolism and blood pressure [1, 21, 25]. In general, overweight is characterized by increased triglycerides (TG) and low high density lipoprotein cholesterol (HDL-C) levels. In the presence of abdominal obesity the free fatty acids flux from the visceral adipose tissue is increased, which contributes to an overproduction of TG-rich lipoproteins by the liver. The resulting hypertriglyceridemia will promote the transfer of TG to HDL and low density lipoproteins (LDL), while cholesterol is leaving from HDL. After the hydrolysis of TG, small dense lipoprotein particles to be formed and plasma HDL-C level decreases [8]. Fat is an extremely important substrate for muscle contraction [24]. It is widely documented that endurance activities increase the energy utilisation from fat, reduce subcutaneous fat cells weight and body fat percentage, resulting in reduced TG and increased HDL-C levels [5, 18, 22, 24]. The increase of HDL level favours the production of endothelium-dependent vasorelactants and the improvement of hypertension [20].

The methods for the assessment of physical activity by energy expenditure (directly or indirectly) are quite laborious and time-consuming [12, 16, 27]. If the purpose of the study is first of all to estimate physical activity habits or clear out physically inactive subjects, more simple questionnaires can be used. To assess physical activity habits in the elderly subjects, a simple six-graded scale has been proposed [11], which is a modification of the original 4-graded questionnaire by Saltin & Grimby [26]. In the present study the six-graded scale was used to estimate physical activity in the survivors of premature myocardial infarction in the Tallinn region. The special emphasize was laid on the determination whether biological cardiovascular risk factors demonstrate gradual changes by degrees of physical activity habits' scale among the study subjects.

MATERIAL AND METHODS

Subjects

In the present case-control study a cohort of Tallinn men (n=71) who were suffering from myocardial infarction (MI) at the age of 55 years or earlier were studied for cardiovascular risk factors. The male control group (n=85) was chosen from the Estonian Population Register. The participants were invited to the investigation by mail. The participants gave their written consent of being informed and the local ethics committee approved of the design of the study.

Methods

Physical activity (PA) was registered by the following classification system (11):

1) hardly any PA;
2) mostly sitting, sometimes a walk, easy gardening or similar tasks;
3) light physical exercise around 2–4 hours a week, eg. walks, fishing, dancing, ordinary gardening etc., including walks to and from shops;
4) moderate exercise 1–2 hours a week, eg. jogging, swimming, gymnastics, heavier gardening, home-repairing or easier physical activities (see grade 2) more than 4 hours a week;
5) moderate exercise at least 3 hours a week, e.g., tennis, swimming, jogging etc.;
6) hard or very hard exercise regularly and several times a week, eg. jogging, skiing.

To evaluate the financial status of the subjects, a five-graded scale characterizing the balance between income and necessities of the family was filled in. The 1st grade was: only to pay for food is within the means of our family; the 5th grade: we can buy everything that we want. The educational level was assessed also by a five-graded scale: the 1st was higher education and the 5th — elementary school (6 forms or fewer).

Body weight and height were measured, the body mass index (BMI) was calculated: weight (kg) divided by the square of the height (m^2). Waist and hip circumference were determined and the ratio of these values (WHR) was calculated. Systolic and diastolic blood pressures (BP; Korotkoff phase I and V) were measured by a manometer two times, the mean of the readings was used in the study.

Fasting blood samples were drawn and the total serum cholesterol (TC), high density lipoprotein cholesterol (HDL-C) and triglycerides (TG) were determined in the Tallinn Diagnostic Centre with the wet chemistry method using Vitros 250, Johnson & Johnson analyser and reagents. The low density lipoprotein cholesterol (LDL-C) level was calculated by the Friedewald formula [10]. Apolipoproteins (apo) A-I and B were quantified by Laurell`s rocket-immunoelectrophoresis [17] using calibrators from Orion Diagnostica, Espoo, Finland. The method was intercalibrated with the immunoturbidometric assay used in the National Public Health Institute, Laboratory of Analytical Biochemistry, Helsinki. The serum concentration of lipoprotein(a) (Lp(a)) was determined using the immunoradiometric assay in the National Public Health Institute, Helsinki, Finland [14, 28]. The quality control of Lp(a) assay in the present study was the same as described [14, 28].

Statistical methods

All the statistical analyses were made using the programs of Excel and MedCalc packet [19]. The mean values and the standard deviations were calculated, to evaluate the statistical significance of the differences the Student's t-test (parametrical data) or the Mann-Whitney U-test (nonparametrical) were used. The Spearman´s rank correlation coefficients were used to evaluate the associations of nonparametrical values and the linear regression analysis by Pearson in the other cases. Proportions were compared by the Chi-scquare test.

RESULTS

The clinical and biological characteristics of the survivors of premature myocardial infarction (PMI) and the control group by the grade of PA are shown in Tables 1 and 2. Neither any case nor control subject had the 1st grade of PA. The frequency of higher PA grades (the 5th and the 6th) was 10% higher in the control group (30.9%,) as compared to PMI-subjects (19.7%; P>0.05). The indices of BMI and WHR as well as blood pressure did not reveal significant differences in relation to the level of PA (Tables 1 and 2).

Table 1. Indices of cardiovascular risk factors (M±SD) in the survivors of myocardial infarction by the grade of physical activity.

	Physical activity grade				
	2nd, n=5 7.0%	3rd, n=19 26.8%	4th, n=33 46.5%	5th, n=12 16.9%	6th, n=2 2.8%
Age, years	59.6±7.9	48.4±4.7 *	49.2±6.4 *	51.1±7.6	45.5±12.0
BMI	27.8±1.6	28.4±2.7	29.0±4.4	27.6±2.7	31.2±0.3
WHR	0.97±0.02	0.98±0.05	0.96±0.06	0.97±0.06	0.97±0.02
TC,mmol/l	6.36±0.70	6.24±1.13	6.01±1.21	5.59±1.22	5.13±1.36
TG,mmol/l	2.38±0.68	2.17±1.66	1.42±0.60	1.42±0.69*	1.90±0.47
HDL-C,mmol/l	0.76±0.11	0.97±0.42	1.06±0.36	1.10±0.23*	1.56±1.13
LDL-C, mmol/l	4.53±0.80	4.29±0.93	4.32±1.17	3.85±1.07	2.72±2.71
Apo B, g/l	1.38±0.11	1.32±0.25 [b]	1.27±0.29	1.13±0.24*,[a]	1.09±0.18
TC/HDL	8.48±1.01	7.38±2.98 [b]	6.30±2.28 *	5.34±1.66* [a]	4.89±4.42
Lp(a), mg/l	413±236	321±330	454±527	443±324	250±310
95% CI for mean	120–707	162–480	264–644	237–649	–2532–3032
Median	316	187	234	455	250
Syst. BP, mm/Hg	138±28	130±16	130±16	134±20	143±7
Diast. BP,mm/Hg	81±12	84±12	88±12	87±12	93±6

* p<0.05, as compared to the group of the 2nd grade of physical activity

[a] p<0.05, as compared to the group of the 3rd grade of physical activity

[b] p<0.05, as compared to the group of the 5th grade of physical activity

Table 2. Indices of cardiovascular risk factors (M±SD) in the control group by the grade of physical activity.

	Physicial activity grade				
	2nd, n=5 6%	3rd, n=20 23.8%	4th, n=33 39.3%	5th, n=19 22.6%	6th, n=7 8.3%
Age, years	48.2±5.4	48.3±6.9	48.3±4.4	48.1±6.8	47.4±4.7
BMI	28.8±6.0	28.0±3.3	28.9±6.0	25.6±4.4 [a]	27.5±3.38
WHR	0.97±0.08	0.98±0.09	0.97±0.08	0.93±0.05 [a]	0.96±0.05
TC,mmol/l	5.30±1.65	5.28±1.24	5.10±0.91	4.81±1.11	6.09±0.55
TG,mmol/l	1.41±0.45	1.06±0.73	1.35±0.85	0.97±0.36 *	1.38±0.41 [a,b]
HDL-C, mmol/l	0.80±0.20	1.03±0.29	0.96±0.32	1.22±0.35 *	1.16±0.55
LDL-C, mmol/l	3.87±1.59	3.77±1.17	3.57±0.80	3.15±1.11	4.32±0.80
Apo B, g/l	1.18±0.31	1.02±0.25	1.00±0.20	0.94±0.20	1.09±0.06
TC/HDL-C	7.03±2.69	5.66±2.55	5.91±2.12	4.35±1.91 *,[a]	6.30±2.90
Lp(a), mg/l	376±295	166±228	288±352	217±324	412±283 [a,b]
95% CI for mean	10–742	57–276	161–415	60–373	150–674
Median	576	81	155	89	327
Syst. BP, mm/Hg	127±14	136±19	130±19	129±17	131±14
Diast. BP,mm/Hg	89±16	88±15	88±13	84±11	90±13

* $p<0.05$, as compared to the group of the 2nd grade of physical activity
[a] $p<0.05$, as compared to the group of the 3rd grade of physical activity
[b] $p<0.05$, as compared to the group of the 5th grade of physical activity

In the control group (Table 2) the gradual changes in serum TC, LDL-C, apo B and TC/HDL-C ratio were similar to those in PMI-subjects from the 2nd up to 5th grade. However, these differences did not reach statistical significance. It was somewhat surprising that the physically most active control men (the 6th grade of PA) had the highest serum levels of TC and LDL-C although the differences were not significant. Lp(a) level was the highest in the control subjects who had the 6th degree of PA (Mann-Whitney U-test). The age of control subjects did not differ from the groups of PA grade.

The serum level of Lp(a) in the men who suffered from PMI correlated negatively with age (Spearman' r=0.24; P=0.040). There were no other significant correlations between the age and lipoprotein parameters neither in PMI nor in the control group.

The grade of financial status of the family correlated negatively with the TC/HDL-C ratio in control subjects (Spearman r=–0.24;

P=0.031) and with the level of apo B in PMI subjects (Spearman' r=–0.25; P=0.038).

The only significant difference in anthropometrical risk factors by degrees of PA was significantly lower BMI value in the control men at the 5th grade of PA as compared to those at the 2nd grade of PA.

DISCUSSION

It is generally accepted that PA is a relevant means to control body weight and risk factors related to lipid metabolism. Many studies have demonstrated lower levels of blood plasma atherogenic lipoprotein fractions, but the higher anti-atherogenic HDL-C concentration in physically more active subjects [9, 22, 23]. Our results, demonstrating the gradual decrease of serum TC, LDL-C, TC/HDL-C ratio and apo B concentrations with a concomitant HDL-C increase by the scale of PA habits, are in a good accordance with these results. The only unanticipated result was the higher level of indices of serum atherogenecity (TC, TG, LDL-C, TC/HDL-C) in the control subjects at the highest grade of PA, although the differences with other PA grades were mostly not significant. A factor that is known to be in positive association with these lipid markers is age, but there were not any age-differences between PA grade groups of control subjects. In addition, the lipid factors did not correlate with age neither in the controls nor in the PMI subjects. It is known that a favourable effect on the lipid profile is exerted only by endurance training [3, 4, 13, 22, 24], the strength training can be associated with more atherogenic lipid profile [4]. We speculate that among the control subjects of the 6th grade of PA there can be subjects doing hard physical work, e.g. loaders. A factor that can be related to increased CHD risk is a low socio-economic status [1]. The status can be characterized in this study by the grade of financial status of the family and the educational level. The inferior the financial status, the higher was the TC/HDL-C ratio in the control group and the apo B level in the PMI subjects. In the not numerous group of the control men at the 6th grade of PA a significant inverse correlation between TC and educational level (Spearman' r=0.87; P<0.033) was revealed. Higher educational level is associated, in the countries in which the CHD risk is declining, greater improvement in health-related life-style is characteristic of the educated people [1]. The less educated follow these principles less often.

There was not any regular trend in serum Lp(a) levels in relation to the PA grade in this study. The only significant difference (by Mann-Whitney U-test) was a higher Lp(a) level of the control men at the 6th PA grade as compared to the men with grades 3 and 5. The differences were not significant by the analysis of 95% CI for the means. In the Young Finns Study physical activity was associated with favourable Lp(a) levels, as high levels of Lp(a) (>25 mg/dl) were less frequent in the physically most active subjects [29]. In general, it is considered that blood Lp(a) concentrations are mainly genetically determined [6, 7, 30], and are not associated with behavioural risk factors [7, 15]. The highest Lp(a) level in the control men of the highest PA degree is an occasional result that is caused by the great individual differences, which are characterizing for this marker.

The used classification system of physical activity by Grimby was quite sensitive first of all for the evaluation of relationships between physical activity and blood lipoprotein parameters.

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NEW CASES OF TREPHINATION FROM A 10–11TH CENTURY HUNGARIAN SITE

Zsolt Bereczki, Antónia Marcsik, László Paja

Department of Anthropology, University of Szeged, Hungary

ABSTRACT

New cases of surgical and symbolic trephination were found in a 10–11th century cemetery near Hődmezővásárhely, South-Hungary. The skull of a senile male individual showed the evidence of a special symbolic trephination. In the skull of a senile female individual the signs of a healed symbolic trephination could be observed. A mature female individual was surgically trepanned in the right parietal bone, but the wound was affected with an infectious inflammatory process and she probably died soon after the operation. In the fourth case an adult male got injuried on the right parietal bone possibly due to a sword-cut. The portion of the circular cut to the temporal direction may have been more seriously damaged, so the help of a surgeon was needed to even the edge of the trephination-like wound. Though the edges of the opening began to heal, the individual may have survived only for a short time after the trephination.

Keywords: 10–11th century, symbolic and surgical trephination, Hungary

INTRODUCTION

Dealing with the problems of fractures, luxations, amputations, etc. the examination of traumatic alterations is an important field of historical anthropology. One of the most extraordinary traumatic lesions is trephination. There is a lot of evidence of this practice all over the world from the Neolithic Age [15, 20, 21] to the Middle Ages [5,21]. It is the artificial removal of the cranial bone carried out in different ways and for different purposes [21]. Concerning living subjects in case of primary surgical trephination, a portion of the cranial vault is completely cut out in order to cure headaches, mental retardation, brain tumors or other diseases. Secondary trephinations are fractures caused by accidental events like sword-cuts, hits, etc. that have been treated by a surgeon in order to even the edges, remove bone splinters and bandage the wound. The holes remaining after these two operations may be very similar. Trephination-like holes were also made on corpses in order to obtain bony fragments with magic properties [20]. The third type, the so-called symbolic trephination, was cultivated by a great number of peoples in Eastern Europe [15,20]. In these cases only the upper compact and the spongious parts are removed in a distinct spot of the calvaria without creating a connection between the endocranial space and the outer world. The real object of symbolic trephination is still unknown, it is as possible to be made for ritual-religious reasons as for therapeutical purposes.

After conquering the Carpathian Basin (896 AD) early Hungarians tried to continue their old traditional way of life in the 10th century [20]. Among many others the ritual custom of eastern origin [6, 7, 11, 12,16] trepanning remained cultivated through more than one hundred years. It was only performed in the adult age in both sexes, the infantile evidence of symbolic trephination has not been found yet [6, 12, 16]. The prevalence of cases decreased in the 11–12th centuries after the reign of Stephen I, who introduced Christianity as a state religion in Hungary [6, 20].

In this paper we would like to present some new interesting cases of surgical and symbolic trephination from a 10–11th century cemetery in the southern part of Hungary.

MATERIAL AND METHOD

In the year 1957 a 10–11th century cemetery was found on the outskirts of the town of Hódmezővásárhely (Csongrád County, Hungary) in an area called Nagysziget. The archeological excavations were completed in several periods supervised by Gyula Gazdapusztai in 1957–1959 and László Révész and Katalin B. Nagy in 1982–1992 [2, 3, 4, 8, 10, 13, 14, 17, 22]. According to the latest data the burial site contains 135 graves. Most cases of trephination derive from the southern, 10th century part of the cemetery. It is the so-called "lined-cemetery", which is characteristic of the Hungarian sites in that epoch. From the total grave number 135, the calvaria of 59 individuals were suitable for investigation. Trephination was observed in the skulls of 4 individuals (2 surgical, 2 symbolic). Besides morphological examination metric analyses (Table 1) were also carried out using Martin's method [19]. The stature was calculated on the basis of Sjøvold's method [23]. Sex and age at death were determined applying the method of Acsádi-Harsányi-Nemeskéri [1]. The skeletal material is deposited at the Department of Anthropology, University of Szeged, Hungary.

Table 1. The stature, the cranial measurements and indices of the four examined individuals of the series Hődmezővásárhely-Nagysziget.

	no. 16161		no. 14649	no. 14467	no. 16171	
Long bone measurements						
	R	L	–	–	R	L
humerus1	336	–	–	–	337	333
humerus2	331	–	–	–	331	324
radius1	–	248	–	–	249	248
radius1b	–	244	–	–	247	247
ulna	272	273	–	–	267	265
femur1	454	456	–	–	–	–
femur2	452	452	–	–	–	–
tibia1	360	365	–	–	–	–
tibia1b	358	359	–	–	–	–
fibula	–	–	–	–	–	–
stature	170,1		–	–	170,6	

	no.16161	no.14649	no.14467	no.16171
Cranial measurements				
1	183	179	182	205
5	–	–	97	–
8	153	–	141	–
9	97	128	96	–
17	–	94	126	–
20	113	–	–	119
40	–	111	90	–
45	–	–	–	–
46	101	–	88	–
47	–	–	117	–
48	–	–	71	–
51	41	–	39	–
52	30	–	35	–
54	27	23	22	–
55	51	–	50	–
62	48	–	41	–
63	–	–	43	–
65	–	–	–	–
66	107	77	–	–
69	–	27	32	–
70	59	57	60	70
71	33	25	30	34
Cranial indices				
8:1	83,6	–	77,47	–
17:1	–	52,51	69,23	–
17:8	–	–	89,36	–
20:1	61,74	–	–	58,04
20:8	73,85	–	–	–
9:8	63,39	–	68,08	–
47:45	–	–	–	–
48:45	–	–	–	–
52:45	–	–	–	–
52:51	73,17	–	89,74	–
54:55	52,94	–	44	–
63:62	–	–	104,87	–

CASE REPORTS

Inventory number: 16161
Sex: male
Age at death: senile (60–65)
The skeleton showed a paleopathological condition that can possibly be attributed to the advanced age at death: all the teeth were lost ante mortem, degenerative arthrosis with symptoms like osteophytes in the lumbal-sacral articulation, the proximal epiphyses of radii, the halluces, osteophytes and Schmorl-nodes on the intervertebral faces of the vertebrae were formed. The ossification of the xiphoid process of the sternum and the enthesopathic alteration of both calcaneuses were observed. Thoracal vertebrae 11 and 12 were both of a lumbal character.

To the right from the middle of the left parietal bone near to the sagittal suture a sharp and thin elliptic scar can be observed with the size of approx. 4×2.5 cm. The left-dorsal section of the scar is healed or ab ovo uncut for the line is interrupted by 2 cm of intact bone section. The scar, being very definite, differs totally from the post mortem fissures of the skull (Fig. 1). The elliptic shape is so regular that it cannot be attributed to anything else but intentional human intervention. The trepanning method used here, however, is ambiguous. Bartucz's description of the skull no. 23 from Tiszaderzs and many other previous papers on the topic confirm our diagnosis of symbolic trephination [5, 6, 12]. Most possibly it was carried out by incising the bone with a special trepanning implement (needle, sharp knife or trepan) for the lines are very definite [5, 12, 18]. After carving the contours into the bone the surgeon began to remove the upper cortical layer of the encircled area by scratching or rubbing the bone. The evidence of this practice can be seen as a shallow semi-healed depression in the middle of the ellipse. We presume that the procedure of trepanation was interrupted at the beginning and was never completed, so the marks of the intervention could almost perfectly heal. Owing to the post mortem effects (bursting), the anterior part of the elliptic scar appears more sharply.

Symbolic trephinations occur most frequently around bregma and along the sagittal or coronal sutures [6, 16, 20]. The present case is found in the latter localisation.

Figure 1. Sharp, elliptic scar surrounding a semi-healed depression in the case of symbolic trephination of a male senile individual (inv. no: 16161).

Inventory number: 14649
Sex: female
Age at death: senile (60–70)
The skull is post mortem deformed partially. The postcranial bones are missing. There were no paleopathological features found on the skull.

A deep depression of 3×2 cm extension can be observed on the left parietal bone in the corner of the sagittal and coronal sutures and its margin involves the sagittal suture as well. (Fig. 2). The surface of the depression is uneven but not rough, the edges cannot be defined properly. It is undoubtedly a healed symbolic trephination that was made up decades before the death of the individual. It must have been carried out with scraping the contours into the bone and carving out the middle part [18, 20].

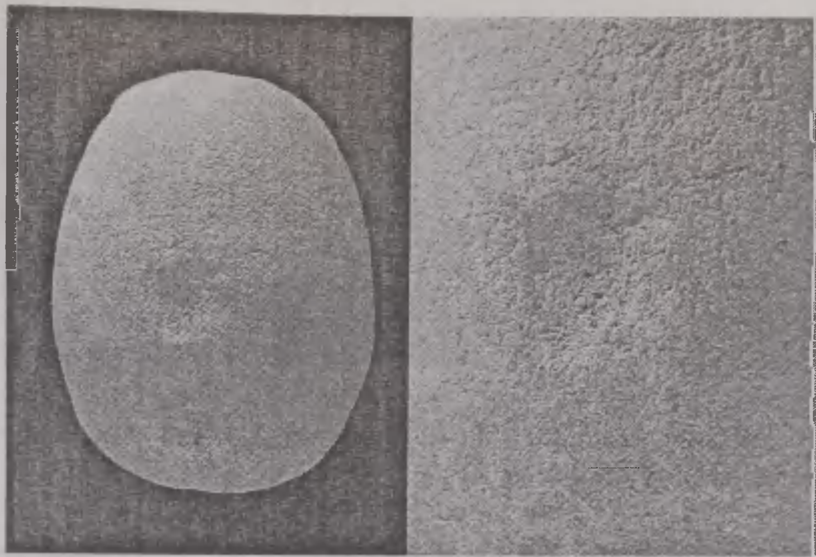

Figure 2. Round-shaped symbolic trephination on the left parietal bone in the corner of the sagittal and coronal sutures of a female senile individual (inv. no: 14649).

Inventory number: 14467
Sex: female
Age at the death: mature (40–50)
The postcranial bones are missing. The articular surface of the left condyle of the mandible has a small circular additional outgrowth on the anterio-lateral part. Caries appears in 7 teeth of the 20 present at the examination.

An almost round hole is seen in the right parietal bone with the edge being pointed towards the sagittal suture and the temporal bone (Fig. 3). The hole is 4 cm long, 3 cm wide and it is situated 2 cm above the right temporal bone. There is a very porotic and lacunatic zone surrounding the edge. Both endocranial and ectocranial surfaces show hypervascularisation and periostitis on the endocranial surface (Fig. 4).The hole is most likely to be an unhealed surgical trephination, that, after being prepared became infected [21]. The inflammatory processes may have caused the death of the individual. However, she must have survived the operation for some time [24].

Figure 3. Non-healed surgical trephination in the right parietal bone (left) of a female mature skeleton (inv. no: 14467). X-ray picture (right) of the same subject.

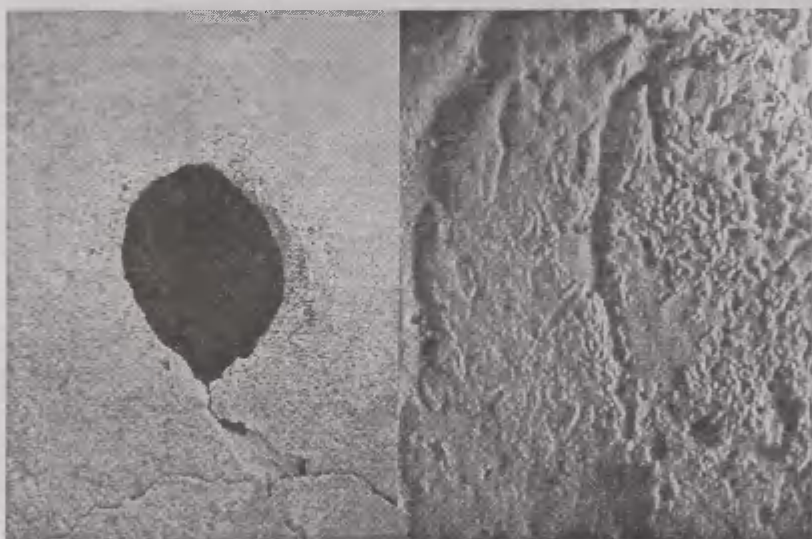

Figure 4. Porosity around a non-healed opening (left) and periostitis on the endocranial surface surrounding the surgical trephination (right), mature female individual (inv. no: 14467).

A hole on the cranial vault with porotic edges could be regarded as the sign of metastatic carcinoma. In this case additional holes of the same charateristics should have been observed on the skull and small metastatic lesions should have been visible on the X-ray pictures. In our case their is no evidence of such features that could disprove our diagnosis (Fig. 3).

Inventory number: 16171
Sex: male
Age at death: adult (35–42)
The skull is post mortem heavily deformed. Marked entheses are observed on both calcaneuses, sacroiliacal surfaces and iliac crests. The vertebrae are involved in advanced degenerative arthrosis: the vertebral bodies are porotic, compressed and deformed, osteophytes and Schmorl-nodes can be observed in all spinal regions. The endocranial surface of the occipital bone is irregularly devided by ridges.

Figure 5. Circular semi-healed wound in the right parietal bone of an adult male individual (inv. no. 16171).

A 6×6 cm circular hole can be seen in the middle of the right parietal bone (Fig. 5). The hole continues towards the temporal bone in a trapezoid form. Reaching the temporal bone, the hole shrinks to 2.5 cm width. The gap may continue on the temporal bone which is missing. The edge of the circular hole is almost horizontal; it must be the aftermath of an enormous sword-cut. The cut, however, may not have been complete. The flat of the sword got stocked in the wound. As the sword was pulled out, the circular bone-cap broke off causing additional fractures below the original cut. The help of a surgeon was needed to remove splinters, to clear and even the edges of the cut and to bandage the wound. The three layers of the bone are visible in the circular part of the hole so no healing processes were initiated there except for a 1 cm long section. On the margins to the direction of the temporal bone the marks of the surgical intervention are still visible for the broken edges are smooth-rubbed. The low level of healing indicates that the man has not died immediately after the injury and the operation, but only survived for a short time [9, 21].

CONCLUSIONS

The total prevalence of trephination in the cemetery is 6.7%. Two cases of symbolic trephination were found among 59 skulls: the 3.4% prevalence of these highly exceeds the 1.4% ratio observed by Nemeskéri et al. in other 10–11th century series of Hungary [20]. The area around Nagysziget belonged to the lordship of chief Ajtony who organised stiff resistance against the spreading of Christianity and modernization during the reign of Stephen I (1000–1038). The people of Ajtony followed their old pagan customs [17], which in fact may account for the high ratio of symbolic trephination in the cemetery.

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THE GROWTH OF MENTALLY RETARDED CHILDREN. A LONGITUDINAL STUDY

J. Buday

Eötvös Lóránd University, ”Bárczi Gusztáv” Faculty of Special Education, Department of Patophysiology, Budapest, Hungary

ABSTRACT

For almost thirty years, mentally retarded children at an institution in Hungary have had their body sizes measured twice a year. Between 180 and 220 children are measured year by year.
With the aim of evaluating the personal measurements, the subjects were divided into three groups according the aetiology of their mental retardation: i. intrauterin and perinatal, ii. postnatal and iii. unknown damage. Because of the limited number, the known gametopathias (like the Down's syndrome and also some undifferentiated aminoacidurias) were excluded from the present study.

The subjects were also grouped according to the severity of their mental retardation. In the most serious group (moron) more growth disorders were found than in the others. The value of peak height velocity was found to be the least, and onset of it latest in this group. The oigarche median and also its confidence interval were high (13.90±1.24).

INTRODUCTION

There have been statistical data recording the numbers of disabled children in Hungary since 1953. On average the proportion of disabled children is between 3 and 4%, which means some 40,000 schoolchildren annually. This number is too high to be ignored and the rehabilitation of those children is an important task for medical doctors, special teachers and social workers. The number of mentally retarded children has grown in this period, partly because of the changes in institutional care.

Authors of human biological studies of the disabled usually select the persons to be examined on the basis of having the same type of disability as a common feature and often do not even consider either the severity or the aetiology of the disability. This is due to environmental pressure. Often the aetiological background of a given case cannot be found from the well-known documents. Therefore aetiological classification is difficult, except for some well known cases like the Down's syndrome. On the other hand, if we select according to severity, earlier damage is generally found among the more severe cases.

There are some well-known *cross-sectional growth studies* of mentally retarded children based on very large patterns. These studies have shown that:

- the mean body measurements of mentally retarded children are different from the "normal" schoolchildren's but the differences are seldom statisically significant;
- the differences are manifested during the growth process;
- the body build of these children may often be disproportional, due to differing body-part measurements;
- the standard deviation of these means is higher than that of the "normal" ones because the mentally retarded group is not homogenous aetiologically;
- the secular trend which was proven in different countries (Eiben 1988, Järvelaid 2001, 2001a) can be found in mentally retarded groups (Drobny and Stefunko 1982, Buday 2002) except some aetiological groups such as the Down's syndrome.

No more results can be expected from the cross-sectional studies, even if the number of examined children is increased.

MATERIAL AND METHOD

Our *longitudinal growth study* of mentally retarded children has been in operation since 1975 in an institution for the mentally retarded in the Szolnok county, in South-East Hungary. There are two hundred boys in the institution and they are measured twice a year. In the last ten years there have also been some girls, but their number is not enough for evaluation yet.

The pupils are aged of from 4 to 16 years but we often have some younger and older pupils. A detailed program was carried out with 14 body measurements, ten of which are for the evaluation of anthropometric somatotypes.

The most important consideration in grouping any kind of biological examination is the aetiological background of mental retardation. This classification is based on the chronological order of the damage, based on the grounds that generally a serious stage may be caused by some earlier damage. The pupils were also selected according to this point, but not quite as we would have wished. The following groups were formed:

- Prae and perinatal damage.
- Postnatal damage.
- "Unknown".

In addition, we also have a group named "gametopathia". There are some children with the Down's syndrome, one with the Williams syndrome (7p deletio) and others with some supposed but never verified enzymopathia, like mucopolysaccharidosis, phenylketonuria, succininoargininuria, congenital methaemoglobinaemia, etc. This group is the most heterogenous and this is why it was excluded from this study. An individual evaluation is necessary for each case.

Pupils have also been separated according to the severity of their mental retardation into two groups: "children with a learning disability" and "children with a mental disability",the terms used in special education.

In this study the individual growth curves of body height are analysed according to the AUXAL program. The curves were also compared to the results of the "Budapest Longitudinal Growth Study" (Eiben et al 1992).

RESULTS AND DISCUSSION

In the first aetiological group "prae and perinatal damage" there is one child with the Gregg syndrome (embriopathia rubeolosa), some with fetal alcohol syndrome, EPH gestosis and also cerebral palsy, but most of the children in this group are "small for date babies". The greatest distance was found between their average body height and the "normal" one (Fig. 1.). The inflexion points of the growth velocity curve will be discussed later.

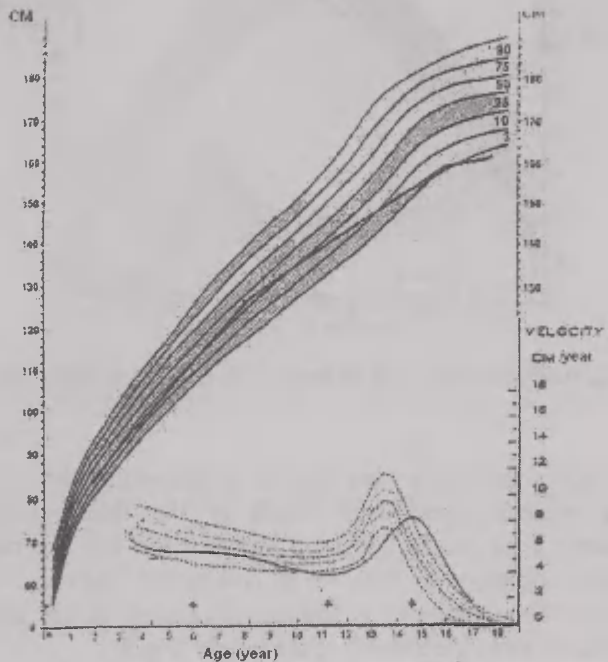

Figure 1. Body height curve of boys with prae- and perinatal damages.

The second aetiological group (postnatal) is the smallest one. Most of these pupils are epileptic. "Morbus sacer" is not a sufficient cause of mental retardation in spite of the fact that progressive oligophrenia was seen together with it. The real aetiology in these cases would be the cause of epilepsy, but it is seldom known. We also have some children with meningitis and encephalitis due to the complication of some other childhood disease. Their average body height also differs from the "normal"one, but the shape of the growth curves is similar (Fig. 2.).

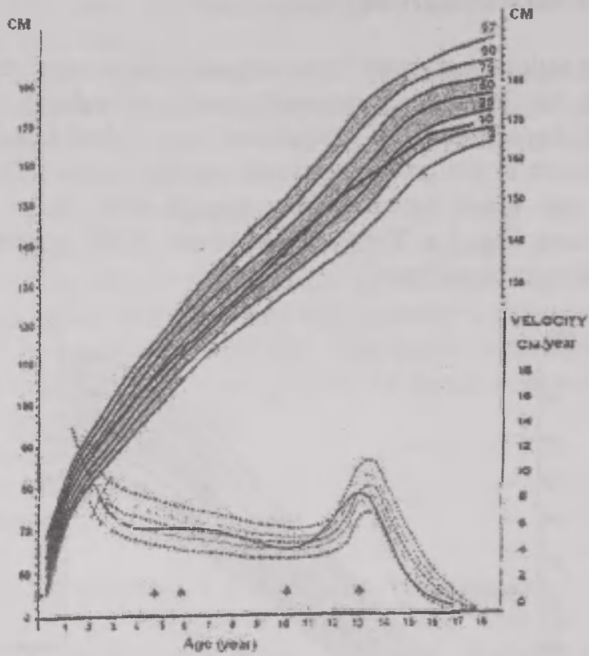

Figure 2. Body height curve of boys with postnatal damages.

Almost half of the pupils have no data on the aetiological background of their mental retardation, which is the third group named "unknown". To evaluate this large number, we have to refer to the well-known opinion of Penrose in connection with the diagnostic difficulties of the aetiology of mental retardation. In this group, there is less difference in the growth of the height (Fig 3.).

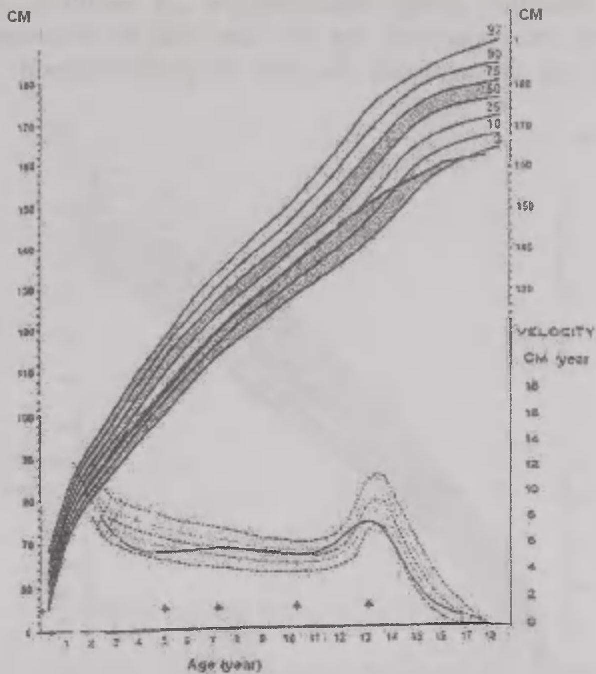

Figure 3. Body height curve of boys with unknown damages.

Regarding the distribution according to the severity of mental retardation, it is important to mention here that the aetiology of the learning disability syndrome group is usually "multifactorial-familiar" like the insufficiency of sociocultural background, or having one or both parents with the same IQ level. The average curve of their body height growth curve is more or less the same as that of the 25th percentile of the normal one (Fig 4.).

In the group of children with mental disability grave biological damages were found to be the aetiological factor, like a rude trauma, or a serious illness. Their growth curve goes under the 25th percentile of the "normal" ones (Fig. 5.).

The changes of the velocity of height growth i.e. the minimal height velocity in praepuberty, later on the peak height velocity and also the age of their onset are very important characeristics of puberty (Table 1). In the mental disability group, both extreme values of the growth velocity curves are less than six months later than that of the learning disability group. According to the aetiology of mental retardation both values are one year later and its measurements are more than one cm/year less in the prae- and perinatal group.

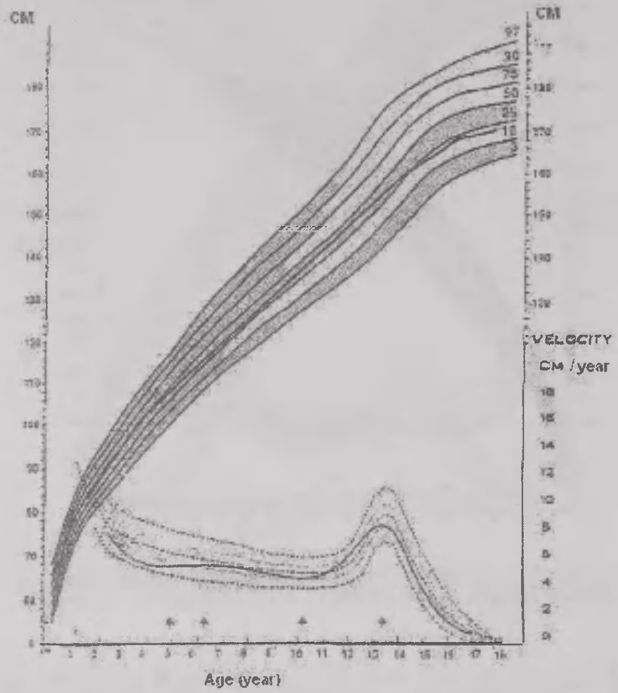

Figure 4. Body height curve of boys with a learning disability.

Table 1. Inflexion points of the growth velocity curve of mentally retarded boys.

	learning disability		mental disability	
	age	cm/year	age	cm/year
MHV	10.1	5.01	10.6	4.7
PHV	13.4	9.1	13.8	8.2

	prae- & perinatal		postnatal		Unknown	
	age	cm/year	age	cm/year	age	cm/year
MHV	11.1	4.1	10.1	5.2	10.2	5.8
PHV	14.6	8.7	13.1	9.8	13.2	8.4

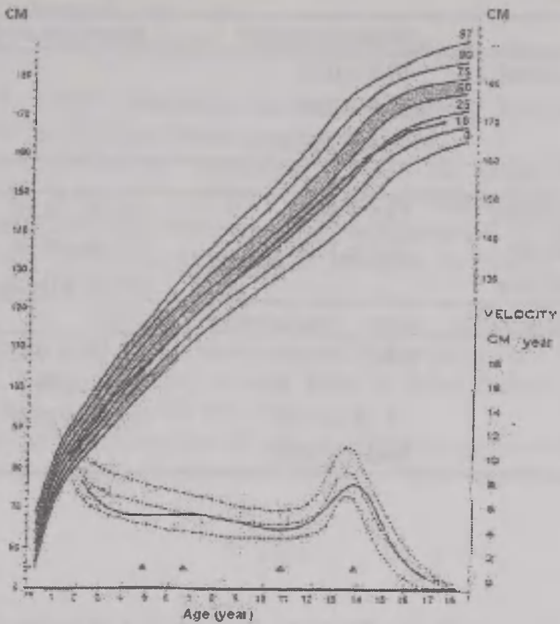

Figure 5. Body height curve of boys with a mental disablility.

We have noted the first pollution of the boys (and also the first menstruation of the girls), which is the task of the nurse in the institution.We also have data on the first pollution of the boys. Because of its pedagogical consequences, it is important for the teachers to know it. In the Budapest Longitudinal Growth Study the oigarche median was 13.3 (Table 2). It was a little higher in our group but the confidence interval of these data is more than one year. It has to be mentioned here that the prae- and postoigarceal differences in adolescent boys (Veldre 2001) could also be shown in boys with mental disability.

For the sake of comparison some data of the median age at the menarche of mentally retarded girls is also noted. The median age at the menarche of girls with mental disability was 13.34 ± 0.96 year and the girls with the Down's syndrome was 13.45 ± 0.48 year as was found earlier (Buday 1990). These data are compared with the two median ages of normal girls (Pantó and Eiben 1984, Bodzsár 2002).

Table 2. Oigarche and menarche median of mentally retarded children.

	Oigarche median	Menarche median
Prae and perinatal	13.8 ± 0.74	
Postnatal	13.6 ± 0.68	
Unknown	13.9 ± 1.23	
Learning disability	13.5 ± 0.85	12.48 ± 0.98
Mental disability	13.9 ± 1.24	13.34 ± 0.96
Down's syndrome		13.45 ± 0.48
Control	13.3	13.09 ± 0.15 Pantó and Eiben 1984
	13.55 ± 0.13 Bodzsár 2002	12.54 ± 0.09

* * *

Studies on the growth and the body development of mentally retarded children have also some practical goals. The importance of anthropological examinations is reinforced by the fact that most adult disabled persons will do some sort of physical work, except for a smaller group of hearing impaired, visually impaired and physically handicapped people. Therefore their body build and physical fitness are the fundamental factors influencing success at work. Work performed happily would help them in achieving a fully meaningful life, thus contributing to the improvement of their quality of life which is so often talked about today.

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INDIVIDUAL VARIATIONS OF THE IMMUNE STATUS IN RELATION TO THE TYPES OF BODY-BUILD IN 15-YEAR – OLD BOYS LIVING IN THE CITIES OF THE SOUTHERN PART OF RUSSIA

O. A. Butova and V. S. Butov

Department of Human Anatomy, Physiology and Hygiene, Stavropol State University, Department of Physiology, Stavropol Medical Academy

ABSTRACT

The purpose of the study was to evaluate the distribution of body types and severe immune parameters in 15-year-old boys, living in Krasnodar, Stavropol and Nevinnomõsk. 505 boys were involved in anthropometrical measurements and 160 boys for the immune study. The thoracal and the astenoid types were the dominating types of body-build: in Krasnodar (30.5% and 24.8%, respectively, in Stavropol (25.0% and 21.3%), in Nevinnomõsk (32.0 and 19.0%). The muscular and digestive types were found in Krasnodar in 12.6% and 11.4% of boys, in Stavropol 9.0% and 13.3%, in Nevinnomõsk 16.0 and 10.0%, respectively. T-lymphocyte count and the concentration of IgG were below values considered normal for the Russian population. The ratio of T/B lymphocytes was subnormal in Nevinnomõsk, whereas subnormal concentrations of IgA and IgM dominated in Nevinnomõsk and Krasnodar. Convincing evidence for the relationships between body-build and the studied immune parameters were not found.

Key words: body-build, human constitution, immunoglobins, T-lymphocytes

INTRODUCTION

The complex approach for health evaluation requires the investigation of relationships between various systems and measures characterizing the human constitution. At the contemporary time the meaning "human constitution" has become an integral characteristics of health-related parameters. This way the "human constitution" ensures a methodological background for the further development of the system of primary prophylaxis and for actualizing strategies of contemporary medicine aimed health protection of healthy persons. According to this approach the human constitution involves the morphological measures which are related to the functional peculiarities of body's adaptive-compensatory responses [2, 5]. In this order the individual variations of the immune status have to be taken into consideration.

The aim of this paper was an evaluation of the distribution of the morphotypes of body-build and the assessment of their relations to the immune status in 15-year-old boys living in the cities of the Southern part of Russia.

MATERIAL AND METHODS

Subjects

300 boys living in Stavropol, 105 in Krasnodar and 100 in Nevinnomõsk were involved in anthropometrical measurements. The contingent for immune studies was reduced to 100 boys in Stavropol, 30 boys in Krasnodar and 30 boys in Nevinnomõsk. All the boys were clinically healthy and in the age range between 14 years 9 months and 15 years 6 months.

Methods

30 anthropometric parameters were obtained using the unified methodology proposed by Bunak [4]. The instruments of the G.P.M. Gneupel (Switzerland) were used. Somatotypical diagnostics was carried out by Shtefko and Ostrovsky [13] and Chrisanfova and Titov [6]. The formula of body-build was determined as Mx Ey, where

Mx is the average ball of mezomorphological characteristics (measures of bones, absolute and relative widths of forearm, transversal diameter thorax and its girth), and Ey is the average ball of endomorpholgical characteristics (degree of adiposity, weight/height ratio, thoracal measures).

The immune analyses were performed in the Stavropol Regional Clinical Hospital. The study focused on mononuclear leucocytes in blood and immunoglobins in blood serum. The lymphocytes were separated by deposition in the mixture of blood and the medium 195 of the Ficoll-pack gradient (Farmacia, Sweden) [3]. The quantities of T, B, D, and O lymphocytes were determinated by the Mendes method in Grishin's modification [8]. T lymphocytes were separated from the other blood mononuclears with the help of incubation in the theophyline solution and the followed rosette-forming reaction with sheep erytrocytes [10]. The superficial quality of T-rosette-forming cells was assessed with the help of incubation with levamisol [12]. The concentrations of immunoglobins IgA, IgM and IgG in blood serum were determined by an immuno-diffusion method [11] using commercial kids.

Statistical analysis

Unifactoral and multifactoral dispersion analyses were used. (The computer programs SYSTAT 0.5 from the packet of DBASE and EXCEL [7]). Correlations were assessed computing the Pearson correlation coefficient. The probability level 0.05 was designed as significant.

RESULTS

Anthropometric parameters

According to the dispersion analysis (Table 1), pronounced differentces existed in the distribution of the individual measures of the most anthropometric characteristics of teenagers from three cities of Southern Russia. Among teenagers of Krasnodar, it was typical to have frequent cases of boys with the increased body mass, skinfolds and thorax width. They had relatively long extremities and a short trunk. However, they did not differ significantly from the boys of other cities by the distribution of their individual height, thorax and limbs girth.

Table 1. Anthropometrical characteristics of 15-year-old boys from the three cities of the Southern part of Russia (mean ±SD).

Parameter	Stavropol n=300	Nevinnomõsk n=100	Krasnodar n=105	Dispersion F
Height cm	167.7±0.5	166.8±0.8	169± 0.8	2.71
Body mass	55.0± 0.6	55.2± 1.0	57.9± 1.0	3.39*
Thorax girth	80.0± 0.4	80,0± 0.7	81.0± 0.7	0.98
Mean skinfold	7.3± 0.1	7.2± 0.2	7.9± 0.2	2.92*
Upper arm girth	24.2± 0.2	24.0± 0.3	25.5± 0.3	9.57*
Forearm girth	23.0± 0.1	23.2± 0.2	23.0± 0.2	0.39
Thigh girth	48.0± 0.3	47.1± 0.5	47.0± 0.5	1.44
Leg girth	34.0± 0.2	33.1± 0.3	32± 0.3	8.51*
Thorax width	23.2± 0.1	24.0± 0.3	26.1± 0.2	5.26*
Thorax diameter	16.0± 0.1	16.4± 0.2	18.0 0.2	4.40*
Trunk length	55.6± 0.3	55.4± 0.2	48.2± 0.4	11.0*
Arm length	75.4± 0.3	77.0± 0.5	78.0± 0.5	10.1*
Leg length	88.8± 0.3	88.4± 0.5	93.6± 0.4	34.7*

* significant difference ($p<0.05$)

The assessment of the types of body-build by Shetko and Ostrovsky [13] showed that all the seven types were found in all the three cities (Table 2). The thoracal type was found in the majority of boys (25 to 32% of boys). The astenoid type appeared frequently in Krasnodar and Stavropol boys, whereas the muscular type in Nevinnomõsk. The intermediates transitive to astenoid and transitive to thoracal types were found in Krasnodar less frequently than in other cities.

Table 2. Distribution of various types of body-build in 15-year-old boys.

	Stavropol			Nevinnomõsk			Krasnodar		
	%	Mx	Ex	%	Mx	Ex	%	Mx	Ex
Ast	21.3	1.5	1.5	19.0	1.5	1.5	24.8	1.5	1.5
Thor	25.0	2.0	2.0	32.0	2.0	2.1	30.5	2.1	2.0
Mus	9.0	2.6	2.4	16.0	2.5	2.1	12.4	2.6	2.3
Dig	13.3	2.4	2.7	10.0	2.3	2.7	11.4	2.5	2.8
Im		1.8	1.7	10.0	1.7	1.8	6.7	1.7	1.8
Tra	9.3	1.8	1.7	8.0	1.8	1.9	8.6	1.8	1.8
Trt	12.0	2.0	1.9	5.0	2.0	1.9	5.7	2.0	1.8

Mx — average ball of mezomorphological characteristics
Ex — average ball of endomorphic characteristics
Ast — astenoid, Tho — thoracal, Mus — muscular, Dig — digestive,
Im — intremediate, Tra — transitive to astenoid, Trt — transitive to thoracal

Immune parameters

The comparison of immune parameters with the values considered to be normal [9] indicated the decreased counts of leucocytes, total lymphocytes and T-lymphocytes in Stavropol and Krasnodar (Table 3). The boys from Nevinnomõsk differed from “normal” values by the decreased count of T-lumphocytes and the lowered ratio of T/B lymphocytes.

The concentrations of all the three immunoglobins were below normal values in the boys of Nevinnomõsk and Krasnodar, whereas in Stavropol only the concentration of IgG was significantly below “normal” values.

Significant relationships were not established between the types of body-build and the counts of leucocytes, total, T- and B-lymphocytes (Tables 4). Only the ratio of T- and B-lymphocytes was lower in thoracal than in other types. Significant relationships were not established between the types of body-build and the concentrations of immunoglobins.

Table 3. Immune parameters in 15-year-old boys (mean±SD).

	Normal	Stavropol	Nevinnomõs	Krasnodar
Leucocytes Count 10^3	7.48± 0.28	6.22± 0.14*	7.55± 0.38	5.55± 0.29*
Lymphocyte %	33.2± 1.1	31.4± 0.6	31.6± 0.9	43.4± 1.1
Lymphocyte Count 10^3	2.48± 0.18	1.93± 0.05*	2.36± 0.05	1.89± 0.09*
T-lymphoc %	62.6± 1.2	51.5± 0.8*	46.2± 1.7*	52.3± 1.1*
T-lymphoc Count 10^3	1.56± 0.14	1.00± 0.03*	1.08± 0.06*	0.99± 0.06*
B-lymphoc %	14.1 ±0.7	13.5± 0.4	16.4± 0.7*	12.9± 0.6
Ratio T/B lymphocytes	4.44± 0.94	4.11± 0.20	3.00± 0.20	4.43± 0.28
IgA (g / L)	1.12± 0.09	1.02± 0.06	0.84± 0.05*	0.81± 0.04*
IgM (g / L)	1.00± 0.09	0.89± 0.11	0.67± 0.05*	0.70± 0.10*
IgG (g / L)	9.93± 0.38	6.51± 0.36*	6.85± 0.40*	3.39± 0.49*

* — statisticaly significant difference from the 'normal' values established by Lebedev and Ponyakina [9].

Table 4. Leucocyte and lymphocyte count and lymphocyte % by types of body-build.

Type of body built	N	Leucocytes Count	Lymphocyte %	Count
	Astenoid			
Stavropol	34	5.92 ± 0.41	31.4± 1.5	1.99± 0.19
Nevinnomõsk	6	7.61± 0.59*	26.7± 2.9	2.02± 0.32
Krasnodar	10	5.08± 0.19	35.3± 2.31	1.79± 0.12
	Thoracal			
Stavropol	37	6.48± 0.40	31.1± 1.3	1.87± 0.10
Nevinnomõsk	12	7.21± 1.20	32.5±1.3	2.32± 0.39
Krasnodar	6	5.12± 1.18	35.6± 34.0	1.77± 0.34
	Muscular			
Stavropol	5	6.08±0.58	29.2± 3.35	1.80± 0.32
Nevinnomõsk	9	7.70±0.86*	31.0±1.24	2.35± 0.20*
Krasnodar	6	5.25±0.29	34.0± 2.2	1.78± 0.13
	Digestive			
Stavropol	21	6.36± 0.28	32.8± 1.0	2.07± 0.10
Nevinnomõsk	2	6.85±1.05	33.5± 1.0	2.28± 0.25
Krasnodar	5	5.94±1.2	34.4± 2.8	1.98± 0.33

* — statistically significant difference from 'normal' values

DISCUSSION

The comparison of anthropometric parameters in the boys of the three cities of Southern Russia revealed that in Krasnodar the dominating variant of physical development is characterized by the increased body mass, the accumulation of subcutaneous adipose tissue, longer extremities and a shorter trunk. It might express a special adaptation to the concrete combination of environmental factors. A question arises in regard to the genotypical influence. The major part of genetic influence on the body mass phenotype is suggested to occur at the age of 13 years [5]. Accordingly, in 15-year-old boys the genotypical influence on the body mass should have an expression. The tendency to adiposity may constitute a risk factor for cardiovascular diseases and influence the immune reactivity [14]. The present results neither confirmed nor disapproved these links.

In all the three cities the thoracal type of the body-build was most frequent. The second by frequency of appearance was the astenoid type. The muscular type appeared most frequently in Nevinnomõsk in the combination with a comparatively big height.

At the puberty, the climatic-geographic conditions influence the formation of the morphological types in relation to the ecological portrait formulated by Agadganian [1]. Accordingly, climatic-geographic differences in the distribution of various types of body-build have been described [2]. The climate of the Northern Caucasus (temperate winter, cool spring, dry and hot summer, warm and long autumn, the annual average temperature 15° might influence the distribution of the types of body-build in the teenagers of the studied three cities located in the Northern Caucasus.

Immunological indicies do not change only during the ontogenesis but also under the influence of different factors. The obtained results indicated differences in the counts of T-lymphocytes, ratio T/B lymphocytes, and the concentrations of IgA, IgG and IgM in comparison with the proposed normal values [9]. Further studies are necessary to clarify the significance of the noted deviations in regard to "normal" values for the health and the development of male adolescents.

Table 5. Immunoglobin concentrations in blood serum (g/L) by types of body- build (mean±SD).

	n	IgA	IgM	IgG
		Astenoid		
Stavropol	34	1.01±0.22	0.71±0.11	5.95±0.56
Nevnniomõs	6	0.73±0.12	0.67±0.80	8.19±0.73*
Krasnodar	10	0.81±0.07	1,15±0.21	4.55±0.87
		Thoracal		
Stavropol	37	1.16±0.22	1.32±0.56	5.94±0.92
Nevinnomõs	12	0.79±0.07	0.57±0.13*	6.05±1.51
Krasnodar	6	0.88±0.13	1.60±0.10	5.19±0.72
		Muscular		
Stavropol	5	0.84±0.15	0.53±0.13	6.12±2.55
Nevinnimõs	9	0.84±0.11	0.65±0.11	7.43±0.89*
Krasnodar	6	0.93±0.09	0.49±0.25	4.29±1.15
		Digestive		
Stavropol	21	0.96±0.10	0.78±0.13	7.31±0.79*
Nevinnomõs	2	0.76±0.00	0.45±0.05	6.41±0.08
Krasnodar	5	0.75±0.07	0.56±0.13	4.11±1.32

* .— statistically significant difference from 'normal' values

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Papers on Anthropology XII, 2003, pp. 51–61

VARIATION OF STATURE IN ESTONIA FROM THE 12TH TO THE 20TH CENTURIES

Leiu Heapost

Department of Archaeology, Institute of History, Tallinn, Estonia

ABSTRACT

Data from 12th–18th cc. skeletal populations are used along with anthropometric data of contemporary Estonians over the last two centuries. The average stature of the 12th–13th cc. North Estonian population correspond to the Estonian average in the 1930s. A decrease in average stature from the west to the east can be noticed, which has a similar gradient as in the 1930s. In the 13th–14th (15th) centuries the average stature decreases, but shows a slight increase (by 1–2 cm) in North as well as South Estonia in the 15th–17th centuries. According to the used data no very great temporal changes took place in the Middle Ages. The greatest temporal changes have occurred during the last two centuries (over 14 cm for the male population) with the most rapid increase in stature in the second half of the 20th century. Temporal changes throughout centuries may have been caused by a number of factors, including economical and socioeconomic stress factors. Some movement and mixing of people cannot be excluded either. Regional differences in the height of the population have preserved throughout the whole period. These differences can be associated with genetic factors.

Key words: stature, temporal changes, acceleration, past and present populations

INTRODUCTION

Human stature is dependent on two kinds of factors: genetic factors, the genotype, and a number of environmental factors, which either favour or hinder the realization of the genetic potential. Therefore, stature is essential in comparing genetic differences, but it is also of great significance as a sensitive indicator of ecological and socio-cultural stress Data on present-day Estonians' stature as well as on changes in their stature since the end of the 18th century have been presented in several studies (see Tables 2 and 3).

Data about stature in medieval society (and at earlier times) are mostly based on estimates from skeletal material [2, 10, 11, 15, 17]. However, in the first millennium AD cremations predominated in Estonia. At the turn of the second millennium, along with cremations, inhumations in underground graves and in East Estonia also in mounds became ever more frequent. Recently the osteological data of the most numerous archaeological population so far (the Pada village cemetery) from 12th–13th centuries became available [12]. That enables us to give an overview of height variation of Estonians over the last nine centuries.

MATERIAL AND METHODS

The data originating from archaeologically excavated skeletons were used along with data collected from measurements of living people. The earliest skeleton population used in this paper, the Pada sample, belongs to 12th–13th centuries A.D. The Pada village cemetery population is the largest of that period that has been excavated until now. The cemetery is situated in North-East Estonia near the Pada River in the former Viru-Nigula parish. The osteometric parameters and indices of long limb bones as well as stature (according to three different methods) of the population have been published earlier [12]. A few uncremated skeletons of the late Iron Age population have been found all over the country: at Martna in West Estonia (Läänemaa), Küti (near Rakvere), Õvi (Tartumaa) and Lahepera (the western shore of Lake Peipus). The skeletons (complex group of underground graves of the 11th–13th centuries) were measured and described by Karin

Mark [18, 19]. For the present survey the stature of Martna and Küti men (two individuals at both locations) was recalculated by the author.

Usually the cemeteries have been in use for a long time. In the case of the 13^{th}–17^{th} century cemeteries as Makita (**South-East** Estonia) [11] and Kaberla (North Estonia), the skeletal material in this review has been divided into two periods — the earlier (13^{th}–15^{th}) and the later (15^{th}–17^{th} centuries) — according to archaeological datings of the graves [10, 19]. Skeletons without a firm dating were excluded. The individual stature for each skeleton of Pada and Makita populations (and the average stature) was calculated using Trotter and Gleser's [25] equations for stature, based on measurements of long limb bones of both sides of the body (humerus, radius, femur, tibia). For comparison, stature was calculated by the same method for the people from the 11^{th}–15^{th} centuries near Pskov at Irboska — Senno-Viski (five individuals) and Verepkovo (five individuals), measured by K. Mark. Stature of 13^{th} –18^{th} century Estonian populations used in this study was calculated (by the author) based on the average lengths of the same long limb bones. The measurements were taken from literature: Kaberla (North Estonia) and Jõuga (North-East Estonia) [19], St. Barbara (Tallinn) and Tääksi (Central Estonia) [2]; Koikküla (South-Estonia), Iisaku and Kohtla-Järve (North-East Estonia) [2: Table 2; 19].

The data about stature measured on living populations during the last two centuries and used in this survey were taken from literature (Tables 2, 3). The data on late 18^{th}-century men and on young men recruited to the army mostly in the 19^{th} century have been calculated from archive materials [14, 1].

RESULTS AND DISCUSSION

The average stature of Estonian archaeological populations discussed in this survey is given in Table 1.

From the viewpoint of changes in stature, the earliest period (12^{th}–13^{th} centuries), which is represented by the materials of the Pada cemetery, is of particular interest. There are more data about medieval populations. Table 1 shows that 12^{th}–13^{th}-century people in North Estonia (the former Viru-Nigula parish) were tall in stature. Men's stature corresponds well to the average of Estonian men in the 1930s (average — 172.03 cm, Table 2; in Viru-Nigula parish — 171.12 cm [3]). The Pada women are 12 cm shorter than the men. They were also almost as tall as the Estonian women on average, especially as women in the north-eastern Iisaku parish according to J. Aul's data (Table 3). It is interesting to note that the reconstructed biacromial breadth and body weight also correspond well to that of North-Estonian men in the 1930s [12].

Table 1. Stature of 12th–18th cc. Estonian skeletal populations.

Sample	Century	Stature of men		Stature of women	
		n	cm	n	cm
Pada	12–13	37	172.09	31	160.11
Jõuga	12–14	18	168.8	11	156.06
Makita	13–15	7	168.64	8	159.13
Kaberla	13–15	6	169.5	2	154.20
Makita	15–17	9	169.54	6	160.54
Kaberla	15–17	20	171.7	4	155.90
Koikküla	15–17	9	168.71	12	160.38
St.Barbara	14–17	68	169.46	60	157.67
Tääksi	14–18	16	169.44	16	157.60
Iisaku	16–18	12	171.98	15	159.50
Kohtla-Järve	17–18	27	168.8	12	152.84

North-East Estonian men of the 12th–14^{h} centuries, buried in mounds at Jõuga, proved to be on the average by 3 cm shorter than the Pada men.

The late Iron Age skeletal population of Estonia from the complex group of underground graves, dolichomorphic type by K. Mark [18, 19], was of tall stature too. West-Estonian (Martna) men proved to be over 176 cm tall (two skeletons), North-Estonian men (Küti, near Rakvere) — 174.6 cm (two skeletons). Almost the same stature was characteristic of the 11th–15th-century people near Pskov Senno-Viski — over 174 cm — and at Verepkovo (in the 11th–13th centuries) — 175.7 cm.

During the next couple of centuries (13th–14th cc.), the stature of Estonian population according to present data was shorter and did not reach 170 cm (Table 1). At the same time the stature of North-Estonian men (Kaberla) exceeded by 1 cm that of South-East Estonian men (Makita) by 2–3 cm.

The next centuries (15th–17th) show an increase in body height by 1–2 cm in North as well as in South-Estonia (Kaberla and Makita) in comparison with the previous centuries. The average stature of Estonian men (St. Barbara, Tääksi, Koikküla, Kaberla, Makita) in the 14th(15th)–17th centuries, according to the material and methods used in the present study, was 169.7 cm. People were taller in North-Estonia, shorter in South-Estonia. In the 15th–17th centuries St. Barbara (a suburb of Tallinn) showed shorter stature than Kaberla near Tallinn. The shorter stature of suburb dwellers compared to the rural population of the same period could have been caused by poorer living conditions in the suburb. R. Allmäe [2] has also referred to it, relying on the inhabitants' gender dimorphism.

Stature of 16th–18th-century population in North-East Estonia (Iisaku) example was tall, similar to that at Kaberla in the 15th–17th centuries. However, the north-eastern Kohtla-Järve population of the 17th–18th centuries, contrary to Iisaku, was shorter (Table 1).

Table 2. Stature of Estonian men during the last two centuries.

Year of investigation	Location	Contingent, age	N	M	Author
1818–1827	North Estonia	Recruits, 19–39	2210	165.4	Aarma, 1987 [1]
	Harju-Läänemaa		1386	165.9	
	Järva-Virumaa		824	164.3	
1863–1870	North Estonia	Recruits, 20–29	3274	167.8	Aarma, 1987 [1]
	Harju-Läänemaa		2051	168.9	
	Järva-Virumaa		1223	165.9	
1875	Tartumaa, central part		100	164.28	Grube, 1878 [6]

Year of investigation	Location	Contingent, age	N	M	Author
2nd half of the 19th century	Tartumaa			165.3	Waldhauer, 1879 [26]
1886–1887	Tartu	conscript		168.5	Ströhmberg, 1888 [23]
1892	Läänemaa Järvamaa Virumaa	Recruits, 21	1892	169.8 168.1 167.4	Haruzin, 1894 [8]
1899	Tartu	Recruits	1058	169.0	Weinberg,1902 [27]
1920s	All Estonia			172.39	Villems, 1926 [29]
1924	All Estonia	Soldiers, 23–25	8628	171.25	Köstner, 1927 [17]
1932–1936	All Estonia Läänemaa Ida-Virumaa	Soldiers, 22	15110 794 532	172.03 173.5 170.7	Aul, 1964 [3]
1952–1954	13 districts	20–60	1243	171.27*	Vitov et al.., 1959 [30]
1965–1980	All Estonia	20–60	2065	173.2	Mark, 1994 [20]
1962, 1963	All Estonia	Students	1209	176.18	Tiik, 1964 [24]
1966–1969	Tallinn	School-boys, 18	162	176.64	Heapost, 1984 [9]
1984–1985	All Estonia	School-boys, 18		179.0	Silla, Teoste, 1989 [22]
1996–1997	All Estonia	School-boys, 18	189	180.27	Grünberg et al, 1998 [7]

*Total mean has been calculated by the author of the present article.

HEIGHT VARIATION IN ESTONIA OVER THE LAST 200 YEARS

The first data about the stature of Estonians belong to mercenaries who served in the Finnish army from 1768–1806. According to Y. Kajava, the average stature of 72 Estonians was 168.4–169.8 cm [14]. These data have usually been considered a selection, taller from the average, and have not been used as a starting-point for evaluating acceleration. The variation in stature of Estonian men over two centuries is shown in Table 2. The average height of young men from North-Estonia, born at the turn of the 19th century and measured in the Russian army, was 165.4 cm, in western counties of North Estonia (Harju-, Läänemaa) about 1.5 cm taller than in eastern counties (Järva-, Virumaa). During the next fifty years the average height increased over two centimeters (Table 2). Although regional differences remained, there was homogeneous increase in all the counties of the province [1:127].

For decades the tallest men have come from Läänemaa; during 50 years their stature increased by 2.7 cm (from 166.4 cm to 169.1 cm) [1:113]. By the turn of the 20th century their stature had increased to about 169 cm, in 1926–1932 the stature of young Estonian men was already 172 cm, in the 1960s — about 176 cm, in the 1980s — 179 cm and at the end of the 20th century — over 180 cm.

There are less data about the stature of Estonian grown-up women. Some data are shown in Table 3. At the beginning of the 20th century, Estonian women from Tartumaa were unusually short — according to R. Weinberg 154.2 cm. According to J Aul, the average stature in the 1920s varied from 162.4 cm in western to 158.2 cm in eastern districts of Estonia (Table 3). In the 1960s it was 163–164 cm, in the 1980s — 166.5 cm and at the end of century — 167.6 cm.

Table 3. Stature of Estonian women.

Year of investigation	Location	Contingent, age	N	M	Author
1900–1902	Tartumaa		135	154.2	Weinberg, 1903 [28]
1927–1928	Saaremaa, Sõrve	20–30		161.1	Klein (Aul), 1929 [16]
1931			72	159.5	Reiman, 1931 [21]
1939	Iisaku parish, NE Estonia	20–30	642	158.2	Aul, 1977 [4]
1940	Tõstamaa & Audru parish N.Pärnumaa	20–30	852	162.4	Aul, 1977a [5]
1939–1966	All Estonia	20–30	1044	161.8	Aul 1977 [4]
	West-Estonia		131	162.6	
	SE Estonia		128	160,8	
1962, 1963		Students	1196	163,26	Tiik, 1965 [24]
1966–1969	Tallinn	School-girls, 18	202	164.15	Heapost, 1984 [9]
1984–1985	All Estonia	School-girls, 18		166.5	Silla, Teoste, 1989 [22]
1996–1997	All Estonia	School-girls, 18	296	167.62	Grünberg et al, 1998 [7]

When comparing the changes in stature from the 12th to the 20th century, one has to take into consideration that the stature of the 12th–18th-century populations is based on estimates from excavated skeletons. However, different methods for estimating stature, also different limb bones used as a basis for stature reconstruction may give somewhat different results. Mostly stature is reconstructed on the basis of femoral length. However, body proportions differ among populations. In this study, as the basis of estimating stature, four long limb bones of both sides were used for comparison with the somatometric data of the present population. Moreover, the sample sizes are often too small. Still, relying on the scanty data available, one can say that in the first centuries of the second millennium the inhabitants of Estonia were tall everywhere in Estonia. The average male stature of the Pada 12th–13th-century population was the same as the average measured stature in the same area in 1930s. The women's stature was about 12 cm shorter than it is nowadays. The stature of men on Saaremaa and Muhu Island was tall (average about 173 cm) [13], especially high according to the present data of West-Estonian Martna men in the 11th–13th centuries (over 176 cm); it was high in Pada and Küti. In the same period, stature also was high in the Russian territory near the south-eastern border of Estonia — in Senno, Viski and Verepkovo. The north-eastern Jõuga population of the 12th–14th centuries was somewhat shorter.

In the 13th–14th centuries a decrease in men's stature by 2–3 cm can be observed both in South and North Estonian rural populations. An increase in stature took place in the 15th–17th centuries in North (Kaberla) as well as in South-East Estonia (Makita). According to Y. Kajava [14] the Estonian soldiers serving in the Finnish army in the late 18th century were approximately of the same stature. They need not have been a special sample of tall men.

The present-day variability in Estonians' stature in the west-east direction corresponds to the people's general anthropological type (West and East Baltic type). On the islands and in West Estonia the stature of men is 173–174 cm, being especially high in the coastal area of West Estonia (mean over 175 cm); in Ida-Virumaa and Võrumaa it is about 171 cm [3: 43–54]. The studied data also revealed regional differences in men's average height.

Early 19th-century Estonian men were of medium height (165.4 cm). They were approximately 7 cm shorter than the average Estonian men in the 1930s or the North Estonian Pada men in the 12th century. Men in North-West Estonia were taller than in North-East Estonia. In the following 50 years height increased by more than 2 cm in western as well as eastern regions. Mean stature increased throughout the 19th century. However, the temporal increase of mean stature was slow. The speed of stature increase has changed; it accelerated especially from 1920 to 1980 with very rapid changes during the first decades of the second half of the 20th century. However, during World War II and for some time after the war such a temporal trend was reduced.

According to the used data, no very great temporal changes took place during the Middle Ages. The greatest temporal changes occurred during the last two hundred of years, with the most rapid increase in the second half of the last century. During the last two centuries the increase in stature has been over 14 cm.

The temporal changes in the stature of population through centuries may be caused by various stress factors, such as environmental factors (as global climatic change), socio-economic factors, epidemics, etc. A certain influence of migration and mixing of people cannot be excluded either. Still, regional differences in the height of the population have preserved. These differences can be related to anthropological types.

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Papers on Anthropology XII, 2003, pp. 62–77

NEW TEMPORO-SPATIAL COMPARABLE BONE HEALING MODEL OF RAT TIBIA

Piret Hussar[1], *Tiit Haviko*[2], *Ülo Hussar*[1]

[1] Institute of Anatomy, University of Tartu, Estonia
[2] Clinic of Traumatology and Orthopaedics, University of Tartu, Estonia

ABSTRACT

A comparison of the new experimental model of bone repair — bicortical perforation of tibia, and segment osteotomy in micro-anatomical, histological and histochemical evaluation and by computerized histomorphometry was made. An investigation of posttraumatic bone repair after resection osteotomy and bicortical perforation was carried out on 87 adult male Wistar rats. The repair was studied in normal and affected animals (training, immobilization) from the 4th to the 35th day after operation. In our series, posttraumatic bone callus development and soft tissue repair occurred as ordinary processes of osteohistogenesis and organogenesis. In trained rats bone repair was somewhat enhanced, which was reflected in increased angiogenesis and more rapid ossification. In immobilized animals it was inhibited and complicated. The pathway of ossification occurring after osteotomy is primary periosteal and secondary endosteal chondral. After perforation the formed callus is smaller and initiated mainly by medullary response. The ossification is primary endosteal desmal and secondary periosteal chondrous. In perforation group ossification and replacement of the defect achieved more rapidly. Mechanically stable situation at defect site in perforation group and physical activity enhances the bone repair. We used a new perfect model (bicortical perforation of tibia), elaborated previously, for efficient comparable study of peri- and endosteal posttraumatic bone repair in rats in various external conditions.

Key words: posttraumatic fracture healing, bone repair histology, callus, enhancement of bone repair.

INTRODUCTION

Posttraumatic bone repair is a specific and complex phenomenon, which in favourable conditions leads to complete restoration of the bone. Incidence of nonunions in long bones varies with each bone and with methods of treating acute fractures [17]. Traumatology and ortopaedics are based on the use of knowledge about repair morphology of the skeletal hard (osseus, chondrous) tissues. The problems of posttraumatic bone repair morphology after trauma are (opposite to other mesenchymal tissues): formation of the external and internal callus as a special material for repair process, two different bone formation pathways — desmal (intramembraneous) and (endo)chondral ossification, the role of fracture fixation and blood supply in this process, interactions between callus tissues [3, 20]. Different experimental models have been devised (external and internal bone fracture, scrap, incision-slit-cutting-fissura, standard defect of osteotomy, etc.) for qualitative and quantitative study of bone repair after surgical injuries of different degrees [6, 9].

Bone healing is influenced by a number of local internal (blood supply, state of osteogenic zones, etc.) and external factors (physical activity, etc.). In trained rodents bone repair is stimulated [7, 10, 11, 12, 14], whereas in those immobilized or hypokinezed after tenotomy it is inhibited and complicated by osteoporosis and pseudoarthroses [7, 10, 16, 22]. The blood supply of the bone and fracture or defect site is an important factor which regulates the cell proliferation and differentiation into chondroblasts and/or osteoblasts [23, 28], determing the balance between chondro- and osteogenesis.

The aim of the present study was the use of a new standardized experimental model — bicortical perforation, elaborated previously [16], in post-traumatic bone healing of rats tibia after resection (segment) osteotomy and bicortical perforation of trained and immobilized animals — to give new comparative temporo-spatial parameters for bone repair histology. In order to compare the effect of perforation factor to fracture healing in mechanicaly stable situation, we worked with two different injuries — bicortical perforation and resection osteotomy.

MATERIAL AND METHODS

In the present experimental study, 87 male young adult (growing) Wistar-rats with body weight 200–220 g were used. The guidelines for the care and use of the animals were approved by the Medical Ethics Committee of the University of Tartu.

The animals were divided into two groups: 1) resection osteotomy (n=40) and 2) perforation through both tibial cortices (n=47). The groups were subdivided into three subgroups: 1) controls; 2) trained animals and 3) immobilized animals. Training was performed in special swimming-pool with the size of 40 cm × 40 cm × 70 cm at water temperature 22±2°C. In the immobilized subgroup, rats were isolated into narrow boxes (cages), one animal in each box; so their ability to move was significantly reduced.

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

The animals were sacrificed between the 4th and 35th days after the operation (Table 1).

Table 1. Distribution of animals by sacrification time.

Main groups	Subgroups	4th day	7th day	14th day	21st day	28th day	35th day
Osteotomy	Control	3+2*	4+2*	2	2	8	4
	Training	–	–	–	–	5	–
	Immobi-lization	2*	2*	–	–	4	–
Perforation	Control	2+2*	3+2*	9	5	5	2
	Training	–	–	–	4	3	–
	Immobi-lization	2*	2*	–	3	3	–

* — Animals for histochemistry with HRP

Operative technique

Two different operations were performed:
Group 1. Resection osteotomy, 4 mm in length, was performed between the diaphysis and proximal epiphysis: 1 mm and 5 mm below the tibial tubercle, two transverse osteotomies were performed and the bone fragment was removed. A relatively stable fixation of the bone fragments was achieved by an *in situ* fixation by the intact fibula.

Group 2. On the anterior surface of tibia, a perforation hole, 1.5 mm in diameter, was bored through the bone cortex between the diaphysis and proximal epiphysis, 1 mm below the tibial tubercle. Such kind of experiments permit: 1) to standardize the amount and localization of the injury and 2) to separate the periosteal and endosteal zones of the callus and their compartments, especially the areas of angiogenesis.

Postoperative management

For the postoperative period, the rats were kept in special boxes, three animals in each (except the immobilization group of rats). They were given special rat food ("Dimela" — Finland R-70 or R-34 in the early postoperative period) and water in abundance.

Macroscopic and microscopic investigation

The sacrification was performed by decapitation of animals anaesthesized with ketamine and diazepam. The average size of the material collected for histological evaluation was 0.5–1.0 cm.

Histology and histochemistry

The material was fixed with formalin and Zenker formol by Maximov and demineralized with the solution of Shampy (Group 1), or by EDTA (Group 2). Paraffin embedded slices with a thickness of 7 μm were stained with hematoxylin and eosin, azure 2-eosin, Heidenhain iron hematoxylin, by van Gieson, alcian blue and safranin-O (for histochemistry of glycosaminoglycans). The cells in mitotic division were observed by immersion magnification on slides stained with Feulgen. Vascular permeability of the repair callus was studied with horse-radish peroxidase (HRP) by the method of Shiose [27].

Investigation of vascular permeability

To observe and compare the permeability of the repair callus vessels after osteotomy and perforation in the groups of trained and immobilized animals as well as in the control group 40 mg horse-radish peroxidase (Reana, Budapest, Hungary) dissolved in 0.5 ml physiological saline was injected into the rat tail vein on the 4th and the 7th postoperative days. Five and 15 minutes after the injection the material was collected and fixed in 4% PFA-1%GLA-PBS for 1 hour, thereafter washed with PBS and carried into 20% sucrose and OCT (Tissue–Tek) compound in which the material was left to freeze at –5°C. After this procedure cryostat sections (5 μm) were made and left for air dry for about 15 min. Washing with PBS and DAB reaction (with 5mg 3.3`-diaminobenzidine tetrahydrochloride) for 20 min at room temperature followed. After several rinses in distilled water the specimens were postfixed in ethanol an increasing percentage and embedded in Bio-Mount.

Computerized histomorphometry

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

Statistics

Statistical analysis was performed using the unpaired t-test at the level of significance $p<0.05$.

RESULTS

In Group 1 (resection osteotomy) the post-traumatic repair callus formation is similar to embryohistogenesis — with periosteal primary (intramembranous, desmal) and endosteal secondary (chondrous) ossification (Table 2).

Table 2. Some characteristics of post-traumatic bone repair after osteotomy with lenght of 4 mm (I) and after perforation with diameter of 1.5 mm (II).

Characteristics	I	II
Mode of ossification (primary, secondary, peri-and endosteal)	Primary periosteal (intramembranous direct OHG). Secondary endosteal OHG (like embryohistogenesis)	Primary endosteal OHG. Secondary periosteal chondrous OHG
Intensity of callus development		
– chondrous	++	++
external	+++	++
internal	++	–
– osseous	++	+++
external	++	+
internal	++	+++
Angiogenesis		
– periosteal	+++	+
– endosteal	++	+++

(+++) — intensive; (++) — moderate; (+) — flat; (–) — without effect

After the removal of the bone fragment, tissue destruction induces an initial inflammatory response, consisting of lymphocytar, polymorphonuclear and macrophageal infiltration with simultaneous early neoangiogenesis. In addition, soft tissue reparative changes are represented: appearance of multiplicated fibroblasts and chondroblasts, and degranulation of tissue basophils. The granulation tissue becomes gradually denser on days 4–7, when it is identifiable as fibroreticular tissue. This newly formed tissue is referred to as fibrous callus (on the 4th–7th days) and later as chondrofibrous and osseous callus (on the

14th–21st day, particularly on the 7th day). On the 28th day a periosteal thickening (periosteal bone callus) surrounding the fracture is formed. It is also filling the gap between the two ends of the tibial fragments (initial phase of the endosteal bone callus). Frequently, the compact and trabecular bone callus are mixed (Fig. 1). The borderline between the peri- and endosteal callus is not clear. The definitive woven bone callus (but not a compact lamellar bone yet) is formed later (on the 35th day), after partial replacement of chondrofibrous and chondrous callus and the beginning of recanalization by increased activity of osteoblasts and osteoclasts.

The bone repair after osteotomy had one peculiarity: the repair process expanded to the bone marrow cavity and formed there obliterated endosteal trabecles and cords, probably metaplastic (Fig. 1).

In trained rats (exercises in swimming) osteochondral callus formation is somewhat stimulated (development of dense capillary network, living removal of calcified cartilage, resorption of the woven bone and replacement with lamellar bone, a relevant increase in callus thickness in the middle zone). In immobilized animals differentiation of callus tissues was inhibited and altered. Formation of hard callus was significantly inhibited. The little islets of compact bone and thin bone trabecles were observed on the 28th day after the osteotomy. Bone revascularization and vascular permeability were inhibited (weak peroxidase staining of vascular wand cells, intense staining of the content inside the capillaries) (Table 3).

Permeability of the vessels of the repairing callus was measured with HRP injected in the tail vein on the 4th and 7th day after the injury. The vascular permeability after the trauma and immobilization of animals was inhibited on the 4th day (the HRP stain in minor vessels was weak compared to control group) and restored by the 7th day.

In Group 2 (bicortical perforation), the main fracture repair response originated from bone marrow. Endosteal callus formed primarily (desmal osteogenesis, without chondrous stage) and periosteal callus secondarily (with a chondrous stage) or directly (mesenchymal ossification) — “inverted” ossification (Table 2).

Table 3. The intensity of peroxidase staining of vessels wand in wound healing of rat tibia after osteotomy (I) and perforation (II).

Groups and days after injury	5 min after HRP injection	15 min after HRP injection
I Osteotomy		
Control		
day 4	+	+
day 7	+	+++
Immobilization		
day 4	–	–
day 7	–	+
II Perforation		
Control		
day 4	+	++
day 7	++	+++
Immobilization		
day 4	–	±
day 7	–	+

(+++) — intensive; (++) — moderate; (+) — flat; (–) — without effect

The perforation of the bone caused, like in other groups, hemorrhage and tissue destruction as well as reparative changes on the 4th–7th days. In addition, reparative changes occurred in soft tissues of medullary callus: proliferating fibroblasts and chondroblasts, appearance of newly formed capillary network, degranulation of tissue basophils, appearance of macrophages and osteoclasts, lymphocytes. Angiogenesis was the most intense in the endosteal callus (Table 2). Fibroblasts began intensively to synthesize extracellular substance, including collagen. (7th–14th days). The ossification in internal callus was initiated and occurred by intramembranous pathway in the medullary part of the callus. In the periosteal part of the callus, the extent of bone formation was low (Fig. 2, 4). The bone fragments (relicts) remained by drilling up to 3 weeks after perforation, were removed by active cells of capillary sprouts penetrating into them. Later (on the 28^{th}–35^{th} days) the periosteal bone formation wass activated. Periosteal and endosteal bone callus had a similar extent (Fig. 3, 5, 6). Post-traumatic osteohistogenesis finished mainly on the 21^{st} day, but organomorphogenesis (bone formation) and remodelling continued up to the 28^{th}–35^{th} days.

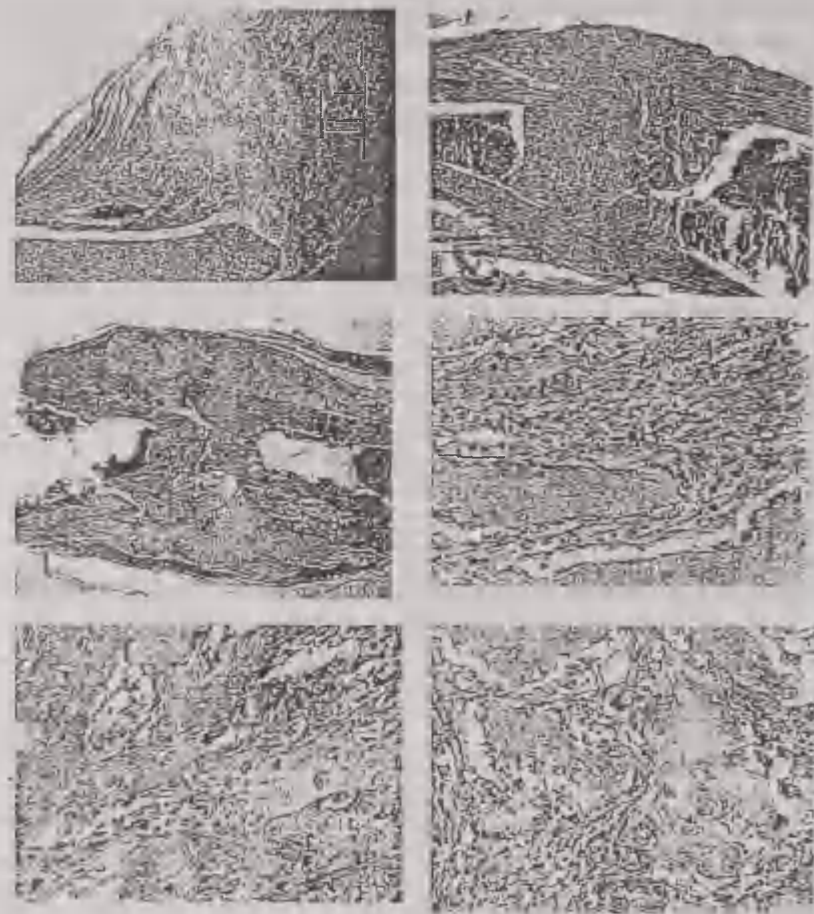

Fig. 1 - 6 (left - right, up - down)

Figure 1. The post-traumatic bone repair in rat tibia 28 days after resection osteotomy. Frequently the compact and trabecular bone callus are varied. Newly formed trabecles and cords in the bone cavity. Haematoxylin and eosin. 12.5x

Figure 2. The post-traumatic bone repair in rat tibia 14 days after bicortical perforation. The external chondrofibrous and bony callus as well as internal fibrous and bony callus are formed. The internal (endosteal) bony callus is more extent compare to external (periosteal) callus. Haematoxylin and eosin. 12.5x

Figure 3. The post-traumatic bone repair in rat tibia 28 days after bicortical perforation. All four tissue responses (bone, chondrous in the external part of callus, supporting tissue, inflammation) are occuring simultaneously. The callus has (in sagital section) a fusiforme appearance ("repair bicone"). The callus is largely composed of bone tissue, in equal part both external and internal bony callus. Haematoxylin and eosin. 12.5x

Figure 4. The post-traumatic bone repair in rat tibia 21 days after bicortical perforation. The intensive intramembranous bone formation in the internal (medullary) callus. On the left newly formed bone islets are seen, surrounded by osteoblastic layer. Haematoxylin and eosin. 400x

Figure 5. The post-traumatic bone repair in rat tibia 28 days after bicortical perforation. The periosteal bone formation is observed. Actively proliferating chondous tissue with mitoses of chondroblasts (right lower angle) replaced by forming bone (left upper angle). Haematoxylin and eosin. 400x

Figure 6. The post-traumatic bone repair in rat tibia 21 days after bicortical perforation. Capillary sprout, penetrating bone fragment, produced by drilling. Haematoxylin and eosin. 400x

Bone repair after perforation had one peculiarity: endosteal ossification followed directly without the chondrous stage, but periosteal — mostly through the chondrous callus.

In the trained animals, definite organogenesis was observed (the lamellar bone formation, recanalization of bone). In immobilized rats, bone repair was inhibited. Bone revascularization was destroyed on the 4th day (vascular permeability was inhibited) and began to be restored on the 7th day (compared to control group the ability to peroxidase staining of vessels wand was weak) (Table 3). Vascular permeability was inhibited strongly in the endosteal callus, in the region of active post-traumatic angiogenesis (Table 2).

* * *

Our data suggest that post-traumatic bone healing histology, like embryohistogenesis, has similar repair stages as well as similar tissue and cell responses. However, the stages are varied and dependent on the mode and degree of the injury. After the osteotomy (Group 1), a mainly primary periosteal (direct, intramembranous) and secondary endosteal chondrous ossification, but after perforation (Group 2) a primary endosteal and secondary periosteal ossification were observed ("invert" ossification). In Groups 1 and 2 (osteotomy, perforation) immobilization of the animals inhibited the repair (Table2).

Quantitative histology with histomorphometry of callus areas gave new results (Table 4).

Table 4. Areas of callus tissues 28 days after the osteotomy and perforation in control and under the conditions of training and immobilization (percentage of callus area ±SD).
Computer field in use: 16.7%; 120000 pixels (100%).

Group (number of animals)	Total callus	Hard callus+	Soft callus+
Osteotomy			
Control (8)	31.6± 3.1	21.3± 2.8	10.3± 1.7
Training (5)	35.8 ±3.3	25.9± 3.5	9.9 ±2.6
Immobilization (4)	20.4± 3.4*	8.1 ±1.0*	12.3±2.5
Perforation			
Control (5)	20.1±1.1**	15.8± 0.8	4.3± 0.5
Training (3)	25.7± 3.2	19.5±2.1	6.2± 0.9
Immobilization (3)	21.2± 2.8	6.6 ±0.7*	14.6± 1.7*

+ hard callus is bone and chondrous callus, soft callus is the inflammatory area with adjacent cells and mixed connective tissue
* differences between the values of this group are significant ($p < 0.05$)
** differences between the values of this group and control of Group 1 are significant ($p< 0.05$)

There exists a clear difference between Group 1 and Group 2. Total callus area after osteotomy is equal to 31.6±3.1, after perforation — 20.1±1.1 ($p<0.05$). The hard callus area is twice (Group 1), or even four times (Group 2) larger than the soft callus area (21.3±2.8 and 10.3±1.7, or 15.8±0.8 and 4.3±0.5 respectively). In training groups similar results were obtained. In both groups hard callus areas were about three times larger than soft callus areas, i.e. in Group 1 somewhat larger and in Group 2 somewhat smaller than in the control group. Training was more effective in the osteotomy group.

In immobilized animals the total callus area in Group 1 was significantly smaller than in the control group (20.4±3.4 and 31.6±3.1 respectively; p<0,05). In Group 2 the total callus area was similar to the controls (21.2±2.8 and 20.1±1.1 respectively). In both groups the hard callus area was 1.5–2 times smaller than the soft callus area. In both groups immobilization strongly affected hard callus formation, while total callus formation was affected only after osteotomy.

New results of morphometry are in accordance with results of histology (Tables 2, 4; Fig. 1, 3).

DISCUSSION

The main factors of post-traumatic bone repair were observed — degree and mode of the injury, fixation, vascularization, tissue interactions, external physical and chemical loadings, etc. It is known that callus formation is dependent on the mode and degree of the injury [5, 8, 9]. It is known that stable environment leads to the primary bone repair [4, 25, 26, 29], and flexible fixation causes formation of more extensive callus, and the ossification is mainly secondary, endochondral [21].

By these criteria, our resection osteotomy model and perforation model correspond to flexible and absolute fixation, respectively. In Group 1 (osteotomy), where stabilization was not absolute, some delayed repair of bone was observed with high amount of hard callus. In Group 2 (perforation), where movements at the bone defect site where absent, there were no complications, bone repair occurred rapidly and with minimal amount of callus (Table 4). Absence of motion at the bone defect site (Group 2) diminished soft tissue reaction, stimulated the vascularization of endosteal callus (Table 2) and activated bone marrow reaction in bone repair. Although the start of ossification was delayed (measured with temporo-spatial parameters) the complete ossification of the defect was achieved more rapidly compared to osteotomy (Group 1) [16].

The osseus and chondrous callus formation was dependent on the mode and degree of the injury (Table 2, 4). The total bone callus after after osteotomy on the 28th day was equal to 31.6±3.1, after perforation 20.1±1.1; p<0.05. Our data suggest that the total areas of bone tissue callus in Groups 1 and 2 were opposite to the degree of the trauma: a more serious trauma in Group 1 caused smaller values in bone tissue callus area development and a slight trauma in Group 2 caused a very large development of bone tissue callus (45.8±3.4 and 85.7±6.6) [16]. In the groups, hard callus (bone, cartilage) formed 65–75% of the total callus. Our results suggest a dependence of callus formation on the functional requirements to the repairing bone (necessity of consolidation, etc.) and not so much on blood supply (post-traumatic angiogenesis).

The revascularisation of the destroyed bone and soft tissues adjacent to the fracture is necessary for optimising the results of fracture treatment [15, 19, 28]. It has been shown that insufficient supply of oxygen causes deviation of fracture repair from osteogenesis to chondrogenesis [13]. In tissue cultures *in vitro* the destroyed bone tissue precursor cells without oxygen have differentiated into chondroblasts and with normal vascularisation and O_2 supply into osteoblasts [2]. The rabbit osteogenic cells *in vivo* in a diffusion chamber, inoculated into athymic mouse for 20 days, were differentiated into osseous and chondrous cells, which, depending on vascularization, synthesize types I and II of collagen [1].

In our previous experiments on the 4th to the 14th days after the injury capillary sprouts of cancellous bone formed lacunas filled with a discrete cell population — osteoprogenitor cells, dead cells, osteoclasts and mononuclear macrophages, etc. Capillaries of compact bone formed cutting cones with similar cell content (compartments). Neoangiogenesis similary to osteogenesis of trained rats increased and of immobilized animals decreased and was atypical compared with the control group [16].

Bone repair is influenced by numerous mechanical, physical, chemical, neural, endocrine, general environmental and local factors [6, 18, 24]. In our experiments bone repair was somewhat stimulated by moderate physical load (swimming) and inhibited by limited possibility of movement (immobilization). Physical activity did not additionally enhance the bone total as well as hard callus areas, while immobilization caused its fall in the osteotomy group, and hard callus fall in the perforation group. Physical activity (swimming) may accelerate bone repair in osteotomized tibia of rats [12], but it is also known that sufficient physical activity for a successful bone tissue repair may be achieved even by normal weight bearing, whereas tenotomized rat tibia repair is inhibited [11].

We used our new experimental model (bicortical perforation), comparable to osteotomy, and the new temporo-spatial parameters of the histology, morphometry and histochemistry for the study of post-traumatic bone repair dynamics after injury in mechanically stable and unstable environment (osteotomy, perforation) after training or immobilization of animals. New comparable results were obtained (great variety of tissue reactions, enhancement or inhibition of bone repair after different injuries and external loadings, etc.).

SUMMARY

The functional activity of the blood vessels in the callus during bone repair was evaluated with horseradish peroxidase (HRP). On the 4th and the 7th days after osteotomy and perforation of the rat tibia 4 mg of HRP was injected into the tail vein. 5 and 15 min after the injection the material was collected. In both groups (osteotomy and perforation) immobilization of rats caused a decreased HRP staining in the wand of the vessels.

Total callus area in post-traumatic bone repair of rat tibia after osteotomy is in control and training group 1.5 time higher than in other groups (osteotomy of immobilized animals, perforation — all groups).

In the osteotomy group the hard callus area is twice and in the perforation group even four times larger than the soft callus area. In training groups similar results were obtained. Hard callus areas are in both groups about three times larger than soft callus areas, i.e. in Group 1 they were somewhat larger and in Group 2 smaller compare to controls. Training was more effective in the osteotomy group.

In immobilized animals the total callus area in Group 1 (osteotomy) was significantly smaller compared to controls, in Group 2 (perforation) the total callus area was similar to controls. In both groups after immobilization the hard callus area was 1.5–2 times smaller than the soft callus area. In both groups immobilization strongly affected hard callus formation, while total callus formation was affected only after osteotomy.

ACKNOWLEDGEMENTS

We wish to thank PhD student Alar Toom for his help in animal operations and computer analysis.
This work was supported in part by Estonian Scientific Foundation Grant 3007.

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BREAKFAST SKIPPING AND ASSOCIATED BIOPSYCHOSOCIAL FACTORS AMONG ADOLESCENTS

Mari Järvelaid

Department of Polyclinic and Family Medicine, University of Tartu, Estonia
Department of Public Health, Ministry of Social Affairs of Estonia

ABSTRACT

The aim of the study was to investigate the breakfast eating behavior and associated biopsychosocial factors among Estonian adolescents. The sample included 838 schoolchildren in agegroup 15- to 17-year-olds. Regular breakfast eaters were 58.7% of girls and 70.6% of boys. Regular breakfast eaters had the smallest mean body weight and the breakfast skippers the biggest mean body weight. The breakfast skippers showed worse school archievement, less healthy behavior and less psychological welfare. Skipping breakfast in adolescence is an indicator of health damaging life-style and is associated with health-compromising behaviors.

Keywords: female adolescents, eating breakfast, body mass index, Beck Depression Inventory, health damaging risk behaviors

INTRODUCTION

Breakfast literally means “breaking the fast” from the evening meal the night before. This “fast breaking” provides fuel to the body for the coming day. Studies have shown that eating breakfast improves the overall nutritional status, reduces the likelihood of obesity, improves cholesterol control, and improves the feelings of health and wellbeing [1, 2, 3].

Eating breakfast is important for the health and the development of children and adolescents. Breakfast is even referred to as the most important meal of the day. Skipping breakfast has a greater physiological effect on children compared to adults. The increased stress effect of the overnight fast relates to the higher ratio of brain weight to liver weight in children and the greater demand this places on glycogen stores. [4]

Evidence suggests that breakfast contributes to wellbeing in a number of areas. First, it is a central component of nutritional wellbeing, contributing to total daily energy and nutrient intake [5]. A number of studies have also found that breakfast skippers have relatively worse intake of various vitamins and minerals. In fact, skippers are more likely to eat high-fat snacks, to have high blood pressure, to lack exercise habits and to have higher cholesterol levels than do breakfast consumers [2, 4–8].

It has also been contended that skipping breakfast has deleterious effects upon various aspects of cognitive functioning. Teachers report that hungry children are more likely to be apathetic, inattentive, and disruptive, so skipping breakfast can affect performance at school.

Missing meals can be seen as a part of the voluntary restriction of food intake associated with eating disorders, such as anorexia and bulimia nervosa. Skipping breakfast and other meals can be used as a possible indicator of subclinical eating disorders.

Breakfast has also been linked to long-term health. Eating breakfast is one of the healthy habits. Those who ate breakfast almost every day and did not often eat between meals, reported better physical health than skippers [1, 3, 7, 8].

The aim of the current study was to investigate the prevalence of breakfast eaters among 15- to 17- year-olds and the associated biopsychosocial factors with skipping breakfast.

SUBJECTS AND METHODS

The sample included 838 schoolchildren at the age of 15-to 17-years in grades nine to twelve, 501 girls and 339 boys in Tartu. The pupils completed a self-administered 70-item questionnaire and the 21-item Beck Depression Inventory in their classrooms during a regular class period. Height and weight were measured in the morning by the school nurse and the body mass index (BMI, kg/m^2) was calculated.

The questionnaire contained items on socioeconomic and health status, and emotional and physical welfare. The respondents were asked about their parents' education, the number of siblings, and engagement in athletics in addition to physical education at school. Further, they were inquired about their communication with parents, satisfaction with life, self-assessed health status, school achievement, somatic complaints and health behavior. These questions were to be answered on a 5-point Likert scale from "always" to "never". The 21-item Beck Depression Inventory (BDI) was used to measure depressive feelings [9]. The scores of the single items of Beck Depression Inventory were added up for all the respondents.

Differences in the proportions between the groups were tested using the Pearson chi-squared test. The critical alpha for significance was set at 0.05. After observing a significant correlation between two variables, to predict the relationship between the predictor variables and the indipendent variables, binary logistic regression analysis was used. The dependant variable was the breakfast eating or the skipping behavior of respondents (1 = skipping breakfast; 0 = eating breakfast). The indipendent variables were all other items explored in the questionnaire. For all the statistical analysis the Statistical Package for Social Sciences (SPSS) version 10.0 for Windows was applied.

RESULTS

The breakfast eating behavior of boys and girls differed. Among girls, 58.7% reported always eating breakfast *vs* 76.6% of boys, 24.0% eating it in most mornings *vs* 17.2% of boys, 6.8% eating it sometimes *vs* 3.8% of boys, 8.4% eating it seldom *vs* 7.0% of boys and 2.1% of them reported always skipping breakfast *vs* 1.5% of boys. The mean height, the weight and the body mass index of respondents are shown in Table 1 and 2. The mean weight was the biggest in the group of breakfast skippers, both for girls and boys. The respondents who sometimes eat breakfast and sometimes not, had the biggest mean body mass index among the girls, but the lowest mean body mass index among the boys. The body mass of the breakfast eaters and the breakfast skippers were significantly different among the girls ($p = 0.03$), but not among the boys.

The breakfast skippers had significantly higher mean BDI summed score compared to breakfast eaters (see Table 1 and 2). The BDI total score was zero for 3.5% of the girls and 9.8% of the boys and all of them were regular breakfast eaters.

Table 1. The mean age, height, weight, body mass index (BMI) and Beck Depression Inventory (BDI) mean total score by response of girls to the question "How frequently do you eat breakfast?".

Eating breakfast (%)	Age in years; ± SD	Height in cm, ± SD	Weight in kg, ± SD	BMI kg/m^2, ± SD	BDI total ± SD
Always N = 293 (58.7)	15.9 ± 0.8	1.68 ± 5.8	56.3 ± 7.4	19.99 ± 2.23	8.45± 6.32
Mostly N = 120 (24.4)	15.9± 0.8	1.68± 5.9	57.8 ± 7.2	20.46 ± 2.32	9.55± 6.48
Sometimes N = 34 (6.6)	15.9 ± 0.8	1.69 ± 5.3	60.2± 11.2	20.85± 3.54	8.62± 6.29
Seldom N = 42 (8.2)	15.9 ± 0.9	1.66 ± 5.5	57.0 ± 7.4	20.64 ± 2.62	13.49± 8.65
Never N = 10 (2.1)	16.1 ± 0.9	1.70 ± 3.1	60.4 ± 8.9	20.82 ± 3.31	13.30±10.59
TOTAL N = 499 (100)	15.9 ± 0.8	1.68 ± 5.7	57.1 ± 7.7	20.23 ± 2.42	9.25± 6.82

Table 2. The mean age, height, weight, body mass index (BMI) and Beck Depression Inventory (BDI) mean total score by response of boys to the question "How frequently do you eat breakfast?".

Eating breakfast (%)	Age in years; ± SD	Height in cm, ± SD	Weight in kg, ± SD	BMI kg/m^2, ± SD	BDI total Score, ± SD
Always N = 238 (70.6)	15.9 ± 0.8	1.79 ± 0.07	66.3 ± 9.3	20.62 ± 2.39	4.96 ± 4.57
Mostly N = 59 (17.2)	15.9 ± 0.8	1.79 ± 0.06	66.9 ± 9.6	20.77 ± 2.47	6.85 ± 5.41
Sometimes N = 13 (3.8)	16.1 ± 0.7	1.77 ± 0.06	65.1 ± 8.5	20.40 ± 1.39	8.17 ± 7.18
Seldom N = 24 (7.0)	16.2 ± 0.7	1.78 ± 0.08	67.2 ± 10.6	21.24 ± 2.93	8.64 ± 7.68
Never N = 5 (1.5)	16.0 ± 1.0	1.79 ± 0.04	67.8 ± 9.4	21.12 ± 3.36	8.40 ± 6.11
TOTAL N = 339 (100)	15.9 ± 0.8	1.79 ± 0.07	66.4 ± 9.3	20.64 ± 2.67	5.70 ± 5.22

In psychosocial idicators there were different associations with breakfast skipping for girls and boys. Both, girls and boys, who skipped their breakfast, showed worse archievement in school and the higher prevalence of daily smoking (see Table 3). But the girls who skipped their breakfast had worse relationships with parents, the higher prevalence of being sexually active, frequent alcohol drinking respondents than the girls who regularly eat breakfast. The boys who skipped breakfast had tried illicit drugs significantly more often than the boys who eat breakfast regularly, but there were no more associations found between breakfast eaters and breakfast skippers (Table 3).

Table 3. Items correlating with eating or skipping breakfast behavior among 15- to 17- year-old schoolchildren by gender (Odd Ratio; lower and upper 95.0 % C.I. for Exp (ß); significance). The dependent variable is skipping breakfast = 1.

Item	OR	95.0 % C.I. (lower-upper)	Significance (p)
Girls			
BMI between 19 and 24 kg/m^2	1.5	1.03 – 2.20	0.033
Desire to be thinner	0.8	0.66 – 0.94	0.006
Good relationship with parents	2.5	1.47 – 4.25	0.001
Pleased with eating all the family together	1.3	1.03 – 1.63	0.026
Using belts in the car	1.4	1.13 – 1.76	0.002
Good school achievement	1.6	1.11 – 2.25	0.001
Non-smoker	2.3	1.26 – 4.15	0.007
Have not been drunk	1.5	1.10 – 1.92	0.008
Sexually active	0.5	0.29 – 0.79	0.004
Boys			
Good school achievement	1.5	1.02 – 2.20	0.041
Non-smoker	2.1	1.08 – 4.24	0.029
Had tried illicit drugs	0.4	0.18 – 0.94	0.034

DISCUSSION

The results of the current study showed that approximately 60% of girls and 70% of boys ate breakfast daily. It is a higher proportion than 43% daily breakfast eaters among the tenth grade students reported by Cohen and colleagues and fewer than 81% among the ninth grade students reported by Nicklas and colleagues [10, 3]. Australian studies estimate the prevalence of skipping breakfast amongst school-aged children at between 4 and 25% [5, 6]. Most of the studies found a greater proportion of female adolescents skip breakfast compared to males, but a greater proportion of male adults (16 to 64 years) skip breakfast [1, 6].

The high body mass index was significantly associated with adolescent breakfast skipping and the similar association has been reported in literature [8, 10]. The significantly higher body mass among breakfast skippers is indicating that the breakfast skippers are more likely to eat high-fat snacks than breakfast consumers do [5].

In the current study a gender difference in some associated psychosocial welfare indicators was found. Similar gender difference associated with breakfast skipping has been reported by Buddeberg-Fischer and colleagues. A significant correlation between the disturbed eating behavior and the concurrent psychological and physical symptoms was found in female, but not in male subjects. Young women are more open to report psychosomatic symptoms, and partly by the fact that they deal with stress differently. Females tend to react with psychosomatic symptoms or autoaggressive behavior. Boys, on the other hand, are more likely to act out and direct agressive feelings outwards [12]. Parental breakfast eating is the most significant factor associated with adolescent breakfast eating [8]. Socially independent girls are more likely to smoke, and less likely to eat breakfast and meals with their family [11].

Skipping breakfast was more marked among students with poor school performance in several studies [13–15].

The students who smoke were more likely to skip breakfast. In both sexes smoking was significantly associated with irregular breakfast eating. Similar association has been reported in literature [7, 10, 14–17].

CONCLUSIONS

For adolescents, skipping breakfast was connected with a higher body weight, depressive mood and associated with the health damaging lifestyle and risk behaviors.

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ON THE BEGINNINGS OF THE SPECIMENS COLLECTION OF NORMAL HUMAN ANATOMY AT THE UNIVERSITY OF DORPAT (TARTU)

Jaan Kasmel

Centre for Physical Anthropology, University of Tartu, Estonia

During its more than 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 [1]. 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 [2].

By that time human anatomy as one of the oldest branches of natural sciences had become a scientific discipline. This happened in the 16th century, thanks to the major work of Professor of Padua University (founded in 1222) A. Vesalius *On the Structure of the Human Body*, published in Basel in 1543, which, along with Paracelsus' works reformed medicine as a whole. If throughout centuries dissections of the human corpse in the interests of science had been conducted at accidentally chosen places, then, relying on the ideas of the anatomist A. Benedetti, temporary wooden rooms or buildings of the amphitheatre type began to be built for demonstrating the dissections. The first of them was completed in Padua in 1497.

In Padua also the first permanent building constructed for that purpose, an anatomical theatre, was opened nearly a hundred years later, in 1594. Later, several anatomical theatres were built on its model.

Along with that, the first methods of anatomical research and the technique of preparation of anatomical specimens had evolved. This in its turn made it possible to prepare dry and wet specimens of several kinds. To preserve them, anatomical theatres established small collections, which later grew into museums [3].

In summary, all this provided better opportunities for studying the human body structure and facilitated the satisfaction of the growing need for better anatomical knowledge in medical education.

Next, we would explore who and when and under which circumstances was the first at the Medical Faculty of Tartu University to use anatomical specimens to illustrate lectures on normal human anatomy (or related subjects), also laying a foundation to a collection of specimens of this subject, and what the university statutes valid at the period said about such a collection.

To get a full answer to the questions, we should look back at the history of the Medical Faculty at the University of Tartu, beginning with the two periods under Swedish rule when the university used Latin as the language of tuition.

The statutes of *Academia Gustaviana Dorpatensis* (1632–1665) and *Academia Gustavo-Carolina* (1690–1710), which had been taken over from the University of Uppsala (the statutes of 1625 and 1655 respectively), provided two professors for the Faculty of Medicine. One of them was to lecture on anatomy, botany and physics, and the other taught illnesses and their treatment. Each year there was supposed to be a dissection. Due to the small number of students, often only one professor was employed, and sometimes even that was missing.

In the period of *Academia Gustaviana*, from 1632–1642, the first professor of medicine was Johann Below (1601–1668), who had studied and acquired his degree at the University of Rostock. In Dorpat (Tartu) he also lectured on anatomy and botany to the students of other faculties. Most probably it was he who dissected carcasses of cats and dogs for instructional purposes, inviting also townspeople to watch the dissections. As there were no trained doctors in Dorpat (Tartu) at the time, Below's main occupation was working as the municipal doctor. He was also the *medicus ordinarius* of the highest court of Livonia.

The next professor of medicine Sebastian Wirdig (1613–1687) worked in Dorpat (Tartu) from 1647–1654. He had defended his degree of Master of Philosophy in Wittenberg and Doctor of Medicine in Königsberg. S. Wirdig lectured in Dorpat (Tartu) on general problems of medicine and psychiatry and supervised two medical disputations. In 1650 he sold to the university library A. Vesalius' pioneering work on the structure of the human body [1].

While the data on the years of *Academia Gustaviana* are scanty, a greater amount of more versatile materials can be found on tuition and research in medicine in the days of *Academia Gustavo-Carolina*.

The first professor of medicine during that period was Lars Micrander (?–1706?) who had acquired his education at the universities of Leiden and Uppsala and thereafter travelled abroad. Despite his short stay in Dorpat (Tartu) (1690–1691), L. Micrander MD made noteworthy endeavours to update the standards of teaching medicine and to develop medical research. The lecture programme of 1690 shows that he lectured on physics, chemistry and anatomy. As in Uppsala anatomical dissections were performed in a tower-like anatomical theatre built in 1662–63, L. Micrander emphasized the necessity for building a special “anatomy house” in Dorpat (Tartu) too. In addition he can be considered the pioneer of balneology in the Baltics (in the summer of 1691 he discovered and immediately exploited for medicinal purposes two mineral springs near Helme in South Estonia) [1].

After L. Micrander’s departure the post of the professor of medicine remained vacant until the arrival of Jakob Friedrich Below (1668–1716) as late as at the end of 1695. Below had acquired his medical education in Utrecht and defended his degree there. He, too, immediately started working energetically, considering it important to illustrate lectures with anatomical material. Thus, in 1697 the university requested through the governor from the municipal government that the corpses of criminals or those who died in the almshouse should be given to the professor of medicine. Therefore, in the lecture programme for 1697/98 J. F. Below could already announce that he arranged dissections of human corpses and animal carcasses “also for satisfaction of public interest.” In the winter of that academic year, he anatomized the corpses of a male and a female [1]. This was definitely a step forward in teaching of medicine. Obviously, the dissection of a human body was something extraordinary in Dorpat (Tartu) at that time. It is known that anatomization made its way into universities but slowly. Thus the anatomization of two human corpses by J. F. Below in Dorpat (Tartu) more than 300 years ago could also be considered noteworthy on the international scale as in many countries (universities) dissection was inhibited by religious prejudice. As no anatomical theatre had been built in Dorpat (Tartu) yet, one might suppose that he lectured in the main building of the university (the present 8 Jaani St.) that had repeatedly been rebuilt to meet the needs of the university. He had furnished one of the rooms of the building as an anatomy hall, providing it with in-built benches [2].

J. F. Below also considered it necessary to found a university hospital as a teaching and research base in order to improve the training of doctors at bedside. A respective application was submitted to the town's commandant. The establishment of the university clinic did not materialize, obviously because of lack of necessary funding. Thereafter, Below accepted the invitation of Lund university and left Dorpat (Tartu) in 1698 [1].

The last professor of medicine at *Academia Gustavo-Carolina* was Laurentius Braun (1657–1730), whose career mostly fell into the period when the university had been transferred to Pärnu (1699–1701 and 1705–1710).

He had been educated in Uppsala, Leiden and Utrecht and had defended his doctoral dissertation in 1689. Thereafter he had worked as a naval doctor, lecturer of logic and physics in Kalmar and professor of medicine in Åbo [1].

L. Braun set out to continue enthusiastically the work of his predecessors L. Micrander and J. F. Below at building the anatomy hall. In Pärnu no one doubted the necessity of such a hall. The initial idea was to build it according to the design Prof. J. F. Below had made in Dorpat (Tartu); later, however, it was decided to model it on the anatomical theatre of Uppsala university.

Already in 1699 L. Braun and his colleague, Professor of History S. Caméen, began to arrange "physical investigations" in a so-called anatomy room twice a week (on Tuesdays and Saturdays). In his lectures Braun also discussed pathology and medicinal remedies (pharmacology).

As the Northern War had begun, then from 1702–1795 Prof. Braun was engaged on active service, treating soldiers in Courland.

After that he supervised practical exercises in anatomy in Pärnu again and delivered lectures on the structure of the human body. He also lectured on therapeutics and surgery, which was obviously dictated by the state of war [1].

Although the construction of the anatomical theatre in Pärnu did not materialize, a solution for better teaching of anatomy was still found. Although the war escalated, L. Braun undertook a public anatomization of a human corpse on 17 October 1709 as this was provided for by the university constitution. This was done in a building whose medieval walls were still standing quite recently, after the last war — in the so-called Elephant Barn. The dissection was also described by the University Rector C. Schultén in his letter to Chancellor A. Horn. The chancellor was also presented a detailed program of teaching anatomy, which the chancellor approved, saying that the university would benefit greatly from this science [4].

Professor of Medicine L. Braun was also the municipal doctor of Pärnu. His merit was that during the plague epidemic of 1710 he compiled a leaflet on the necessity of immediate burying of those who had died of plague.

All the professors who worked at the university under the Swedish rule met the standards of the time, as they had been educated at the best universities of Europe. Despite many difficulties, in both periods the quality of teaching and research at the university more or less corresponded to the usual level of that time's universities [1].

The answer the first questions posed by us can be summarized as follows.

From the days of *Academia Gustaviana* there are no data on anatomization of human corpses, using of anatomical specimens at lectures of anatomy and existence of or attempts to start any rudimentary anatomical collections.

From the period of *Academia Gustavo-Carolina* it is known that both in Dorpat (Tartu) and in Pärnu a few anatomizations of human corpses were carried out. The necessity of building an "anatomy house" or an anatomy hall was discussed in both towns, but they were not built. Still, in Dorpat (Tartu) and Pärnu, in order to improve the teaching of anatomy, an anatomy hall and an anatomy room respectively were taken into use. Whether they resembled buildings of the amphitheatre type, so that they could be called anatomical theatres, cannot be ascertained because of the scarcity of data. Whether the professors of medicine who worked in those rooms preserved anatomical specimens with an aim to found collections or to add to existing ones, and whether they used specimens to illustrate their lectures of anatomy is also unknown because of lack of data.

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 [1].

Hoping to curb 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 it 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 [5].

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 midwifery; 5) botany and *materia medica* (study of medicinal remedies, 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 anatomical preparation with a prosector and his two assistants; 5) 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 [6].

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 (1759–1829) and full professor of chemistry and pharmacy Erdmann Heinrich Gottlob Arzt (?–1802) [7].

While the preparations for opening not only the Medical Faculty but also 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 of the university in Dorpat (Tartu), not about its opening, as years ago, in the early 18th century it had wound up its activities there [5]. (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 [5]. 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 had 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 midwifery; 2) pathology, semiotics, therapy and clinic; 3) dietetics, state and popular medicine and *materia medica*; 4) chemistry and pharmacy.

The professor of public 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 [8].

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 [7].

M. E. Styx who had been employed as full professor of anatomy and forensic medicine somewhat more than a year and four months before the reopening of the University of Tartu became the first full professor of these disciplines in the history of the university. In this position he could not deliver a single lecture in either of the subjects, and it is not known which preparations he made during that time for starting to fulfil his obligations. According to the statutes of the university, confirmed early in 1802, Styx was transferred on 9 April, that is three weeks before the official beginning of lectures, to the post of full professor of dietetics, state and popular medicine and *materiae medicae*.

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 (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 [5]. 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 midwifery remained vacant.

The number of students at the Faculty of Medicine was a modest three; by the end of the first semester it increased to six [9].

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. Along with obligatory lectures, professors gave students individual tuition and rarely supervised some practical work. Checking of knowledge acquired by the students was superficial and unsystematic. Thus, a number of problems concerning the organization of studies had to be solved [5].

Concerning the next question we were interested in — what the statutes of the University of Tartu (Dorpat), including these from the Swedish period, said about a collection of specimen of normal human anatomy — a cursory examination of these documents gives the following answer: neither the statutes of the university at its Swedish period (1632 and 1690), the plan for foundation of the university (1799) nor its first statutes (1802) specified the need for such a collection at the Faculty of Medicine.

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 [10]. 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 [11].

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, to be more exact the full professor of anatomy, physiology, surgery and midwifery envisaged by the university statutes of 1802, had not taken office yet, Prof. Balk also lectured on osteology, which forms part of normal human anatomy, and demonstrated bone specimens to the students. Therefore, we might speak about the existence of at least a partial collection of specimens of normal human anatomy [10].

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 about the human being, which 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) [12]. Here we should add that Balk's private collection, which consisted of an anatomical and a pathological section (pathological anatomy had separated from anatomy in the mid-18th century), was relatively large for the time. To the collection's owner it could really seem like a museum, especially if he had to rent a larger flat for housing it, as the university had no appropriate rooms yet.

Thus Prof. Balk laid the foundation to the specimens collection of both normal and pathological human anatomy at the University of Dorpat (Tartu) and, indirectly, also to the anthropological collection.

It is possible that because of the existence of Prof. D. G. Balk's anatomical and pathological collection, the university statutes confirmed on 15 September 1803 for the first time included in the list of ancillary institutions of the Faculty of Medicine a collection of anatomical specimens and a study room of pathology.

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 pathology study room was not specified. It was also considered necessary to finance the collections of anatomical and pathological specimens by a total of 1000 roubles annually and the anatomical theatre by 300 roubles [13]. Here we should note that in the first years after the reopening of the university, the official documents of the university often used inexact names for the ancillary institutions; in the present case, even the statutes did so.

The lecture programmes of the university mentioned the anatomical collection and the pathological collection for the first time in the autumn semester 1805, using names that did not correspond to the statutes. With the first mention of the anatomical theatre in the list of ancillary institutions in the lecture programme of the autumn semester of 1810, the anatomical collection disappears from the list but the pathological collection remains [12].

The disciplines were divided in the last statutes 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 midwifery. 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, for the first time, also got the rights and obligations of a professor extraordinary [13].

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 Dorpat (Tartu) could be very satisfied; theology even got more professorships here (four) than in Moscow (two) [5].

The last 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 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 [13].

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.

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 [7]. From 1780–1787 he studied at the Medical Faculties of Königsberg and Berlin Universities [14]. 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.

The list of Prof. D. G. Balk's lectures is not short. He taught introduction to pathology, general and special pathology, semiotics, health science and, to law students, medico-philosophical jurisprudence, using 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 [12].

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 [15]. He was involved in the construction of the so-called Old Anatomical Theatre, which began on 8 June 1803. In addition, he was involved in the construction of the clinics in 1806–1808 [16].

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 medical clinical institute and to the latter also 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 [15].

Prof. D. G. Balk also participated actively in the administration of research. It was at his suggestion that the future naturalist of world-wide renown Karl Ernst von Baer wrote his doctoral dissertation *On Estonians' Endemic Diseases* (1814) [15]. Professor of anatomy, physiology and forensic medicine Karl Friedrich Burdach (1776–1847) 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 [17].

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 [5].

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 [18]. 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 [15]. On 5 June 1817, at the age of 53, Balk was forced to hand in his resignation [19]. By that 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 [15].

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 [15].

We have earlier mentioned that the lectures of medico-philosophical anthropology delivered by Prof. D. G. Balk in the autumn semester of 1802 and this lecture course as a whole could be considered the first in the field of anthropology at the University of Dorpat (Tartu) and the universities of Tsarist Russia throughout the times [20].

As a result of the present study, we can add the following to the biography of full professor of pathology, semiotics, therapy and clinic D. G. Balk. He can be considered the first professor at the Medical Faculty of the reopened University of Dorpat (Tartu) who started (although forced by the circumstances, to substitute for the absent professor of anatomy, physiology, surgery and midwifery) teaching normal human anatomy by his lectures of osteology that belong to the area of this discipline.

At that, he was the first professor in the history of the University of Dorpat (Tartu) who used specimens from his own anatomical and pathological collections to illustrate his lectures on normal human anatomy, as osteology forms a chapter of this subject. Therefore, from 1 August 1802, which was the beginning of the autumn semester, Prof. Balk can be considered the founder of the collection of specimens of normal human anatomy at the University of Tartu.

Additionally we can remark that in the oldest institution of higher education in Lithuania, the University of Vilnius (founded in 1579), the museum of anatomy was founded by prosector J. Briotet (1746–1819) in 1777 [21].

Although Riga was not a university town in these years, it also had an anatomical theatre that was used to teach anatomy to local surgeons and midwives. There are data on a display of anatomical specimens at this anatomical theatre from 1753 [22].

Thus, the collection of normal human anatomy specimens at the University of Dorpat (Tartu) cannot be considered the oldest in the Baltic countries.

As the other section of Prof. Balk's private collection contained specimens of pathological human anatomy, he can be also considered the founder of the collection of pathological anatomy from the same time.

In the following years the development of the collection of anatomical specimens at the University of Dorpat (Tartu) was continued by full professors of anatomy who acted as heads of the anatomical theatre or, in their absence, prosectors as deputy heads in the capacity of professors extraordinary. By 1 January 1886 the collection included 1170 items of 882 different anatomical specimens [23]. A. Rauber (1841–1917), who became professor of anatomy in Dorpat (Tartu) in February of the same year added to this rich anatomical material three bone specimens and 36 topographical specimens of his own, systematized the collection skilfully [24] and opened in 1890 the museum of anthropology [25], which won general recognition and served as a model for similar new museums.

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Papers on Anthropology XII, 2003, pp. 102–112

CHANGES IN RELATIONS BETWEEN GIRLS' BASIC ANTHROPOMETRIC MEASUREMENTS IN PRE- AND POSTPUBERTAL PERIODS

Jaan Kasmel[1], Helje Kaarma[1], Ene-Margit Tiit[2], Säde Koskel[2]

[1] Centre for Physical Anthropology,
[2] Institute of Mathematical Statistics, Faculty of Mathematics and Informatics,
University of Tartu, Estonia

ABSTRACT

In the paper the average ratios of several anthropological measurements have been regarded in girls aged 7–8 (pre-puberty), 12–13 (puberty) and 17–18 (post-puberty). Eight different types of changes were defined depending on the direction and intensity of change in different periods. It was revealed that several characteristics (especially such indices as BMI, skinfolds and fat ratios) have tendency to increase, several others (e.g. relative depth, breadth and circumferences) — to decrease. In most ratios characterising the growth of trunk the direction of change changed after puberty. The speed of change also revealed different trends — in about half cases acceleration, half cases deceleration and also cease of change in post-puberty occurred.

Key words: growth, puberty, ratios of body measurements

Anthropometric studies of girls at the age of growth have revealed the great individual variability of in their basic anthropometric measurements as well as indices and body composition characteristics [2, 3, 5, 7, 9, 10, 11, 12, 13, 14, 15]. Particularly great changes take place during the period of puberty [1, 4, 16].

Therefore, it is important, in addition to studying age-related changes in the averages of basic body measurements, to study the changes in body proportions, in relations between body measurements in different age groups.

Until now, this question has received relatively little attention. Therefore, the aim of the present study was to analyze the variability of relations between basic measurements in three essential periods — at the age of 7–8 years, at the age of puberty (12–13 years) and at the final stage of the growth period (17–18 years).

MATERIAL AND METHODS

The sample under study consisted of 746 South-Estonian schoolgirls aged 7–8 (pre-puberty, $n = 205$), 12–13 (puberty, $n = 185$) and 17–18 years (post-puberty, $n = 256$). All the girls were practically healthy. They were measured according to an anthropometric measurement programme that included 34 basic measurements and 10 skinfolds. The measurements were conducted according to the method of Martin [8]). The list of skinfolds was selected from the handbook of Knussmann [8].

From the collected body measurements and skinfolds, 54 indices and body composition characteristics were calculated, which are listed in Table 1.

The data were analysed statistically by Säde Koskel.

Table 1. Average values of girls' measurements.

Type of Ratio	Ratios of measurements	Average values in age groups			Direction of change			Ratio
		prepub	puberty	postpub	prepub	postpub	Total	Dif1/Dif2
Ratios of length measure-ments	Relative head-neck length	20.27	18.92	18.64	↓	↓	↓	4.68
	Relative upper body length	40.84	38.58	39.51	↓	↑	↓	2.44
	Relative lower body length	59.16	61.42	60.49	↑	↓	↑	2.44
	Relat upper limb length	43.79	44.05	43.96	↑	↓	↑	2.88
	Relative lower limb length	53.35	55.32	54.48	↑	↓	↑	2.34
	Relative trunk length	28.86	28.13	29.13	↓	↑	↑	0.73
	Relative abdomen length	20.60	19.71	20.49	↓	↑	↓	1.15
Ratios of body breadth and depth to stature	Relative biacromial breadth	21.64	21.30	21.65	↓	↑	↑	0.97
	Relative chest breadth	14.95	14.53	15.20	↓	↑	↑	0.62
	Relative waist depth	13.01	12.67	13.39	↓	↑	↑	0.47
	Relative pelvis depth	15.77	16.07	16.77	↑	↑	↑	0.43
	Relative chest depth	10.80	10.28	10.50	↓	↑	↓	2.35
	Relative abdomen depth	10.56	9.68	9.74	↓	↑	↓	14.68
Ratios of body circumfe-rences to stature	Relative head circumference	40.96	34.97	32.97	↓	↓	↓	3
	Relative lower chest circumference	45.86	44.42	46.56	↓	↑	↑	0.67
	Relative waist circumference	41.48	39.62	41.12	↓	↑	↓	1.24
	Relative pelvis circumference	51.37	50.49	54.66	↓	↑	↑	0.21
	Relative hip circumference	52.93	54.49	58.24	↑	↑	↑	0.42
Ratios of limb bones' thickness to stature	Relative femur breadth	5.98	5.52	5.34	↓	↓	↓	2.54
	Relative ankle breadth	4.57	4.12	4.04	↓	↓	↓	5.64
	Relative humerous breadth	4.01	3.77	3.78	↓	↑	↓	26.33
	Relative wrist breadth	3.31	3.17	3.09	↓	↓	↓	1.86
Ratios of limb circum-ferences to stature	Relative upper thigh circumference	30.66	31.88	34.84	↑	↑	↑	0.41
	Relative upper leg circumference	20.48	20.69	21.73	↑	↑	↑	0.2
	Relative arm circumference	14.16	14.44	15.92	↑	↑	↑	0.19
	Relative forearm circumference	13.63	13.27	14.12	↓	↑	↑	0.42
	Relative wrist circumference	10.11	9.68	9.53	↓	↓	↓	2.78

Type of Ratio	Ratios of measurements	Average values in age groups			Direction of change			Ratio
		pre-pub	puberty	postpub	prepub	postpub	Total	Dif1/Dif2
Ratios of upper limb measure-ments	Arm circumference / upper limb length	33.42	33.50	36.18	↑	↑	↑	0.03
	Forearm circumference / upper limb length	31.24	30.14	32.14	↓	↑	↑	0.55
	Wrist circumference / upper limb length	23.17	22.00	21.69	↓	↓	↓	3.77
	Humerus breadth / upper limb length	9.19	8.58	8.61	↓	↑	↓	17.08
	Wrist breadth / upper limb length	7.58	7.19	7.03	↓	↓	↓	2.46
Ratios of lower limb measure-ments	Upper thigh circumference / lower limb length	57.51	57.67	63.99	↑	↑	↑	0.03
	Upper leg circumference / lower limb length	38.42	37.42	39.91	↓	↑	↑	0.4
	Lower leg circumference / lower limb length	26.26	24.77	24.86	↓	↑	↓	17.68
	Femur breadth / lower limb length	11.22	9.98	9.80	↓	↓	↓	6.94
	Ankle breadth / lower limb length	8.57	7.45	7.42	↓	↓	↓	36.26
Ratios of trunk depth to circum-ference	Chest depth / chest breadth	72.42	70.92	69.25	↓	↓	↓	0.91
	Abdomen depth / waist breadth	81.24	76.53	72.83	↓	↓	↓	1.27
	Biacromial breadth / pelvis breadth	137.47	132.83	129.40	↓	↓	↓	1.35
	waist circumference / pelvis circumference	80.84	78.52	75.23	↓	↓	↓	0.71
Body compo-sition indices and characte-ristics	Body mass index	15.68	18.20	21.75	↑	↑	↑	0.71
	Relative mass of fat by Siri	16.48	16.60	16.92	↑	↑	↑	0.35
	Mean skinfold	0.84	1.09	1.65	↑	↑	↑	0.44
	Mass of subcuteneous adipose tissue	3.64	6.88	12.68	↑	↑	↑	0.56
	Relative mass of subcuteneous adipose tissue	14.02	15.36	20.48	↑	↑	↑	0.26
	Total cross-sectional area of arm	25.88	40.21	57.39	↑	↑	↑	0.83
	Total cross-sectional area of tight	121.37	196.48	274.49	↑	↑	↑	0.96
	Bone muscle rate of the cross-sectional area of arm	18.37	28.79	39.28	↑	↑	↑	0.99
	Fat rate of the cross-sectional area of arm	7.51	11.41	18.11	↑	↑	↑	0.58
	Bone muscle rate of the cross-sectional area of thigh	89.34	150.65	193.00	↑	↑	↑	1.45
	Fat rate of the cross-sectional area of arm	32.03	45.50	81.48	↑	↑	↑	0.37
	Bone-muscle rate of the cross-sect. area of arm	0.72	0.72	0.69	↑	↓	↓	0.15
	Bone-muscle rate of the cross-sect. area of thigh	0.74	0.77	0.70	↑	↓	↓	0.48

RESULTS

The mean values of ratios and body composition characteristics in age the groups of 7–8 (pre-puberty), 12–13 (puberty) and 17–18 years (post-puberty) are presented in Table 1, see columns 3–5. All ratios were divided into nine groups (see column 1) depending on the measurements used.

To characterise the changes we calculated the differences between the ratios, measured at different times and assessed the dynamics of changes — whether they revealed a tendency of growth (↑) or decrease (↓):

- Difference between the second measurement (at age 12–13) and the first one (at age 7–8), see column 6;
- Difference between the third measurement (at age 17–18) and the second one (at age 12–13), see column 7;
- Difference between the third measurement (at age 17–18) and the first one (at age 7–8), see column 8.

In addition, we assessed the dynamics in the speed of changes, which is revealed by the ratio of absolute values of the changes in the first and in the second period, see the last column of the Table 1. If this relation exceeds 1, then the greater change happened in the prepubertal period, and in the postpubertal period the value of the observed ratio had a tendency to stabilize. On the contrary, if the relation between the changes is smaller than 1, (shaded cells in the table), the respective ratio or index began to change considerably only in the postpubertal period.

Thus, we could differentiate between four main types of change (see Fig. 1).

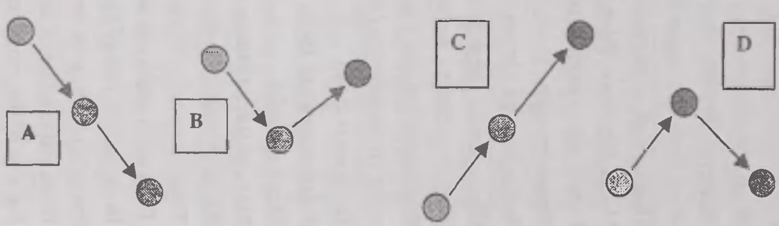

Figure 1.

Type A represents the situation where the ratio of measurements decreased during both the prepubertal and postpubertal periods. Type A divides into two subtypes, which are accelerating decrease A1 and decelerating decrease A2.

The other type of unidirectional change is type C, in the case of which the ratio of measurements increased during both the prepubertal and postpubertal periods. C1 denotes accelerating and C2 decelerating growth (see Fig. 2).

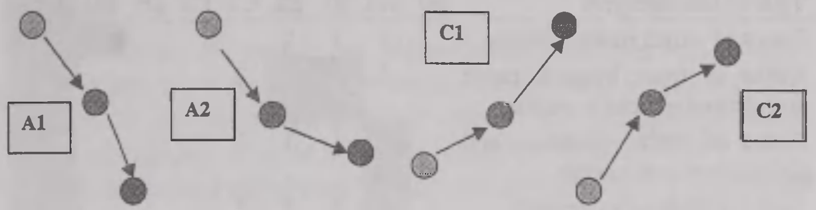

Figure 2.

In addition, there are two types of trends with a change in direction — B and D (see Fig. 3).

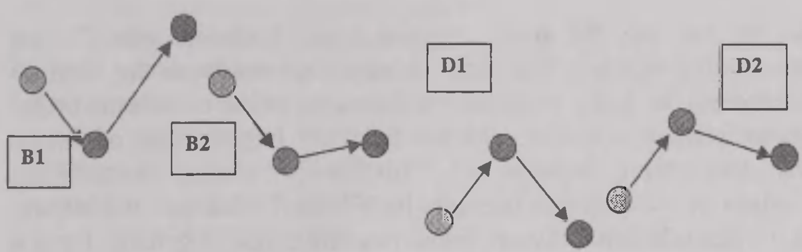

Figure 3.

Type B (decreasing-increasing) falls into two subtypes. If during the postpubertal period the change is faster, we can call it a process of summary increase (B1). If the change is faster in the prepubertal period, then such a decreasing-increasing process is a process of summary decrease, (B2).

The subtype of type D (increasing-decreasing), where the change is faster during the postpubertal period, is summarily the decreasing type D1.

The subtype of type D with a faster initial stage is in summary the increasing type D2 (see Fig. 3).
In such a way, we assessed the 54 relations between body dimensions and classified them into six types of ratios of measurements, where similar classes 2 and 3, 4 and 5 and also 6 and 7 are merged (Table 2).

Table 2. Distribution of relation types according to types of changes.

Type of measurement	A1	A2	B1	B2	C1	C2	D1	D2	Total
Ratios of length measurements		1	1	2				3	7
Ratios of trunk breadth, depth and circumferences to stature		1	5	3	2				11
Ratios of limbs' thickness and circumference to stature		4	1	1	3				9
Ratios of limb measurements		4	2	2	2				10
Ratios of trunk breadth and depth to circumference	2	2							4
Body composition indices and characteristics					10	1	2		13
Total	2	12	9	8	17	1	2	3	54

As we can see, the most common type of change was C1, i.e. accelerating increase. This type characterizes nearly all the relations determined by body composition, but also ratios of several limbs' circumferences to stature. Another relatively frequent type of change was decelerating decrease A2. This type of change characterizes changes in the relations between limb bones' thickness and stature, also other relations between limbs' measurements. In general, C1 is a type of change that is rather widely spread in the case of relations between measurements of different types.

When we regard different relation classes (Table 2), we can see that most relations between length measurements do not change evenly — nearly half of them first decrease and then start to increase, and there are as many of those that first increase and then begin to decrease (at that growth predominates).

In the relation of trunk breadth, depth and circumference to stature also a change in direction occurs — the initial decrease later changes into increase; at that, growth predominates more often.

In all relations between limbs' measurements, the most common type of relations is decelerating decrease.

The relations of trunk breadth and depth to trunk circumference generally show a tendency of decrease.

The indicators of body composition display accelerating growth.

In conclusion, our study revealed that in 22 measurement relations out of the 54 observed, during the postpubertal period as compared to prepubertal period, a transition occurred from decrease to growth (the more frequent situation) or from growth to decrease (the more unusual situation).

The speed of change in measurement relations also varied considerably — somewhat more frequently the more intensive change occurred in the prepubertal period than in the postpubertal period (when the change of some relations practically ceased), but in almost 45% of cases the postpubertal change was greater than the prepubertal one.

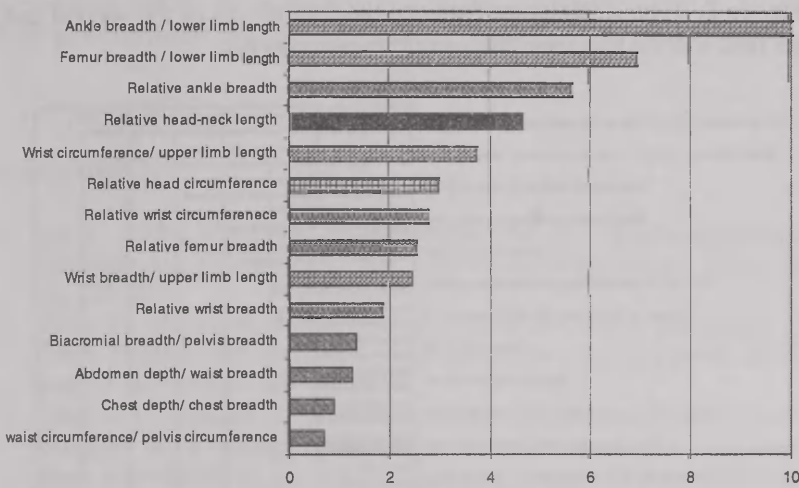

Figure 4. Type A. Relation between the differences of the second and the first and the third and the second measurements.

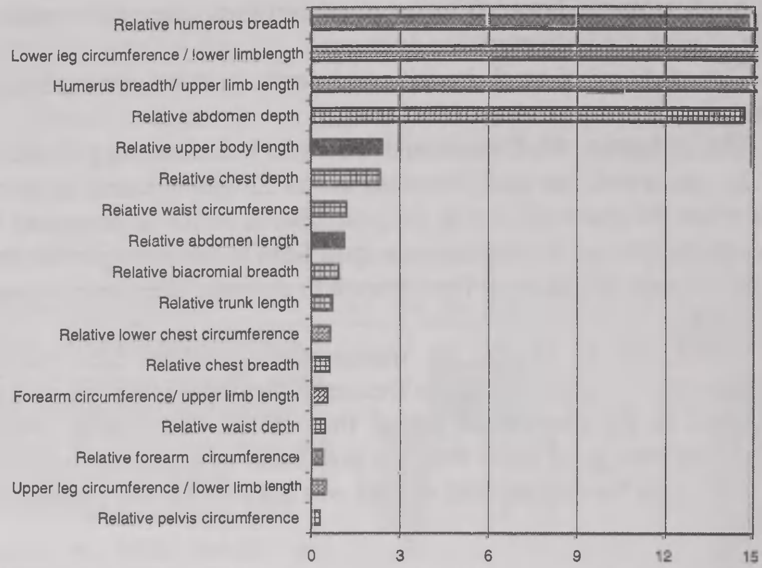

Figure 5. Type B. Relation between the differences of the second and the first and the third and the second measurements.

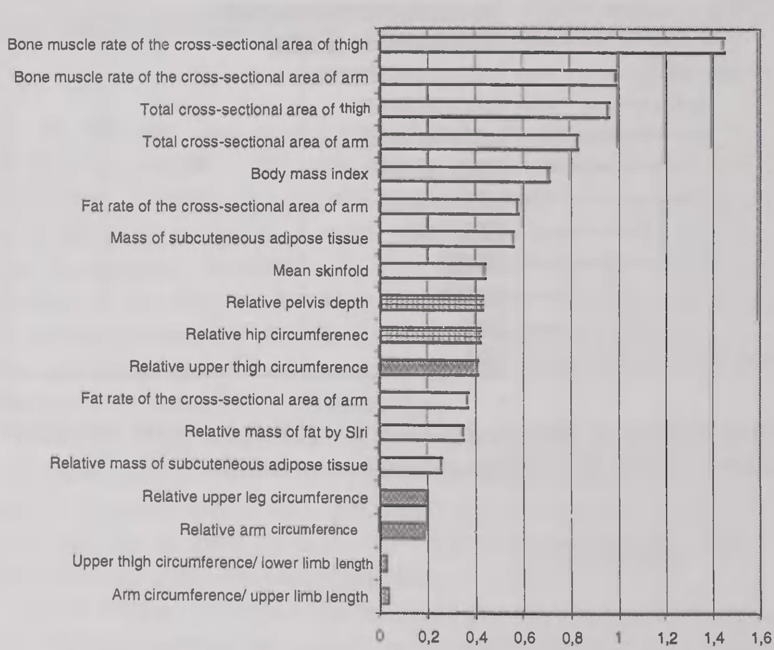

Figure 6. Type C. Relation between the differences of the second and the first and the third and the second measurements.

From that we can conclude that changes in girls' measurement relations do not happen evenly during the whole growth period, but in many cases the changes during the prepubertal and postpubertal periods have a different character.

DISCUSSION

Although, in addition to basic characteristics, indices and body composition indicators are often observed when studying growing girls' body build, the literature available to us did not contain comparative analysis of changes in proportions during the age from 8 to 18 years.

Our results showed that in pre- and postpubertal periods changes in indices could have different directions. The speed of changes in relations also varied considerably.

Consequently, the question would need further research, using both general material and classifications into different somatotypes.

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Papers on Anthropology XII, 2003, pp. 113–123

CARDIOVASCULAR DISEASE RISK FACTORS IN PRESCHOOL CHILDREN

Elvira Kurvinen[1], *Katrin Aasvee*[1], *Riina Zordania*[2]

[1] Estonian Institute of Cardiology, Tallinn, Estonia
[2] Tallinn Children`s Hospital

ABSTACT

Aim of the study was to determine traditional risk factors of cardiovascular disease and assess association Apo E phenotype with risk factors in preschool children. A cohort of 6-year old children (n=73) were investigated. We did not find differences in lipoprotein values according to gender, but Russian children had significantly higher TG levels compared to Estonian ones. Dyslipidemias were diagnosed in a half of investigated children. The most frequent dyslipidaemia was hypo-alphacholesterolaemia and elevated LDLC. A familial history of early myocardial infarction and/or stroke was reported on average for 32% of children. The prevalence of risk factors (dyslipidemia, obesity) did not differ in the groups of positive and negative familial history. The prevalence of obesity was 15.6% among girls and 11.1% among boys. BMI correlated positively with systolic blood pressure in the whole group of children. There were not significant differences in mean blood pressure according to gender in children, but Russian children had lower systolic and diastolic blood pressure as compared to Estonian children. The children carrying Apo E4 isoform had significantly higher systolic blood pressure as compared to those with ApoE3/3 phenotype. Children with ApoE3/3 phenotype had higher prevalence of risk factors as compared to ApoE4 carriers but in Apo E4 subjects different combinations of risk factors were more frequent than in Apo E3/3 phenotype group.

Key words: cardiovascular disease risk factors, preschool children, Apolipoprotein E

INTRODUCTION

Atherosclerosis begins in early childhood, although clinical symptoms of cardiovascular disease (CVD) do not appear until the fourth decade of life or later. Several studies have shown that there is a wide distribution of levels of the traditional risk factors in preschool-aged [1, 2] and school-aged children (3–7). A lot of investigations have studied extensively longitudinal cohort for CVD risk factors from birth into adulthood (11–16). Serum lipid levels measured in children and young adults are associated with atherosclerotic changes and predict coronary heart disease (CHD) as well a mortality due to cardiovascular diseases in middle age. Therefore, it is important to identify CHD risk factors as early as possible. CVD risk factors are often appearing in combination and aggregate together already from childhood, substantially increasing CVD risk [17, 10]. The main epidemiological studies [12, 18, 19] have shown that children with elevated total cholestrol (TC) or low density lipoprotein cholesterol (LDLC) levels tend to maintain high levels throughout childhood and into adult life. Being overweight in childhood has been shown to be predictive of a wide range of adverse health effects, especially increased morbidity from CVD in adulthood [20, 21]. In obese children dyslipidemia is considered to mediate the increased risk of future CVD [22]. Apolipoprotein (Apo) E, a component of plasma chylomicrons, chylomicron remnanats, very low density lipoproteins and high density lipoproteins (HDL) has three main isoforms E2, E3 and E4 [23]. Apo E phenotype is associated with TC and low density lipoprotein levels in blood serum [24, 25]. As Apo E polymorphism strongly affects the tracking of serum cholesterol the usefulness of cholesterol screening in predicting future cholesterol has to be evaluated taking into consideration of apo E phenotype [25] The aim of our investigation was to determine common risk factors of cardiovascular disease and assess association Apo E phenotype with risk factors in preschool children.

MATERIAL AND METHODS

Subjects

A cohort of 6-year old children (n=73) who were investigated first time at birth (1994–1995) in the framework of the projects *Distribution of risk factors of noncommunicable diseases in young families and their primary prevention and Monogenic lipid markers as a possible risk factor for early cardiovascular disease.*

Methods

This study includes inquiry by questionnaires, anthropometric measurements, clinical and biochemical investigations.

By questionnaires the *h*istory of CVD of parents and second degree relatives, child`s health indices were registered.

Anthropometric data. Height and weight were measured. Body mass index (BMI, kg/m^2) was calculated. Scinfolds on the triceps muscle (SCF 1) and subscapular area (SCF 2) were measured twice using Harpenden scin-fold caliper.

Blood pressure levels were measured twice on the right arm using mercury sphygmomanometer. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were recorded as the first and the fifth Korotkoff phases, respectively.

Blood samples. Fasting blood samples were drawn and total serum cholesterol (TC), high density lipoprotein cholesterol (HDLC) ang triglycerides (TG) were determined enzymatically in Tallinn Diagnostic Centre. Low density lipoprotein cholesterol (LDLC) level was calculated by the Friedewald formula [26]. Apo A-I and B were quantified by Laurell`s rocket-immunoelecrtoelectrophoresis [27] using references of Orion Diagnostica, Espoo, Finland. The method was intercalibrated with the immunoturbidimetric one used in the National Public Health Institute, Helsinki. Apolipoprotein E was determined by isoelectrofocusing with consequent protein blotting [28].

Risk factors threshold criteria.

Variable	Threshold criteria
Positive family history of CVD	Premature ($\leq$ 55 years) myocardial infarction or/and stroke in relatives
Biochemical parameters	Dyslipidemia (29):
	TC $\geq$ 5.2 mmol/l
	HDLC<0.9 mmol/l
	LDLC $\geq$3.4 mmol/l
	TG$\geq$1.7 mmol/l
Arterial hypertension	Boys >113/71 mmHg
	Girls>111/71mmHg (30)
BMI	Boys $\geq$17.3, girls $\geq$17.15 (30)

Statistical methods. *All statistical analyses were done using MedCalc packet (31). Mean values and standard deviations were calculated, to evaluate the statistical significance of the differences Student`s t-test was used.*

RESULTS

Serum lipoprotein values and dyslipidemia

The mean serum lipid and lipoprotein values by gender groups are shown in table 1. We did not find differences in lipoprotein values according to gender, but Russian children had significantly higher TG levels compared to Estonian ones (0.76±0.29 vs 0.64±0.18 mmol/l, $p<0.05$).

The prevalence of high lipid and lipoprotein values exceeding the risk thresholds accepted in Estonia is presented in table 2.

Apolipoprotein E polymorphism. The Apo E phenotypes were determined in all children. The most of the subjects had Apo E3/3 phenotype (62.7%). Carriers of E2 isoform (phenotypes 2/2+2/3) was 14.9% and E4 isoform (phenotype 4/3) 19% of children. No one children has ApoE4/4 phenotype. We did not find differences in Apo E phenotype frequencies between genders.

Table 1. Serum mean lipoprotein values according gender in preschool children.

Variable	Boys M ± SD, n=34	Girls M ± SD, n=36	p
TC, mmol/l	4.20 ± 0.72	4.24 ±1.05	ns*
HDLC, mmol/l	1.05 ± 0.25	0.99± 0.25	ns
TG, mmol/l	0.69 ± 0.22	0.68 ± 0.26	ns
LDLC, mmol/l	2.84 ± 0.73	2.95 ± 0.99	ns
Apo B, mg/dl	80.61 ± 11.53	83.05 ±18.40	ns
LDLC/Apo B,g/l	1.35 ±0.25	1.40 ±0.41	ns
HDLC %	25.45 ±6.43	24.17 ±7.21	ns
TC/HDLC	4.2 ±1.17	4.48 ±1.24	ns

*ns – difference between boys and girls is not significant

Table 2. Prevalence of dyslipidemias in preschool children.

Lipid variables	Prevalence (%)
TC≥5.2 mmol/l	14.3
LDLC≥3.4 mmol/l	22.9
HDLC<0.9 mmol/l	45.7
TG >1.7 mmol/l	–

Familial history of early CVD

A familial history of early myocardial infarction and/or stroke was reported on average for 32% of children. In 67% of cases the genetic load was mainly transmitted through mothers. In positive familial history group TC mean value was slightly higher (4.37±1.1 mmol/l) as compared to the group of children with negative familial history (4.17±0.85; $p>0.05$). Similar results were obtained for mean LDLC level (3.0±0.97 mmol/l and 2.83±0.83 mmol/l respectively, $p>0.05$). The prevalence of risk factors (dyslipidemia, obesity) did not differ in the groups of positive and negative familial history.

Obesity. Anthropometric data of children are presented in table 3. The girls showed significantly higher scin-fold thickness compared to boys. Sum of scin-fold thickness was significantly correlated to BMI (r=0.70;p<0.001). There were no significant differences in mean BMI between girls and boys. The prevalence of obesity was 15.6% among girls and 11.1% among boys. BMI correlated positively with systolic blood pressure (r=0.34; p<0.05) in the whole group of children.

Blood pressure. Mean blood pressure data according to gender are presented in table 3. There were no significant differences in mean blood pressure parameters in children, but Russian children had lower systolic (86.79±7.03 vs 91.22±7.22 mmHg; p<0.05) and diastolic (54.05±7.98 vs 58.42±7.92 mmHg,p<0.05) blood pressure as compared to Estonian children. The children carrying Apo E4 isoform had significantly higher systolic blood pressure as compared to those with ApoE3/3 phenotype (93.23±9.73 vs 86.65±5.79; p<0.05).

Prevalence and aggregation of CVD risk factors among children. Only third of children had no risk factors of CVD. Above half of the children had dyslipidemia (hyperTC and/or hypoHDLC and/or hyper LDLC). Obesity was diagnosed in 12.3% of children. One third of children had a complicated familial history for early CVD. Nearly half of children had one risk factor, 13% — two and 3 children (5.6%)– three risk factors.

Children with ApoE3/3 phenotype had higher prevalence of risk factors (79.5%) as compared to ApoE4 carriers (42.9%, p<0.05). In Apo E4 subjects different combinations of risk factors were more frequent (14.3%) than in Apo E3/3 phenotype group (2.9%;p<0.05).

Table 3. Anthropometrical data and blood pressure in preschool children.

Variable	Boys M ± SD, n=36	Girls M ± SD, n=37	p
Height, cm	120.10±5.82	121.05±3.76	ns
Weight, kg	21.84±3.39	22.42±3.81	ns
BMI, kg/m^2	15.10 ±1.65	15.25 ±2.01	ns
SCF 1, mm	10.45±2.33	11.72±2.33	<0,05
SCF 2, mm	5.69±1.19	7.13±2.72	<0,05
Birthweight,gr	3611.81±637.64	3387.68±622.56	ns
Systolic blood pressure, mmHg	88.17±7.25	89.73±7.6	ns
Diastolic blood pressure, mmHg	56.08±8.54	57.28±7.44	ns

Table 4. Prevalence of cardiovascular diseases risk factors in preschool children.

Risk factor	Prevalence (%)
Dyslipidemia	51.4
Obesity	12.3
Hypertension	–
Positive familial history to premature CVD	32.1

DISCUSSION

As more as learned about the natural history of the development of atherosclerosis, it is clear that the process that results in morbidity and mortality in adults, has its origins in childhood and adolescence. It is also clear that the traditional risk factors, such as dyslipidemia and hypertension are important in early stages of the process [32, 33].

Our study was aimed to identify the cardiovascular risk profile in cohort of preschool children. In our study the mean serum TC levels were higher than those of similar age children in study performing in Estonia previously [34]. It may be explained by differences in laboratory methods. We did not find differences in lipoprotein mean levels according to gender, but Russian children had significantly higher TG levels compared to Estonian ones. The most frequent risk factor among investigated children was dyslipidemia, the result is in accordance with previous studies in Estonia [8, 10]. Familial history for premature CVD was positive in one third of children. Some authors have demonstrated more atherogenic lipid profile in children with positive familial history for premature CVD, which is considered to be associated with certain genetic disorders influencing lipid metabolism [37, 35, 36]. The differences in serum lipid levels according to familial history were not significant in our study.

The anthropometric measurements revealed lower body mass index as compared to the data obtained in Estonia previously [34]. Relatively high percent (12,3%) of obese children may be explained by the critical period for the development of obesity during childhood. These include early infancy, the period between 5 and 7 years, and adolescence [38]. Childhood obesity is known to be a risk factor for adults obesity which is a risk factor for hypertension and contributor to mortality from hyperlipidemia and atherosclerosis [39, 40]. BMI was highly correlated with systolic blood pressure in this study. A stepwise regression analysis showed that waist circumference, age, and BMI were strong predictors for systolic blood pressure, while waist circumference and age were predictors for diastolic blood pressure [40]

Apolipoprotein E phenotype is a genetic determinant of plasma lipid levels and of coronary heart disease risk [41, 42]. The systolic blood pressure was higher and aggregation of risk factors more frequent in the group of children carrying E4 isoform as compared to those with ApoE3/3 phenotype. The phenotype groups did not differ by age and BMI, thus, these factors were not modifiers of blood pressure levels in this study. Controversial data were shown in Young Japanese study where ε4 allele was associated with lower blood pressure [43].

In conclusion, we have evaluated the occurrence of traditional risk factors of CVD in cohort of preschool children. The high prevalence of risk factors, especially dyslipidemia is evident.

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THE MEASUREMENT OF BODY COMPOSITION USING SKINFOLD THICKNESS OR BIOELECTRICAL IMPEDANCE METHODS IN CHILDREN

Aire Leppik, Toivo Jürimäe, Jaak Jürimäe

Chair of Sport Pedagogy, University of Tartu, Tartu, Estonia

ABSTRACT

The aim of this study was to compare the body fat % measured by DXA with different regression equations presented for measurement body composition using skinfold thickness or BIA methods in 11–12 year-old boys (n=26) and girls (n=27). Body fat % was calculated using Slaughter et al. [4] Slaughter et al. [13], Lohman [7] and Boileau et al. [2] skinfold thickness equations. In addition, Houtkooper et al. [5] and Lukaski et al. [9] BIA equations were used. Our results indicated that most of the equations presented for calculation body fat % in children are significantly different for 11–12 year-old boys and girls. The results of this study clearly indicated the importance of selecting a field techniques and regression equations that are appropriate for the population in which they are used. Slaughter et al. [13] skinfold thickness equation is recommended to use in Estonian 11–12 year-old children.

Key words: Body fat %, skinfold thickness, BIA, DXA, children.

INTRODUCTION

There are numerous methods available to assess human body composition. Skinfold measurements and bioelectrical impedance analysis (BIA) are well-known field methods. These methods are simple, inexpensive and non-invasive techniques. Determination of body composition in children is a complex problem. Changes in anthropometrical parameters, body shape, fat proportion and fat patterning during growth may invalidate the assumptions underlying the skinfold and BIA techniques [10]. Furthermore, it is well known that the water and mineral content of fat-free body changes with the development of children [8], invalidating the assumptions of the two-compartment model (fat and fat-free body). As a rule, prior to sexual maturation, children have more water and less bone mineral content than adults, resulting in fat-free mass which is lower in density that the adult value of 1.1 $g \cdot ml^{-1}$ [6]. Accordingly, the use of adult regression equations (which assume a constant composition of fat free body) to estimate body fat % from skinfold thicknesses and BIA in children can result in significant errors [13].

Frequently, dual-energy X-ray-absorptiometry (DXA) has emerged one of the most accepted methods of measuring body composition in human subjects. The popularity of DXA can be attributed to its speed, easy of performance and low radiation exposure [11]. Very frequently DXA are used for validation of different skinfold thickness or BIA equations.

The aim of this study was to compare the body fat % measured with DXA with different regression equations presented for measurement body composition using skinfold thickness or BIA methods in 11–12 year-old boys and girls.

METHODS

The subjects of this investigation were 26 boys and 27 girls, 11–12 years of age. The children were from several schools in Tartu, Estonia (about 100. 000 inhabitants) and all children were in Estonian origin. The children participated in school in 2–3 compulsory physical education lessons per week, which were conducted by a teacher of physical education.

All measurements were performed in the morning at school after emptying the bladder. All children had a light traditional breakfast. The children did not exercise before the testing. All children were on Tanner stage [14] 2 or 3.

The stature was measured using a Martin metal anthropometer in cm (±0.1) and body mass was measured with medical scales (A&D

Instruments, Ltd, UK) in kg (±0.05 kg). The body mass index (BMI) was calculated as weight/height^2 (in kg/m^2). In total, nine skinfolds (triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh, medial calf, mid-axilla) were measured. The skinfold thicknesses were measured using Holtain (Crymmych, UK) skinfold callipers. All anthropometrical parameters were measured according to the protocol recommended by International Society for the Advancement of Kinanthropometry [12]. Body fat % was calculated using Slaughter et al. [4], Slaughter et al. [13], Lohman [7] and Boileau et al. [2] equations.

The body impedance was measured with a multiple-frequency impedance device (MULTISCAN 5000, Bodystat Ltd, UK). Children were placed on a supine position with limbs slightly abducted. Skin current electrodes were placed on the right dorsal surface at the hand and on foot at the metacarpals and metatarsals. The distance between the source and receiving electrodes was all times higher than 5 cm [3]. Body impedance at the standard frequency of 50 kHz was used. Body fat % was calculated with using Houtkooper et al. [5] and Lukaski et al. [9] equations.

Body composition was assessed by whole-body DXA using the DPX-IQ densitiometer (Lunar Corp; Madison, USA). Children were scanned from head to toe in 10–15 min and the total body fat % was used.

Standard statistical methods were used to calculate mean (X) and standard deviation (±SD). Differences between groups or between different body fat % measured by different methods were calculated using Students t-tests. Methodological differences between body fat % calculated by skinfold thickness or BIA equations and body fat measured by DXA were also analyzed by Bland and Altman [1]. Significance was set at $p<0.05$.

RESULTS

Mean anthropometrical parameters are presented in Table 1. Body weight and BMI were significantly higher in boys compared with girls. There was not any significant differences between boys and girls in body height and sexual maturation (Tanner stage).

Table 1. Anthoropometrical parameters of subjects (X±SD).

	boys (n=26)	girls (n=27)	p
Age (years)	12.2±0.7	11.8±0.7	<0.05
Height (cm)	156.7.2±7.2	152.8±8.5	>0.05
Weight (kg)	45.2±8.3	39.4±6.3	<0.01
BMI (kg/m^2)	18.4±2.5	16.8±1.5	<0.01
Tanner stage	2.34±0.49	2.41±0.69	>0.05

Body fat % measured by different skinfold thickness or BIA equations are presented in Table 2. As a rule, body fat % was higher in girls but only using Lohman [7] equations this differences was statistically significant. Significance of differences between body fat % measured by different methods are presented in Table 3. Our results indicated that most of the equations presented for calculation body fat % in children are significantly different. Using body fat % measured by DXA as a criterium we can conclude that only Slaughter et al. [13] skinfold thicknesses methods (both sexes) and Lohman [7] in girls and Boileau et al. [2] in boys are not significantly different from DXA results. Both BIA equations are significantly different from body fat % measured by DXA. As a rule, body fat % measured by skinfold thicknesses or BIA methods using different equations are significantly different (Table 3).

Figure 1 and 2 gives the results of the Bland-Altman analysis for body fat % calculated by skinfold thicknesses and BIA equation calculated and body fat % measured by DXA. Comparison of methods demonstrated wide differences between methods.

Table 2. Mean body composition parameters measured by skinfold thicknesses, BIA and DXA in boys and girls (X±SD).

	Boys (n=26)	Girls (n=27)	p
DXA	17.0±7.1	18.9±5.2	>0.05
SKINFOLDS:			
Slaughter et al. [13]	12.4±5.9	12.4±5.9	>0.05
Slaughter et al. [4]	17.2±6.8	19.3±4.6	>0.05
Lohman [7]	11.0±8.0	20.1±4.1	<0.001
Boileau et al. [2]	18.6±12.1	22.8±8.8	>0.05
BIA:			
Houtkooper et al. [5]	15.4±8.0	17.4±4.9	>0.05
Lukaski et al. [9]	9.7±6.9	9.8±6.4	>0.05

Table 3. Significance of differences between body fat % measured by different methods in boys (girls in bracket).

Method	Slaughter et al. [13]	Slaughter et al. [4]	Lohman [7]	Boileau et al. [2]	Houtkooper et al. [5]	Lukaski et al. [9]
DXA	<0.05 (<0.05)	>0.05 (>0.05)	<0.05 (>0.05)	>0.05 (<0.05)	<0.05 (<0.05)	<0.05 (<0.05)
Slaughter et al. [13]		<0.05 (<0.05)	>0.05 (<0.05)	<0.05 (<0.05)	<0.05 (<0.05)	<0.05 (<0.05)
Slaughter et al. [4]			<0.05 (<0.05)	>0.05 (<0.05)	<0.05 (<0.05)	<0.05 (<0.05)
Lohman [7]				<0.05 (<0.05)	<0.05 (<0.05)	>0.05 (<0.05)
Boileau et al. [2]					<0.05 (<0.05)	<0.05 (<0.05)
Houtkooper et al. [5]						<0.05 (<0.05)

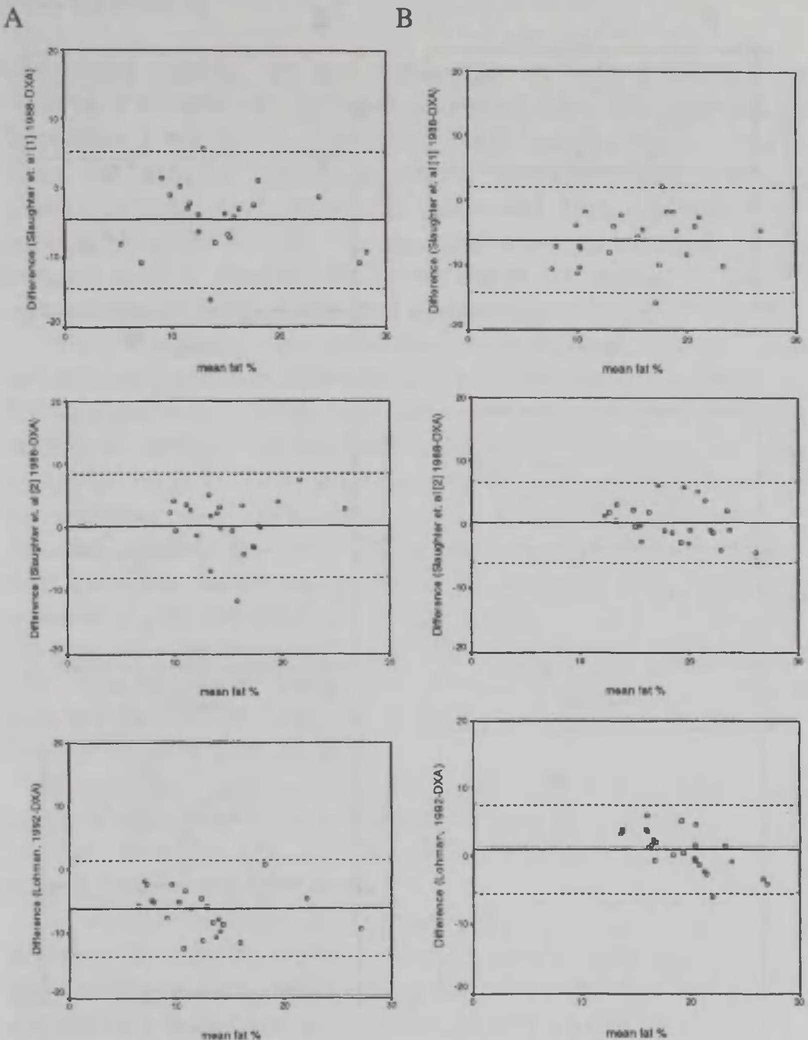

Figure 1. Bland-Altman plots of body fat % calculated by different skinfold thickness equations and DXA in children (A — boys, B — girls).

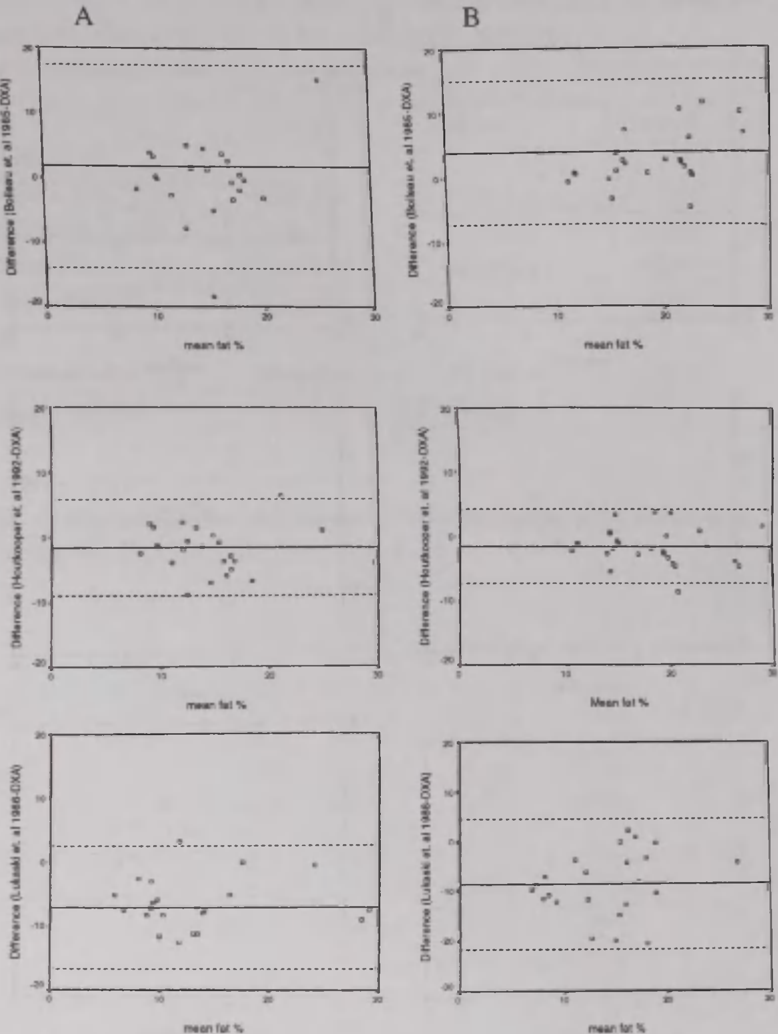

Figure 2. Bland-Altman plots of body fat calculated by Boileau et al. [2] skinfold thickness equation and Houtkooper et al. [5] and Lukaski et al. [9] BIA equations and DXA in children (A — boys, B — gilrs).

DISCUSSION

Our results indicate that the measurement of body composition in children is complicated. Different regression equations presented for calculation body fat % give usually significantly different results. Thus, the need for specific regression equations where age, sex, physical activity level, race, etc., parameters have been taken into account equations is high. On the other side, the relatively simple methods such as skinfold thickness or BIA are needed for routine measurement of body composition in children.

When comparing the differences between body fat % values estimated using the skinfold thickness techniques only Slaughter et al. [13] equations were similar ($p>0.05$) with DXA results. The mean difference between methods was 0.2 and 0.3% respectively in boys and girls (Table 2). Thus, from the used skinfold thickness equations the Slaughter et al. [13] equation is very promising for using in Estonian children. However, there was not a significant differences between DXA results and body fat % calculated by Lohman [7] equation in girls and Boileau et al. [2] equation in boys (Table 3). On the other side, the mean differences between methods were quite high when compared with Slaughter et al. [13] equations. The another equation presented by Slaughter et al. [4] highly underestimated body fat % in Estonian boys and girls.

Surprisingly, both used BIA equations presented significantly different mean body fat % values compared with DXA results (Table 2). The difference was very high when compared the results with using Lukaski et al. [9] equations.

In summary concluded that the results of this study clearly indicated the importance of selecting a field technique and regression equation that is appropriate for the population in which it is used. For measurement body fat % in Estonian children the use Slaughter et al. [13] skinfold thickness equation is reccommended.

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A SHORT REVIEW OF CONSCRIPTS STUDIES AND SECULAR TREND OF EIGHTEEN-YEAR-OLD CONSCRIPTS' HEIGHT AND WEIGHT IN TARTU AND TARTU COUNTY

Mart Lintsi, Helje Kaarma

Centre for Physical Anthropology, University of Tartu, Estonia

ABSTRACT

The aim of the present study was to investigate the secular trend of changes in the height and weight of 18-year-old schoolboys and conscripts from the town of Tartu and Tartu county. Another aim of the present study was to give a short review of research of conscripts. 1459 conscripts at the age of 18 years from the town of Tartu and Tartu county were recruited for the study. Thirty-five anthropometric variables and twelve skinfolds were measured according to the recommendations of R. Martin and R. Knussmann. The data of their mean height and mean weight were compared with the same data of earlier studies of conscripts or 18-year-old schoolboys of town Tartu and Tartu county. The study showed that from 1886 to 1998–2002 the mean height of Tartu and Tartu county conscripts had increased by 11.3 cm. From 1978 the mean height increase stopped. The mean weight of conscripts continued to increase especially as compared with the mean weight of Tartu schoolboys in 1978. The mean height of Tartu and Tartu county conscripts was at the same level as the mean height of their peers from Finland, Sweden, Norway and Germany. The situation of the mean weight is different. Tartu and Tartu county conscripts' mean weight was lower than the mean weight of their peers from Finland, Sweden and Germany.

Key words: body height, body weight, secular trend

INTRODUCTION

The Estonian defense forces rely on compulsory military service and all men reaching the age of 18 years have to meet a conscription board for examination and classification for military service. Attendance includes a medical examination revealing the person's health profile. As a part of medical examination conscripts' height, weight, head and chest circumference are measured.

Like in Estonia, there used to be a tradition of compulsory military service in Czarist Russia and the former Soviet Union, and still is in Finland, Sweden, Norway, Denmark, Germany, Portugal and many other countries of Europe and the world.

As conscripts have been studied thoroughly in a medical, psychological and anthropological sense, there are studies on conscripts' medical screening for pulmonary tuberculosis [9], sexual behaviour and sexually transmitted diseases [63, 64], bone stress injuries [25, 29], patellar dislocation [48], incidence of injuries during military training [16, 50, 60], the possible role of low IQ in risk for schizophrenia [11], possible role of fish eating to the health of fishermen's sons [61], substance use follow-up [66], risk of mortality from drunk driving and risky driving [23], parental divorce influence on conscripts' well-being, mental health and risk for mortality [15], possible influence of inhaled steroids on the height of conscripts [51], birth weight and height influence on conscripts' height [65], influence of social factors on orphans' height [58], association of low birth weight and BMI with reduced visual acuity and impaired hearing of conscripts [53], short body height association with the risk of attempted suicide [21], secular trend changes of conscripts in height and BMI between the mid-1960s and the mid-1990s [5], social class specific changes in secular trends of stature [3], different educational level (basic vocational school vs. secondary school or college students) association with tallness [4]. Conscripts with migrant parents have been found to be taller compared to conscripts with non-migrant parents [27]. The odds ratio for being overweight was four times higher among 18-year-old Swedish conscripts — sons of immigrants from Finland — than among sons of Swedish mothers [52]. Between 1971 and 1995, overweight in 18-year-old conscripts in Sweden increased 2.4 times and the prevalence of obesity 3.5 times [56]. Secular trend of 18-year-old conscripts' height in Portugal has been found to be dependent on social status and geographic area [54].

Secular trend in West German and in East German conscripts before and after reunion has been studied [19]. Secular increase in stature among Belgian conscripts between 1920 and 1970 was 1.6 cm per decade [71]. Height of 18-year-old Czech boys increased from 173.4 cm in 1951 to 178.84 cm in 1991 [72]. Secular increase of army recruits height from 165.8 cm in 1900 to 175.1 cm in 1990 was registered in France [12]. Changes in conscripts' height have studied in Hungary [7, 14], Italy [62], Spain [57], The Netherlands [8], Russia [13], Britain [59], Norway [70], Sweden [18, 30].

In the previous decade, many Estonian researchers, too, have studied conscripts, recruits and servicemen [1, 22, 28, 68, 69]. There are also data on Latvian servicemen and cadets [55].

At the University of Tartu, the Centre for Physical Anthropology, in collaboration with the Department of Psychiatry, started in 1996 a study of anthropometry, temperament, health and nutritional habits of boys in the last forms Estonian-language secondary schools of Tartu [31–34] and from the 1998 anthropometric and body composition research of Tartu and Tartu county conscripts [35–46].

The first aim of the present study was to investigate the secular changes in Tartu and Tartu county 18-year-old conscripts' height, weight and BMI and compare these data with the data of their peers from Finland, Sweden, Norway and Germany.

MATERIAL AND METHODS

The sample considered in this study included 1459 conscripts of 18 years of age from the South Department of the Estonian Defense Ministry (Tartu and Tartu county). 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 at 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), trunk length (suprasternal minus symphyseal height) and lower limb length (iliospinale +symphysiale)/2 were calculated [20].

The measurements were taken following the rules of R. Martin [49] and R. Knussmann [26]. Skinfolds thickness was measured at standardized sites according to Knussmann (26), Lohman et al. [47], Heyward and Stolarczyk [17]. The level of significance was set at $p<0.05$. Statistical package SAS® for Windows 6.12 version was used for these calculations.

RESULTS

The results are presented in Table 1.

The first data of anthropometric measurement of Tartu conscripts are the historical data of Ströhmberg [67] on Tartu schoolboys and conscripts from 1886–1887.

The second anthropometric study of Tartu conscripts was conducted by Weinberg [73] in 1899. Aul [2] investigated Tartu and Tartu county 18-year-old schoolboys in 1957 and 1978.

Table 1. Changes in height and weight of 18-year-old conscripts and schoolboys from Tartu town and county from1886 to 1998–2002.

Variable	Year	Author	Height in cm	Weight in kg	BMI
Conscripts of Dorpat (today Tartu)	1886–1887	Ströhm-berg	168.5		
Conscripts of Dorpat (Tartu)	1899	Wein-berg	167.0		
Schoolboys of Tartu	1957	Aul	174.6	66.21	
Schoolboys of Tartu county	1957	Aul	172.4	64.95	
Schoolboys of Tartu	1978	Aul	179.8	67.28	
Schoolboys of Tartu county	1978	Aul	179.5	69.80	
Schoolboys of Tartu and Tartu county	1996–1997	Lintsi et al.	179.63±6.33	70.36±9.29	21.65±2.33
Conscripts of Tartu and Tartu county	1998–2002	the present study	179.81±6.59	70.38±10.64	21.74±2.84

DISCUSSION

Statistics of conscripts' mean height are an important tool for studying secular changes. Within the 115 years from Ströhmberg's study [67] of Dorpat (today Tartu) conscripts' mean height in 1886 to the present study of Tartu and Tartu county conscripts, the mean height has increased by 11.3 cm. The mean increment of height has been 0.97 cm per decennium. Between Ströhmberg's and Weinberg's study [73] the mean height diminished (decrement 1.25 cm per decade). Between the two studies of Aul [2] in 1957 and in 1978, a substantial increase in height took place. The height of Tartu town 18-year-old schoolboys increased by 5.2 cm, and the height of their peers in Tartu county increased simultaneously by 7.1 cm. The increments per decade were 2.48 cm and 3.38 cm respectively. From 1978 until today, the mean height has been in the phase of a plateau — that means the changes are minimal. The evolution of conscripts' mean height into the phase of a plateau is also symptomatic of the conscripts of Sweden (mean height in 1977 179.0 cm and in 1996 179.4 cm) [30] and Norway, whose mean height increment was only 1 cm during the last 30 years, the mean height being 179.7 cm in 2000 [6]. The situation is similar in Finland where over last 22 years the mean height of 18-year-old boys has increased by 0.9 cm, to 179.1 cm in 1999 [24]. In West Germany the mean height of conscripts increased by 0.6 cm during the last 16 years, to 179.6 cm in 1998 [19]. Thus, we may conclude that height is very homogeneous in Tartu town and county, Sweden, Norway, Finland and Germany.

Next we shall examine the weight of conscripts and 18-year-old schoolboys in Tartu. Auls's [2] study of 18-year-old schoolboys of Tartu town and county in 1957 fixed the mean weight for town boys as 66.21 kg and for Tartu county schoolboys 64.95 kg. In the study of 1978 Aul [2] observed that the mean weight of 18-year-old schoolboys in the town of Tartu had increased to 67.28 kg (increment 0.509 kg per decennium year) and in Tartu county to 69.80 kg (increment 2.43 kg per decennium). Today the mean weight of 18-year-old conscripts in the town and county of Tartu is 70.38 kg. As compared to the data on the mean weight of 18-year-old schoolboys in 1978, the mean weight has increased. It is interesting to note that the mean weight of Swedish conscripts in 1977 was 69.0 kg and in 1996 71.9 kg (increment 1.526 kg per decennium). In Finland the mean weight of 18-year-old boys increased from 1977 to 1999 by 3.2 kg to 72.1 kg (increment per decennium 1.454 kg). The mean weight of West-German conscripts increased from 1978 to 1998 by 4.4 kg to 74.0 kg (increment 2.2 kg per decennium).

Thus, we can conclude that distinctly from the height evolution of conscripts, the weight evolution is still in progress in the town and county of Tartu as well as in Sweden, Finland and West Germany. It is symptomatic that the mean weight of 18-year-old conscripts of Tartu and Tartu county was and still is lower than the mean weight of their peers from Finland, Sweden and West Germany.

The prevalence of overweight and obesity according to international body mass index (BMI) criteria [10] among the conscripts of Tartu town and Tartu county was 8.77% and 1.44% respectively. Estimating the prevalence of overweight and obesity by the same cut-off points for BMI, the prevalence of overweight and obesity among 18-year-old schoolboys of Finland was higher, 15.3% and 2.4% [24].

According to international reference values, the prevalence of overweight in 18-year-old boys increased from 6.5% to 15.3% between 1977 and 1999, and obesity increased from 0.0% to 2.4% in the same period.

The data obtained from compulsory medical examinations held at military induction at 18 years of age in Sweden showed a 2.4-fold increase in the prevalence of overweight over the period of 1971–1995 from 6.9% to 16.3% [56]. Over the same years, the prevalence of obesity increased from 0.9% to 3.2%.

We can summarize our discussion by stating that among the 18-year-old conscripts of Tartu town and county the prevalence of overweight and obesity is lower than among Finnish 18-year-old boys and Swedish 18-year-old conscripts.

It may also be concluded that examinations for military service can offer useful data on the health and development of young men. There is no doubt that comparison of conscripts data over time will enable us to monitor changes in physical development and body build, which can be summarized by the term secular trend in Estonia.

ACKNOWLEDGEMENTS

We thank the Head of the South Department of the Estonian Defence Ministry Captain M. Kraav, the staff and individuals who participated in the present study. We acknowledge the Estonian Science Foundation grants TMTMS 1776, DARCA 1527 and the Estonian Ministry of Social Affairs grant SARCA 06299 for financial support.

We thank Professor Emeritus Ene-Margit Tiit, the former Head of the Institute of Mathematical Statistics of the University of Tartu, for her advice on the statistical aspects of the paper.

We are indebted to Dr Liidia Saluste PhD, Mrs Liina Saluste, Dr Ülle Kirss, Mrs Merike Kompus and Mr Mart Paama for their help to this study.

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LONGITUDINAL CHANGES IN ANTHROPOMETRIC AND BLOOD PRESSURE VARIABLES IN RELATION TO PHYSICAL ACTIVITY IN MEN: A 9-YEAR FOLLOW-UP

Mari-Liis Luuk[1], *Eve Pihl*[2]

[1] Institute of Sports Pedagogy,
[2] Department of Biochemistry, University of Tartu, Tartu, Estonia,

ABSTRACT

The purpose of the study was to evaluate longitudinal changes in overweight values (BMI, skinfold thicknesses, body fat % and WHR) as well as in resting blood pressure in relation to the physical activity level in males. A 9-year follow-up was performed in 42 male subjects aged 30–50 years. The examinations (anthropometric, blood pressure and physical activity measurements) were performed in 1993 and in 2002. Our study results revealed significant changes in the mean body weight, BMI, WHR, body fat percentage, skinfold thicknesses as well as in resting blood pressure during the 9-year follow-up, showing higher values in 2002. The mean body fat of the study group increased 6.7% during the follow-up (approximately 0.75% per year) and the number of obese subjects (body fat >20%) increased from 2 to 10 subjects during the follow-up. The number of hypertensive subjects (BP ≥140/90 mmHg) increased from 4 to 12 during the follow-up ($p<0.05$). The correlation analysis indicated that PA frequency was significantly related to BMI, WHR, and chest skinfold thicknesses. The mean duration of the one PA session and the average training volume were independently related to the body weight, BMI, WHR, body fat percentage, chest and abdomen thicknesses, and hypertension prevalence. No significant correlations were found between PA measurements, thigh skinfold thicknesses and the mean blood pressure values. In conclusion, our 9-year follow-up data showed significant changes in all the measured overweight characteristics, the fat distribution pattern (WHR), and resting blood pressure in men. There were significant independent associations between physical activity characteristics (frequency, duration, average training volume) and overweight values. The duration and the total training volume were inversely related to hypertension prevalence.

Key words: body fat percentage, body mass index, hypertension, middle-aged men

INTRODUCTION

It has been stated that there is a strong relationship between obesity and several health problems, including a cardiovascular disease (CVD) [9, 13]. Several studies have also reported that the regional distribution of body fat is also a significant and independent risk factor for CVD [2, 3, 13]. Positive correlations exist between the body weight, particularly the abdominal fat distribution pattern and CVD risk factors such as elevated blood pressure, altered serum lipoprotein and glucose metabolism [18].

Aging is characterized by gradual changes in the body composition. There is an increase in body fat and a decrease in the muscle mass, the non-muscle lean tissue mass, and the bone mineral density [6, 17]. Some of these changes, notably increased fat mass, have been attributed to decreased physical activity (PA) rather than to an inevitable biological effect of aging itself [4]. It has been stated that regular physical activity is one of the most useful behaviours to reduce body weight and the abdominal fat distribution pattern [19]. Thus, it becomes important to define the relationship between physical activity, the body composition and aging. Increased exercise among aging healthy persons could be encouraged by a better understanding of how it could be expected to improve body compositions and to decrease the risk of disease.

The purpose of the present study was to evaluate longitudinal changes in overweight values (BMI, skinfold thicknesses, body fat % and WHR) as well as in resting blood pressure in males during the 9-year period and to find out the associations between the physical activity level and overweight indices.

MATERIALS AND METHODS

Subjects

A 9-year follow-up was performed in 42 male subjects. Study subjects were moderately physically active when they were included into the study in 1993. All the participants were apparently healthy and without regular medication. The local Medical Ethics Committee of the University of Tartu approved of the protocol and all the participants signed an informed consent document.

All the baseline examinations (anthropometric, blood pressure and physical activity measurements) were performed in 1993 and in 2002, the mean follow-up time was 9.0± 0.8 years.

Anthropometric measurements

The subjects' height and weight were determined by the Martin metal anthropometer (±0.1 cm) and clinical scales (±0.05 kg), respectively. The body mass index (BMI) was calculated ($kg \cdot m^{-2}$). Skinfold thicknesses were measured at chest, abdomen, and thigh [1] by using previously calibrated skinfold calippers (Holtain, Crymmych, UK). The mean of the three measurements was used. The body fat percentage was calculated according to Baun et al. [1]. For the evaluation of fat distribution, waist and hip circumferences were measured, and the ratio of waist and hip circumferences (WHR) was calculated.

Blood pressure measurements

Sitting blood pressure (BP) was measured using a mercury sphygmomanometer after a five-minute rest. Systolic (Korotkoff phase 1) and diastolic (Korotkoff phase 5) blood pressures (BPsyst, BPdiast) were measured twice on the left upper arm, and the average was used for the analysis. According to the hypertension criteria published by the National High Blood Pressure Education Program Working Group [12], a systolic blood pressure ≥140 mmHg and diastolic blood pressure ≥90 mmHg is defined as a mild arterial hypertension.

Physical activity

The subjects completed a questionnaire to evaluate their current physical activity (PA) and during the follow-up time in detail (mode, weekly frequency, mean duration, intensity).

Statistical analysis

The results are presented as a mean ± standard deviation (x±SD). The Pearson product moment or Spearman correlations (r) were used to determine the relationships between variables. The partial correlation analysis was used to eliminate the effects of age. The paired sample T-test for dependent variables was used to determine differences in the variables measured in 1993 and in 2002. Calculations were performed with the SPSS (SSPS Inc, Chicago, IL) statistical package. Statistical significance was defined as $p<0.05$.

RESULTS

Our data showed significant differences in the body weight, BMI, WHR, the body fat percentage and skinfold thicknesses measured in 1993 and 2002 (Table 1), showing higher values in 2002. During the 9 years, the mean weight of the men increased 5.5 kg. The frequency data showed that there were 10 and 15 overweight subjects ($BMI \geq 27.0$) in 1993 and 2002, respectively. The body fat percentage exceeded 20% in 2 and 10 subjects in 1993 and 2002, respectively. The mean body fat of the study group increased 6.7% during the follow-up (approximately 0.75% per year).

Tabel 1. Main anthropometric, blood pressure and physical activity data of the subjects (n=42).

Parameters	1993	2002	p-value
Age (yrs)	39.4 ± 7.5	48.9 ± 6.6	$p < 0.001$
Height (cm)	179.6 ± 7.8	179.1 ± 7.9	$p > 0.05$
Weight (kg)	80.5 ± 11.3	86.0 ± 13.9	$p < 0.001$
BMI (kg/m²)	24.9 ± 2.8	26.8 ± 3.6	$p < 0.001$
WHR	0.86 ± 0.05	0.89 ± 0.06	$p < 0.001$
Body fat (%)	12.0 ± 5.1	18.7± 6.7	$p < 0.001$
Skinfolds (mm)			
Chest	8.9 ± 5.7	14.8 ± 7.0	$p < 0.001$
Abdomen	16.4 ± 8.5	27.3 ± 13.1	$p < 0.001$
Thigh	11.9 ± 5.1	16.7 ± 5.7	$p < 0.001$
BPsyst (mmHg)	121.8 ± 12.9	131.7 ± 14.1	$p < 0.001$
BPdiast (mmHg)	79.3 ± 10.9	86.9 ± 8.8	$p < 0.01$
PA (hr/week)	3.79 ± 3.0	3.92 ± 2.7	$p < 0.001$

Note: PA — physical activity; BPsyst- systolic blood pressure; BPdiast — diastolic blood pressure

There were significant changes in the mean systolic and diastolic blood pressure values during the nine years, showing higher values in 2002. The number of hypertensive subjects (BP ≥140/90 mmHg) increased from 4 to 12 during the follow-up.

Our data showed that the mean weekly sports activity engagement (hours/week) of the study group increased during the follow-up (Table 1). There were 16 men whose PA amount increased and 18 men whose PA amount decreased during the 9-year period, 8 persons did not change their PA activity level.

The correlation analysis revealed that PA frequency was significantly related to BMI, WHR, and the mean chest skinfold thicknesses (Table 2). The mean duration of one PA session and the average training volume were related to BMI, WHR, the body fat percentage, chest and abdomen thicknesses, and hypertension prevalence. No significant correlations were found between PA measurements, thigh skinfold thicknesses and the mean blood pressure values. After adjustment for age, associations between PA characteristics and overweight values remained significant (according to the partial correlation analysis). There were significant positive correlations between hypertension, age, BMI, body fat % and WHR (r=0.375–0.478, p=0.02–0.001).

Table 2. Correlation coefficients (r) between physical activity characteristics, overweight variables, the distribution of body fat and blood pressure data (n=42), in the brackets correlation coefficients adjusted for age are presented.

	PA Frequency (times per week)	PA Duration (min per one session)	PA Average training volume (min per week)
Weight (kg)	–.132 (–.369*)	–.154 (–.399*)	–.124 (–.376*)
BMI (kg/m²)	–.323 # (–.465 #)	–.490 # (–.432 #)	–.517** (–.462#)
WHR	–.437 • (–.531 •)	–.708 • (–.649 •)	–.649 • (–.572 •)
Body fat (%)	–.244 (–.264)	–.578 # (–.450 #)	–.437 # (–.279*)
Chest (mm)	–.339* (–.421#)	–.572 • (–.503 #)	–.495 # (–.407 #)
Abdomen (mm)	–.224 (–.297)	–.477 # (–.404 #)	–.391* (–.293*)
Thigh (mm)	–.210 (–.042)	–.232 (–.216)	–.117 (–.088)
BPsyst (mmHg)	–.074 (–.125)	–.172 (–.240)	–.137 (–.157)
BPdiast (mmHg)	–.125 (–.087)	–.233 (–.205)	–.209 (–.097)
Hypertension	–.204 (–.272)	–.319* (–.387*)	–.280* (–.293*)

Note: PA –physical activity; BPsyst- systolic blood pressure; BPdiast — diastolic blood pressure; hypertension (BP ≥140/90 mmHg); *p<0.05; #p<0.01; •p<0.001

DISCUSSION

In this follow-up study, we found significant changes in all the measured overweight characteristics, fat distribution (WHR) and resting blood pressure in men, showing higher values in 2002. Our data showed significant associations between physical activity characteristics (frequency, duration, average training volume) and overweight values.

It is found that between the ages of 25 and 65, there is a substantial decrease (10% to 16%) in the fat free mass due to losses in the bone mass, the skeletal muscle, and the total body water [7]. Weight and weight change are determined by multiple factors: physical activity, fat intake and total energy intake. However, there is little information on the benefits of the PA in relation to the overweight and fat distribution pattern. Pollock et al. [16] found that the body fat content increased by ~2% over 10 years in highly physically active male athletes. Our data showed that during the 9-years follow-up, the mean body weight increases approximately 5.5 kg and the mean body fat percentage increased 6.7% (Table 1). Although our study group was relatively physically active (the mean PA engagement was 3.79 and 3.92 hours/week, respectively in 1993 and 2002), the mean body fat percentage increased approximately 0.76% per year. The correlation analysis revealed that the duration and the average training volume of the PA were inversely related to all the overweight values (BMI, fat%, WHR, chest and abdomen skinfolds) (Table 2). No significant correlations were found between PA characteristics and thigh skinfolds. The PA frequency had statistically significant associations with BMI, WHR, and the mean chest skinfold thicknesses. Thus, our results confirm that the duration and the total amount of physical activity are more important in the overweight management than the frequency of the PA. In the present study, it seems that physical activity has the strongest associations with the abdominal fat distribution pattern (WHR) in comparison with overweight values (BMI and fat percentage).

Overweight and even a modest weight gain increase the risk of hypertension [8]. In the Framingham Study, the risk of hypertension was related to the weight change after 25 years of age [10]. Our data showed that during the 9-year follow-up the mean systolic blood pressure increased approximately 9.9 mmHg and the diastolic blood pressure 7.6 mmHg. A significant outcome was observed in the hypertension prevalence (2 versus 10 subjects, in 1993 and in 2002, respectively). Our data provide evidence that the body weight, the weight change and overweight values are significantly related to hypertension prevalence. It is in accordance with the previous findings, where obesity and WHR were found to be powerful factors in the hypertension prevalence [14]. However, the duration and the total amount of physical activity were independently (after the adjustment for age) related to the hypertension in our follow-up (Table 2). Intervention studies have shown that regular PA in essential hypertension can reduce systolic and diastolic blood pressure by approximately 3–10 mmHg [11]. Some data have shown that regular physical activity may reduce hypertension without body weight loss [5].

In conclusion, our 9-year follow-up data showed significant changes in all the measured overweight characteristics, the fat distribution pattern (WHR), and resting blood pressure in men. There were significant negative associations between physical activity characteristics (frequency, duration, average training volume) and overweight values. The duration and the total training volume were inversely related to hypertension prevalence.

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Papers on Anthropology XII, 2003, pp. 154–166

ECHOCARDIOGRAPHIC STANDARD VALUES OF YOUNG HEALTHY ESTONIAN WOMEN'S HEART

Eevi Maiste

Department of Cardiology University of Tartu, Estonia

ABSTRACT

In order to establish the normal values of heart standard parameters for Estonian healthy women, 183 women aged from 17 to 40 (22.8±7.8) years were observed.

The subjects were studied anthropometrically and echocardiographically. The main predictor factors like obesity, hypertension, valvular failure and heart failure were excluded. The observation confirmed the continuity of the peculiarities of heart geometry in healthy women from puberty to young adulthood.

In the reference sample we found left ventricle hypertrophy in 5.8% of subjects, which we have to consider their biological individuality, as there is no strong synergistic association between hypertrophy of left ventricle, BMI and overweight in healthy women.

Key words: echocardiography, heart size, women, healthy, somatotype

INTRODUCTION

Structural cardiovascular abnormalities are associated with a higher risk of major arrhythmias and heart failure [4, 5]. Timely identification of changes in heart structure and dimensions is of great importance for reduction of one of the main clinical risk factors for cardiovascular morbidity and mortality during follow-up. But estimation of the remodelling of the heart in its borderline phase is often difficult, as individual peculiarities play an essential role. The problem of "normal values" of the heart has not been solved yet. In principle, the connection between heart dimensions and body composition has been recognized [1, 11]. It is not quite clear, which part in the peculiarities of the heart belongs to the genetic factor and which to enduring environmental influence. In general clinic practice, body surface area (BSA) is used for the correction of individual peculiarities of heart structure as a correction factor, not considering the fact that the connection between cardiac dimension and body surface area is significant but not linear. [13] The results of earlier studies [6, 10, 11] show that systematization of anthropometrical material into 5 weight-height SD-classes is the simplest way for practical purposes, characterizes sufficiently the peculiarities of body size, and could also be used to relate heart parameters with anthropometric measurements.

The aim of the present study was to establish the normal values of heart parameters for Estonian healthy women in five SD-classes of weight and height.

MATERIAL AND METHODS

Study population

The study included 183 healthy Estonian women aged from 17 to 40 years (22.8±7.8 years). The study design excluded subjects with valvular disease, arterial hypertension and heart failure. As from clinical aspects obese people cannot be considered healthy persons, and obesity is associated with the development of disturbances in cardiac structure, persons with BMI >28 were excluded from observation. Part of the subjects (32%) participated in systematic exercise training programs, but there were no high-level athletes among them.

Methods

Somatometric measurements were taken according to the recommendations of the Canadian Society of Exercise Physiology [2]. Morphometry of the heart was investigated with Aloka SSD 700 System according to ACC [12].

The following values and indices were measured and calculated:

- left ventricular inner diameter in diastole (LVIDd and systole LVIDs) (mm);
- right ventricular diameter of outflow tract (RVOT) in diastole (mm);
- thickness of intraventricular septum in diastole (STd) and in systole (STs) (mm);
- thickness of posterior wall of left ventricle in diastole (PWd) and systole (PWs) (mm);
- diameter of left atrium (LA) (mm);
- cross diameter of aorta (AO) (mm);
- left ventricle volume in diastole (LVVd) and in systole (LVVs)in by area-length formula (ml);
- mass of left ventricle (LVMASS) by Devereux formula (g);
- myocardial index mass of left ventricle adjusted in body surface area (BSA) — (LVMASS/BSA) (g/m^2);
- mass of left ventricle adjusted in height (LVMASS/Height) (g/cm);
- relative thickness of posterior wall of left ventricle (RPWT) RPWT = 2 x PWd / LVIDd;
- relative mass of left ventricle (RVLMASS) (g/ml) RVLMASS = RVMASS / LVVd
- left ventricle inner diameter adjusted in BSA (LVIDd/BSA) (mm/m^2);
- volume of left ventricle adjusted in BSA (LVVd/BSA) (ml/m^2).

According somatometric data, the sample was classified into a 5-class height-weight SD-classification: I — small, II — medium, III — large, IV — pycnomorphs, V — leptomorphs.

Statistical analysis was performed using the statistical package STATISTICA. To investigate the relations between heart and body measurements, multivariate statistical methods were used, as $p<0.05$ assessed statistical significance.

RESULTS AND DISCUSSION

The basic somatometric characteristics of the total population and of the subgroups according to the height-weight SD classes are summarized in Table 1. The difference of somatometric data between classes shows a similarity with other studies [6, 9, 11] where height-weight SD classes have been used for systematization of body size. The gold standard in practical medicine — body surface area (BSA) — does not differ in non-correspondence classes (classes IV and V) and is not acceptable as a correction parameter for the heart size of those subjects. The corrected muscle mass and BMI are significantly different between subgroups ($p<0.01$). The mean skinfold thickness differs only between persons belonging to groups with small or relatively small weight (I, II, V) and groups with large weight (III, IV). Correlation analysis by Spearmann shows that BMI correlated with the inner diameter of the left ventricle ($r=0.3$) but not with left ventricle muscle mass in absolutely values as well as in values corrected by BSA or height.

Corrected muscle mass has relatively high correction with values of the left ventricle (LVIDd $r=0.54$; LVVd $r=0.40$; LVMASS 0.29) (Table 2). The linear regression model shows that the best predictors for left ventricle size among body measurements are chest depth, trunk height and circumferences. Although the corrected muscle mass has a relatively high correlation with heart dimensions, it did not appear in any models as a significance predictor. Similar findings have been reported by our other studies [11].

The basic heart values of Estonian women are in correspondence with the standard used in practical medicine (Tables 3, 4). The study of heart size in 5 height-weight SD classes demonstrated that the peculiarities of heart geometry described in girls aged 15 also appeared in young women [9, 10]. Leptomorphous women have a relatively small heart with a thin ventricular wall, pycnomorphs — a relatively small heart a with thick ventricular wall, but in the correspondence classes the volume and ventricular mass gradually increased (Table 5, 6).

Detailed analysis of the subgroups refers to the abnormal distribution of values, to the difference between the significance of mode and expectation mean (Tables 5, 6, 7). In particular, the dichotomized character appears in left ventricle mass, which does not level even if indices are used (Table 6, 8). Considering the intragroup variability, it is more meaningful to be based on the percentiles criteria (10–90%) for establishing the norm of normal values than to use ±2 SD criteria. Similar results were obtained by the authors of Framingham and TOHMS study [13, 14].

Table 1. Values of somatometric parameters and indices of women grouped into 5 height-weight classes.

	All group N=183		Min-Max	I Small N = 30		II Medium N = 31		III Large N = 20		IV Pycno-morphs N = 40		V Leptomorhs N = 62		Significance
	X	ς		X	ς	X	ς	X	ς	X	ς	X	ς	
height (cm)	165.9	6.2	151.5–183.0	159.9	3.43	167.7	1.7	174.9	3.7	164.9	3.6	171.9	5.0	1:2,3.4,5 2:3,5; 3:4,5; 4:5
weight (g)	61.2	9.70	42.8–83.4	50.6	4.23	57.5	2.4	68.6	6.5	64.1	6.5	55.7	4.21	1:2,3,4,5; 2:3 3:4,5; 4:5
BSA (m²)	1.66	0.08	1.5–1.82	1.50	0.06	1.65	0.03	1.83	0.03	1.68	0.08	1.68	0.09	1:2,3,4,5, 2:3; 3:4,5
BMI (kg/m²)	20.7	0.2		19.8	0.2	20.8	0.1	22.4	0.2	24.0	0.2	18.8	0.7	1:3,4; 2:3,4,5 3:4,5; 4:5
Rohrer index	1.24	0.16	0.92–1.56	1.24	0.11	1.26	0.1	1.28	0.1	1.4	0.12	1.1	0.05	4:1,2,3,5 5:1,2,3
corrected muscle mass (kg)	28.96	4.51	19.9–37.9	25.3	2.59	29.2	3.38	34.0	3.88	32.4	4.36	27.2	2.97	1:2,3,4; 2:3,4,5 3:5; 4:5
chest circumf / pelvis circumf	0.93	0.07	0.79–1.07	0.94	0.06	0.93	0.08	0.89	0.07	0.92	0.06	0.94	0.07	–
biacromial breadth / pelvis breadth	1.33	0.07	1.19–2.66	1.35	0.08	1.32	0.05	1.31	0.07	1.34	0.09	1.33	0.07	–
mean thickness of skinfolds (mm)	10.8	3.3	4.2–17.4	9.98	1.6	9.3	3.2	13.5	2.9	13.8	4.5	9.4	2.0	1:3,4; 2:3,4 5:3,4

Table 2. Correlation matrix between left ventricle size and corrected muscle mass (X1). Correlated circumferences of arm (X2) forearm (X3), midthigh (X4), calf (X5) and body surface area (X6).

Variable	XI	X2	X3	X4	X5	X6
LVIDd	0,54*	0,42*	0,32*	0,44*	0,39*	0,30*
LVVd	0,40*	0,19	0,64*	0,31*	0,16	0,20
LVMASS	0,29*	0,42*	–10	0,28*	0,27*	0,21
LVMASS/ BSA	0,08	0,27*	–21	0,26*	0,16	0,09
LVMASS/ Height	0,23	0,40*	–12	0,13	0,24*	0,22
LVVd/BSA	0,12	00	52*	0,9	00	0,20

Table 3. Basic Values of heart measurements of Estonian women (N = 183).

Parameter	M	ς	Mode	Median	Range 10–90%	Clinical practice normal value by Weyman	by Kaddoura
LVIDd	44.1	4.8	40	43	40–50	35–60	35–56
LVIDS	28.9	4.1	30	29	24,7–33,0	21–40	
LVVd	100.1	21.1	70	97	70–129,5	59–138	
LVVs	38.4	14.6	35	35	22,0–58,3	18–65	
STd	8.8	1.7	8,0	8.4	7–11	6–11	6–12
STs	12.2	2.6	10	11.3	10–15.5		9–18
PWd	9.5	1.4	9	9	8–11.3	6–11	6–12
PWs	13.7	2.5	12	13.6	11–17.3		9–18
LVMASS	133.8	28.2	100.8	118	80–163.8	<198	
RVOT	26.2	3.4	25	26	22.0–30.0	7–23	7–23
LA	25.9	3.2	25	25	22.0–30.0	20–40	
AO	28.0	2.7	30	28	24.2–31.0	20–40	

Table 4. Indeces of heart measurements of Estonian women (N=183)

Index	M	ς	Mode	Median	Range 10–90%	Clinical practice normal value by Kaddoura
LVIDd/ BSA (cm/m^2)	26.6	2.3	multiple	26.	23.–29.	23–31
LVVd / BSA (ml/m^2)	59.9	14.1	multiple	57.8	70.0–129.0	
LVMASS/ BSA (g/m^2)	71.5	20.0	multiple	68.3	47.8–97.7	112
LVMASS/ Height (g/m)	71.9	21.4	multiple	68.6	48.6–97.3	89±25
RWT	0.43	0.07	0.4	0.42	0.35–0.53	0.35±0.08
RLVMM (g/ml)	1.22	0.4	multiple	1.21	0.74–1.68	
STd/PWd	0.94	0.1	1.0	0.93	0.7–1.2	<1.2

From the practical point of view, left ventricular hypertrophy is a powerful predictor of an adverse prognosis [9, 3]. The independent predictors of left ventricle hypertrophy are systolic blood pressure, age, BMI, and heart disease [8]. As the population observed by us belonged to the young age group and was healthy, the influence of these risk factors was excluded. Table 9 shows that increased thickness of the interventricular septum was recorded in 5.8% and increased thickness of the posterior wall of the left ventricle in 8.7% of the observed population. Increased thickness of the left ventricular wall occurs in all groups, but more frequently in subjects with larger weight (III, IV class). The mass of the left ventricle had to be considered hypertrophic in 5.8%, which is less than in THOMS study [13]. Although among large persons (III class) hypertrophy appeared more frequently than in other groups, the connection between ventricular hypertrophy and body weight was not fully confirmed.

Table 5. Basic values of heart measurements of Estonian women grouped into 5 height-weight classes.

Parameters	I Small N = 30			II Medium N = 31			III Large N = 20			IV Pycnomorphs N = 40			V Leptomorphs N = 62			Significance
	M	ς	Mode	M	ς	Mode	M	ς	Mode	M	ς	Mode	M	ς	Mode	
LVIDd	42.1	2.7	40	44.7	3.0	46	47.2	4.4	45	46.3	4.1	45.0	43.0	2.8	–	3:1,5
LVIDs	26.6	2.9	25	29.2	3.3	30	29.9	3.0	28	30.9	3.9	30.0	28.2	3.3	30	1:2,3,4
																3:5
LVVd	92.1	20.5	70	99.5	20.5	102	123.5	19.1	125	104.2	21.2	70	98.3	21.5	79	3:1,2,4,5
LVVs	32.6	11.5	22	38.8	12.0	38	46.1	12.2	50.0	39.9	17.0	35	39.6	13.4	35	3:1,2,4,5
																1:4,5
STd	8.2	1.2	8	9.0	1.3	10	9.2	1.4	9.1	9.2	1.2	8.0	8.7	1.8	8.0	1:4
STs	11.3	1.9	10	12.1	1.9	11.2	12.5	1.9	12.3	12.5	2.1	11.0	12.4	2.4	–	1:4
PWd	9.0	1.3	9	9.8	1.2	9.8	10.4	1.4	10.0	9.5	1.3	10.0	9.4	1.5	–	1:3
																3:5
PWs	13.2	1.4	12	13.8	2.5	12	15.6	2.2	16.1	14.0	2.8	12.0	13.5	2.1	–	3:1,2,4,5
LVMASS	107.1	25.0	104	120.7	29.3	117.4	143.0	24.8	134.6	132.0	31.8	120.2	110.1	29.3	109.2	1:2,3,4,5
																3:5
																4:5
RVOT	25.3	3.6	30	26.5	3.7	25.9	26.6	3.0	27.2	27.1	3.3	30.0	25.8	2.8	25.0	1:2; 5:2,3
LA	24.7	2.8	25	25.9	2.9	25.3	27.9	2.3	28.4	26.2	2.8	25.0	25.9	2.3	25.0	–
AO	26.2	2.4	28	28.5	2.7	29.2	27.4	2.3	27.8	29.2	2.1	30.0	27.9	2.4	30.0	1:2

Table 6. Heart indices of Estonian women grouped into 5 height-weight class.

Indicies	I Small N = 30		II Medium N = 31		III Large N = 20		IV Pycno-morphs N = 40		V Lepto-morphs N = 62		Signi-ficance
	X	ς	X	ς	X	ς	X	ς	X	ς	
LVIDd/ BSA	28.7	1.4	26.3	1.2	24.9	1.0	27.0	1.3	25.2	1.9	1:2,3,4,5 3:4
LVVd/ BSA	61.3	13.8	58.7	12.2	66.9	8.9	60.0	16.0	57.1	12.2	3:5
LVMAS S/BSA	71.3	17.7	71.4	16.0	75.6	14.0	86.9	19.6	74.4	18.4	1:2,4 4:5
LVMASS/ Height	67.2	16.5	72.0	17.4	82.5	17.7	91.1	20.0	72.9	19.8	1:2,3,4 5:2,3,4
RWT	0.43	0.17	0.44	0.06	0.46	0.07	0.42	0.08	0.44	0.07	–
RLVMM	1.18	0.32	1.23	0.3	1.2	0.3	1.5	0.39	1.34	0.34	1:2,4 4:5´,3
STd/ PWd	0.93	0.16	0.93	0.1	0.86	0.1	0.98	0.2	0.93	0.2	4:3

Table 7. Range (10–90%) of heart measurements of Estonian women grouped into 5 height-weight classes.

1. Correspondence classes

	I Small N=30		II Medium N=31		III Large N=20	
Parameter	Range	Median	Range	Median	Range	Median
LVIDd	40–47	41.8	40.2–48.5	45.5	43.6–56	45.3
LVIDs	23.4–30	26	25.6–32	30	27–35	28.6
LVVd	70–118	83	71–129	102	88–145	125.6
LVVs	22–49	32	25–61	38	30–62	50.3
STd	7–10	8	7–10	9.2	7–11	9.1
STs	9–14	11	10–15,2	12	10–15.1	12.3
PWd	7–10.8	9	8.2–11.7	9.85	8.9–13.2	10.4
PWs	10–14.5	13	11–17.3	13.5	12–17.3	16.1
LVMASS	75–131	104.5	80–160	117.3	88–220	134.6
RVOT	20–30	25.1	22–32	25.9	20–29.4	27.3
LA	20–28	25	22–30	25.3	23.4–30.4	28.4
AO	22–29	27.3	25–32	28.7	23.4–30.4	27.8

2. Noncorrespondence classes

	IV Pycnomorph N=40		V Leptomorph N=62	
Parameter	Range 10–90%	Median	Range 10–90%	Median
LVIDd	40–52	45.1	40–48	42.7
LVIDs	25–39	30	24–32	29
LVVd	70–138	70	70.4–131	92
LVVs	22–70	35	22–56.7	36.9
STd	7–12	9	7.0–10.3	8.4
STs	9–18	11	10–15.0	12
PWd	8–11,3	9,5	8–12.0	9
PWs	11–18	13.5	11–16.2	13.1
LVMASS	81.8–138.5	127.2	80–152	104.7
RVOT	22–30.4	28	22.5–30.0	25.3
LA	22–30.3	25	21.1–30.8	25.3
AO	26.7–32	29	24.7–30.5	28.1

To establish the connection between BMI and myocardial index, we divided the observed persons by BMI into 3 groups: I BMI>20 N=59; II BMI = 20–24.9 N=89; III BMI≥25 (N=35). The BMI groups were not congruent with height-weight classes, but the in-group variability of BMI values in height-weight classes was dichotomic.

We did not find any synergistic association between overweight and increased myocardial index or thickness of left ventricle walls among healthy young women.

Table 8. Range (10–90%) of heart indicies of Estonian women grouped into 5 height-weight classes.

Index	I Small N=30		II Medium N = 31		III Large N = 20		IV Pycnomorphs N = 40		V Leptomorphs N = 62	
	Range 10–90%	Median	Range 10–90%	Median	Range 10–90%	Median	Range 10–90%	Median	Range 10–90%	Median
LVIDd/BSA	25,8–30,2	27,6	23,9–28,5	26,2	23,4–27,3	24,1	23,9–29,3	26,8	22,9–27,9	25,2
LVVd/BSA	46,4–81,0	55,8	43–77	58,2	49–76	67,4	44,0–76,9	58,4	41,8–76,9	55,8
LVMASS/BSA	47,6–95,0	69,9	48,6–94,3	69,6	46–121,6	72,4	48,4–110,0	75,6	46,8–90,6	63,7
LVMASS/Height	45,8–90,8	66,5	48,7–95,1	69,8	50,4–128,0	78,0	50–123,0	78,2	46,3–88,1	62,0
RWT	0,33–0,51	0,43	0,38–0,53	0,43	0,38–0,6	0,46	0,33–0,54	0,4	0,38–0,54	0,42
RLUMM	0,76–1,6	1,17	0,7–1,7	1,33	0,67–2,0	1,07	0,75–1,7	1,34	0,73–1,8	1,09
STd/PWd	0,69–1,16	1,0	0,74–1,1	0,95	0,64–1,1	0,8	0,73–1,3	1,0	0,69–1,17	0,9

Table 9. Distribution (%) of thickness of ventricular septum and left ventricle posterior wall according to 5 height-weight-classes.

classes	N	para-meter	< 6	8–<6	8–<10	10–<12	≥12
			thickness (mm)				
I small	30	STd	2.5	28.3	56.4	128	–
		PWd	2.5	35.0	30.0	30.0	2.5
II medium	31	STd	–	19.4	32.2	48.4	–
		PWd	–	3.2	45.0	42.2	9.6
III large	20	STd		10	44	46	–
		PWd	–	10	30.4	44.4	16.0
IV pycno-morphs	40	STd	1.2	13.7	45.1	27.4	2.6
		PWd	3.6	41.8	44.0	39.0	7.8
V lepto-morphs	62	STd	4.0	25.5	51.1	13.0	6.4
		PWd	2.1	44.7	25.5	19.9	7.8
Total	184	STd	1.5	20.8	46.8	25.1	5.8
		PWd	1.2	4.0	28.3	59.8	8.7

CONCLUSION

The observations support the continuity of the peculiarities of heart geometry of healthy women from puberty to young adulthood. Hypertrophy of the left ventricle in a small number of persons should be considered a biological individuality in the reference sample. We propose that criteria for heart size according to somatometric characteristics in five height-weight SD classes should be established by percentiles criteria.

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Papers on Anthropology XII, 2003, pp. 167–172

ANALYSIS OF SELECTED STRENGTH VARIABLES IN GIRLS WITH TURNER'S SYNDROME [1]

Katarzyna Milde, Edyta Sienkiewicz, Grzegorz Domino, Romuald Stupnicki, Maciej Sklad

Academy of Physical Education, Warsaw, Poland

ABSTRACT

Turner's syndrome (TS) is a congenital disease, which afflicts only females, the most common symptoms being short stature, postural and maturation disorders and obesity. The aim of the study was to compare TS girls (n=63) aged 11–15 years with healthy ones of short stature (n=67), with respect to selected strength variables measured by means of EUROFIT tests: standing broad jump (SBJ), handgrip (HGR), sit-ups (SUP) and bent-arm hang (BAH). Relative HGR (per kg body mass) was alike in TS and healthy groups (0.509 and 0.503 kg/kg, respectively) and the same applied to correlation coefficients between these variables (r=0.542 and 0.527, respectively). Mean SUP values were significantly higher in healthy than in Turner girls ($p<0.01$). BAH was negatively correlated with body mass (r=–0.401 and –0.636, respectively); the TS girls proved significantly, nearly twice stronger than the healthy ones in that respect ($p<0.01$). In conclusion, TS girls are not inferior to healthy ones in upper body strength.

Key words: Turner's syndrome, strength, development

[1] The study was supported by grant No. 3P05D02422 of the State Committee for Scientific Research. A part of this work was presented at the 23rd ICPAFR conference in Tartu, 5–8.09.2002.

INTRODUCTION

Turner's syndrome (TS) is the most common chromosomal disease of female subjects, its incidence amounting to one per 2000–2500 live female newborns. Growth deficiency and abnormal body proportions, typical of the syndrome, are due to the damage or total lack of an X-chromosome and begin as early as in the foetal life. The bulk of the literature pertains to the growth process and therapy oriented at reducing the growth deficit, as the average body height of adult TS women is about 142 cm [6].

In contrast to that, very few reports exist pertaining to the development of motor and physical fitness of Turner girls [1, 3, 4]. Thus, the aim of this study was to present some more detailed data concerning muscle strength in that syndrome.

MATERIAL AND METHODS

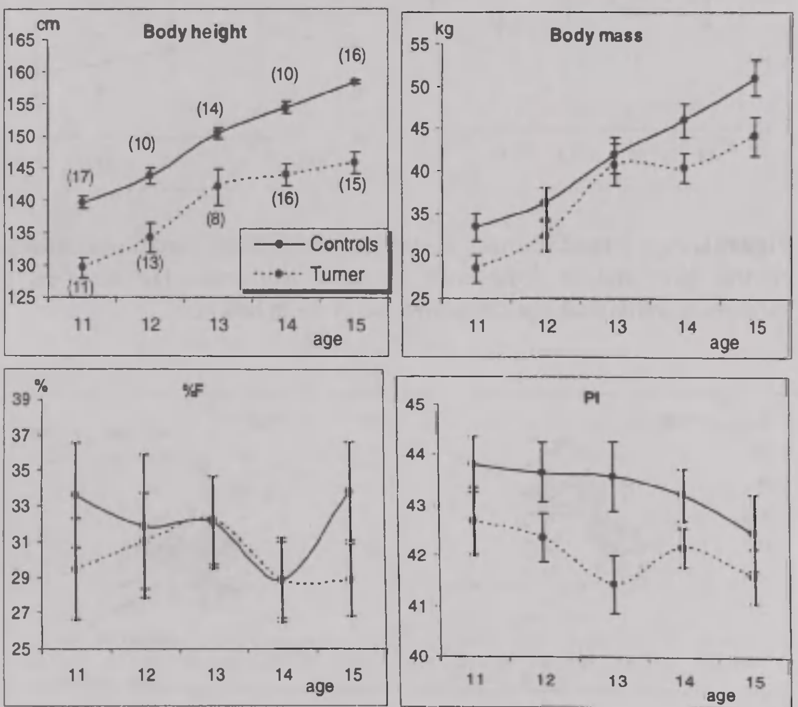
Anthropometrical measurements and selected EUROFIT tests were conducted on 63 girls with Turner's syndrome, aged 11–15 years, in a summer vacation camp in 2001. As a reference group served 67 healthy girls in the same age range, selected from a larger (n=263), representative sample of Polish girls [5]. The selection criteria were: body height below the 25^{th} percentile and ponderal index not exceeding 45.9.

Body fat content was determined from three skinfolds — triceps, subscapular and abdominal, according to Piechaczek [2]. The following strength tests were performed: handgrip (HGR), sit-ups (SUP), standing broad jump (SBJ) and bent arm hang (BAH). The results of the latter were converted to square roots due to highly skewed distributions.

In addition to conventional statistical procedures, multivariate profiles were constructed and regression analysis performed.

RESULTS

Mean results (±SD) of the variables studied are presented in Fig. 1 in relation to age. Turner girls are considerably shorter, somewhat lighter and relatively more robust than the control ones, although body fat content was similar in both groups. Regarding strength variables, Turner girls are inferior to controls in standing broad jump (by about 13% over 12 years of age) and in sit-ups (by about 16%), equal to controls in relative handgrip, and considerably better (nearly twice) in bent-arm hang. The latter variable and handgrip are shown in relation to body mass (Fig. 2), absolute values of the respective correlation coefficients ranging from 0.401 to 0.636, all of them highly significant. The regressions BAH — body mass had nearly identical slopes but significantly different constants ($p<0.001$). These findings are in accordance with age-related changes shown in Fig. 1.



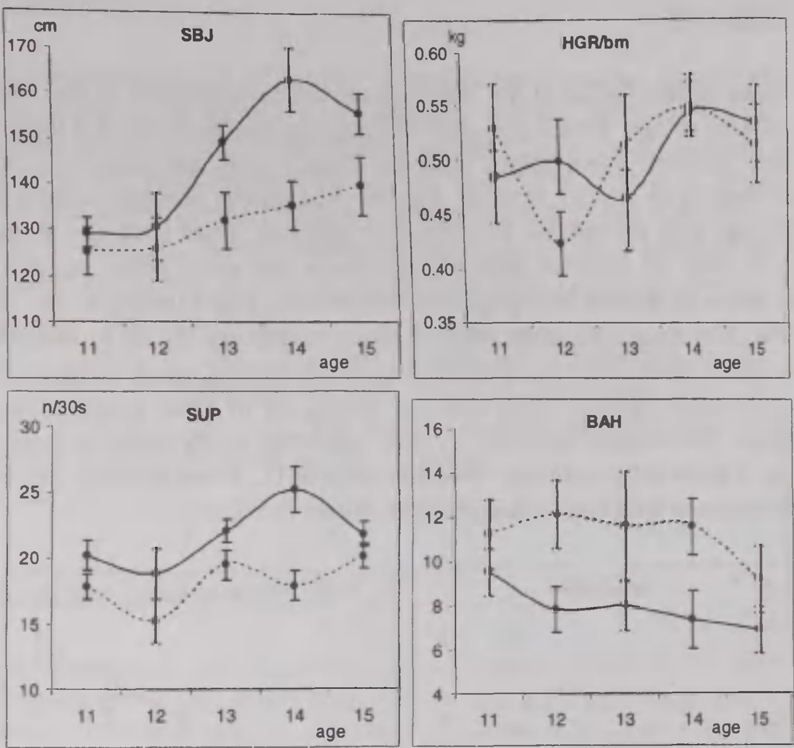


Figure1. Age-related changes in somatic and strength variables in healthy control girls and in those with Turner's syndrome. The numbers of subjects in individual age categories are given in brackets.

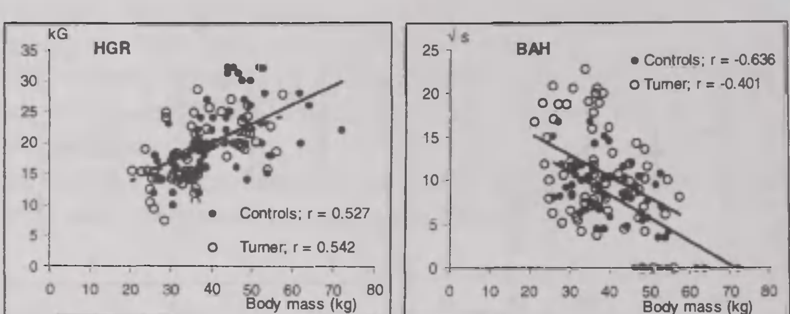


Figure 2. Correlations of handgrip (HGR) or bent-arm-hang (BAH) results with body mass in healthy control girls (n=67) and in those with Turner's syndrome (n=63).

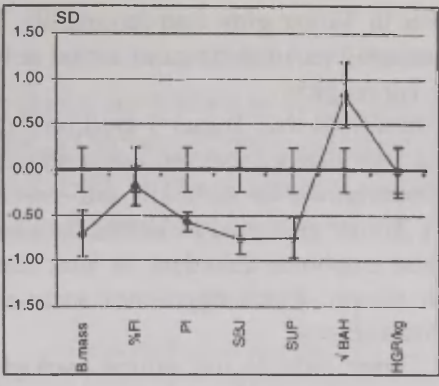


Figure 3. Multivariate profile for girls with Turner's syndrome (n = 63) Points are means standardised vs. control group (n = 67) represented by X-axis (bold) ±2 SE. All points whose bars do not overlap differ significantly (p<0.01).

Legend: B.mass — body mass; %FI — body fat percent age; PI — ponderal index; SBJ — standing broad jump; SUP — sit-ups; √ BAH — bent arm hang (square root of the result); HGR/kg — relative handgrip

An overall comparison of both groups is presented in Fig. 3 in the form of a standardised multivariate profile, in which the effect of age was eliminated.

DISCUSSION

The results presented here are, generally, similar to those reported earlier [3], although in this study Turner girls had lower fat content, comparable with that in healthy girls. Another study conducted by us [1] involved women over 17 years of age, so the results could not be compared.

Our findings seem to be a consequence of the specific body build of Turner girls — a more massive shoulder girdle in relation to the lower part of the body as compared with healthy girls. This is reflected by nearly twice higher isometric endurance of the upper part of the body (BAH test) and equal hand strength (HGR test) relative to body mass of Turner girls, as confronted with their healthy peers. On the other hand, abdominal muscles (SUP test) and legs (SBJ test) are significantly weaker in Turner girls than in controls. These facts are important for formulating recommendations aimed at improvement of physical fitness of Turner girls.

It should be emphasised that Turner's syndrome does not impair mental development; the girls achieve success at schools, especially in the humanities. However, due to their low self-esteem (low stature, obese appearance), Turner girls tend to isolate themselves from their healthy mates. Those emotional disorders, in turn, result in avoiding physical education classes, which aggravates socio-emotional problems related to physical fitness.

In conclusion, Turner girls do not exhibit marked differences in muscle strength compared with their healthy mates. Their physical fitness should, however, be steadily monitored and improved by practising various forms of e.g. recreational physical activities. This is of importance for increasing their self-esteem and, eventually, for their integration with the healthy population.

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Papers on Anthropology XII, 2003, pp. 173–179

RELATIONS BETWEEN WEIGHT-HEIGHT INDICES AND WEIGHT-HEIGHT CLASSES OF A MODEL POPULATION NORMALLY DISTRIBUTED IN WEIGHT AND HEIGHT

Boris Neruda

Department of Anaesthesiology,
Heinrich-Heine-University Düsseldorf, Germany

ABSTRACT

There are no systematic studies on relations between weight-height indexed and weight-height classified populations. In a preliminary study a random model population of 5000 subjects with an assumed normal distribution in weight W and height H was generated. Data underwent 3 x 3 SD WH-classification for somatotyping to create three concordant (I: small; II: medium; III: large) and two discordant (IV: leptomorph; V: pyknomorph) categories. Indices W/H^m (m = 1, 2, 3) were calculated for all subjects; they were significantly different in groups I-III and IV-V. Further classification of WH-indices into 3 subgroups: (1: <mean(x)-SD; 2: $\geq$ mean(x)-SD and $\leq$mean(x)+SD; 3: >mean(x)+SD) revealed that all but the medium somatotype groups were commingled index subgroups. Subgroup 2 contained subjects from all somatotype groups. These interrelations are prone to false assignments when comparing somatotyped and index classified subjects. Furthermore, it was shown on a set of simulated correlation coefficients $r(y.W/H^2)$ that WH-classification may influence such correlations.

Key words: model population, somatotyping, weight-heigth classification, weight-height indices

INTRODUCTION

In descriptive anthropology and in epidemiological studies the two-way classification of weight W and height H has been widely used for somatotyping; shape has been often characterised by the indices derived from W and H. There are interrelations between somatotyping and indexing, but these have not been systematically studied so far. To illustrate some of these issues, a preliminary simulation study was conducted. A random number generator was used to simulate H and W of 5000 subjects, assuming normal distribution. Frequencies in groups and subgroups and correlations with indices W/H^m (m = 1, 2, 3) were studied.

MATERIAL AND METHODS

For the model population H was considered as leading characteristic. A random number generator (SPSS ver. 10) was used to simulate a normal distribution H=N(170,68) (n=5000). H is usually correlated with W ($r \approx 0.5$), but not with W/H^2. To satisfy both requirements an empirical regression equation W=0.86H-N(71.2,10.7) was used for simulating W. Weight and height were classified into 5 groups according to a well accepted procedure [1]. The methods of descriptive statistics, ANOVA, the Scheffé's test and correlation analysis were applied (SPSS. ver. 10). The level of significance was set at $p<0.01$ unless otherwise stated.

RESULTS

The means±SD for simulated H were 170.1±6.8 (CV 4.0; min 147.0; max 192.8) and for simulated W 75.1±12.1 (CV 16.1%; min 33.3; max 121.0), respectively.

The indices of the general form W/H^m (m = 1, 2, 3) showed the following basic statistics: W/H: 44.1±6.5 (range 20.7 to 64.5); W/H^2: 25.9±3.7 (range 12.8 to 40.1); W/H^3: 15.3±2.3 (range 7.4 to 26.3).

Correlations between H and weight-height indices conformed with published correlation coefficients (table 1).

Table 1. Figures from literature and this study for correlation coefficients $r(H.W/H^m)$ (m = 1, 2, 3).

$r(H.W/H^m)$	W	W/H	W/H^2	W/H^3
A. Keys [2]	0.487	0.269	0.036	0.142
This study	0.483	0.260	–0.012	–0.278

Correlation coefficients r from literature are means calculated after the Z-transformation of published values for r from 12 listed studies of a total of 7426 men

These data show that besides being normally distributed the simulated population more or less resembles those encountered in other population studies and thus can be expected to produce relevant results on further processing.

The basic data for the 5 groups resulting from the weight-height classification as well as data for each of the indices within these somatotype groups are listed in table 2. All variables show highly significant differences within groups I-III and IV-V ($p<0.01$).

To obtain more detailed information about the type of subjects in each of the weight-height groups, WH-indices were also classified into 3 subgroups: 1: <mean(x)-SD; 2: $\geq$ mean(x)-SD and $\leq$mean(x)+SD; 3: >mean(x)+SD. This classification into subgroups roughly describes the margins for lower and upper "out-of-range" and "normal" values, though it does not refer to any of the classifications used by experts, but helps to demonstrate the underlying principle in the interrelationship between weight-height classes and index subgroups. For example, BMI-subgroup 2 is a mixed population of subjects coming from all the 5 weight-height classes, whereas subgroup 1 contains only the subjects somatotyped as small or leptomorphous; pyknomorphous subjects can be found in subgroups 2 and 3 (table 3). All the three indices behave similarly.

Such commingled groups in either weight-height- or index-grouping might be relevant in drawing conclusions about the relations between groups, subgroups and the entire population under investigation.

The WH-classification may influence the correlation between variable y and index W/H^m. For instance, the statistically significant correlation coefficient r(y.BMI) for the entire group decreases considerably in some WH-classes, and in unfavourable cases becomes even non-significant. This effect upon correlation coefficients of 4 different simulated values for r(y.BMI) is exemplified in the table 4 and is similar for the other WH-indices under consideration.

Table 2. Basic statistics of H, W and W/H^m indices (m = 1, 2, 3) in 5 weight-height categories

		Smal n=81 I	Medium n=807 II	Large n=824 III	signif.	Lepto-mor-phous n=1246 IV	Pykno-mor-phous n=1310 V	Sig-nif.
H	mean	161.7	170.3	178.5	**	174.0	166.3	**
	SD	3.7	1.9	3.8		4.5	4.5	
	min	147.0	166.8	173.6		166.8	148.6	
	max	166.7	173.5	192.8		190.0	173.5	
W	mean	60.0	75.2	89.8	**	68.1	82.0	**
	SD	6.7	3.5	6.8		8.0	7.9	
	min	33.3	69.1	81.2		37.7	69.1	
	max	69.0	81.1	121.0		81.1	109.2	
W/H	mean	37.1	44.1	50.3	**	39.1	49.3	**
	SD	4.1	2.1	3.7		4.1	4.1	
	min	20.7	39.9	44.0		22.0	41.6	
	max	46.2	48.5	64.5		46.5	64.5	
W/H^2	mean	22.9	25.9	28.2	**	22.5	29.6	**
	SD	2.6	1.3	2.2		2.2	2.4	
	min	12.8	23.1	23.5		12.8	25.0	
	max	31.4	29.0	36.1		26.8	40.1	
W/H^3	mean	14.2	15.2	15.8	**	12.9	17.8	**
	SD	1.7	0.9	1.4		1.3	1.5	
	min	7.8	13.3	12.4		7.4	15.0	
	max	21.3	17.3	20.8		15.4	26.3	

** $p<0.01$

Table 3. Number and percentage of subjects in each of three index subgroups within 5 weight-height classified groups.

WH-index	WH-sub-group	Small		Medium		Large		Leptomorphous		Pycnomorphous		Sum	
		n	%	n	%	n	%	n	%	n	%	n	%
W/H	1	385	48.6					407	51.4			792	15.8
	2	428	12.5	807	23.5	502	14.6	839	24.4	858	25.0	3434	67.7
	3					322	41.6			452	58.4	774	15.5
sum		813		807		824		1246		1310		5000	100.0
W/H²	1	267	34.8					501	65.2			768	15.4
	2	545	15.7	807	23.3	642	18.5	745	21.5	726	21.0	3465	69.3
	3	1	0.1			182	23.7			584	76.1	767	15.3
sum		813		807		824		1246		1310		5000	100.0
W/H³	1	187	23.8			8	1.0	590	75.2			758	15.7
	2	611	17.8	807	23.5	738	21.4	656	19.1	629	18.3	3441	65.8
	3	15	1.9			78	10.1			681	88.0	774	15.5
sum		813		807		824		1246		1310		5000	100.0

WH-sub-groups: 1: <mean(x)-SD; 2: ≥ mean(x)-SD and ≤mean(x)+SD; 3: >mean(x)+SD

Table 4. Influence of the weight-height classification on simulated correlation coefficients r(y.BMI).

Entire group	Small I	Medium II	Large III	Lepto-morphous IV	Pykno-morphous V
0.830	0.700	0.470	0.668	0.662	0.692
0.439	0.335	0.185	0.257	0.277	0.280
0.300	0.211	0.106	0.188	0.184	0.163
0.150	0.087	0.022[o)]	0.127	0.107	0.116

[o)] n.s., for all others p<0.01

DISCUSSION

The study was based on a population with an assumed normal distribution in weight and height. However, real populations are not normally distributed in their basic parameters, which might lead to somewhat different conclusions. This is a certain drawback of this study, but the principles of inter-relations between the weight-height classification and the weight-height indices are obvious and lead to some relevant conclusions.

The means for indices W/H^m (m = 1, 2, 3) differ significantly within groups (I–III and IV–V). This seems to be a characteristic of the weight-height classification per se. Examples of this are mentioned in the literature [3, 4]. Exceptions might occur in strongly skewed distributions.

False assignements must always be taken into account when comparing weight-height-indices with weight-height classified data of a population comprising mixed somatotypes. For example, a subject with a BMI=29 [kg/m²], which would normally be rated as overweight, could either be pyknomorphous or large, which might lead to inappropriate therapeutic consequences. A similar misjudgement could well result in the unreflected use of correlation coefficients, which refer to the whole population and are then applied to classified data. In large populations like in this simulated one more refined results could possibly be obtained by creating a 5×5 SD classification instead of the 3×3 SD classification used in this study. But one would probably arrive at the same basic conclusions.

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Papers on Anthropology XII, 2003, pp. 180–193

EVALUATION OF ANTHROPOMETRIC DEVELOPMENT OF FOETUS BASED ON REPEATED INCOMPLETE ULTRASOUND MEASUREMENTS

Kandela Õun

Department of Business Administration, Pärnu College,
University of Tartu, Estonia

ABSTRACT

The paper investigates the interrelations between foetus measurements and their dynamics during pregnancy. The measurements examined are: biparietal diameter of foetus' head, femur length, abdominal breadth and abdominal depth. In most cases the foetuses have been measured twice during pregnancy, but the measurements are not complete, about a quarter of all measurements is missing. The present paper concentrates on a methodological aim – how to make usable large multivariate data sets with many missing values and how to evaluate the credibility of results retrieved on the basis of incomplete data.

The research uses the data of Tartu Women's Hospital where 1930 live-born healthy newborns were measured in the years 1995 and 1998. It became evident that those measurements were strongly correlated and significantly dependent on the duration of pregnancy. Therefore the missing measurements could easily be predicted by regression models. The description rate the models was about 95% in the case of the first measurement and over 85% for the second measurement. Hence, the prediction error varies between 5% and 15% of the variable's dispersion respectively, which is a satisfactory result.

Key words: ultrasound, foetus measurements, regression models, missing values, imputation

INTRODUCTION

Weight, height and other data of the newborn provide an overview of its state of health and, dependent thereon, its future care needs. Too small babies require much more care than average and big newborns. Body measurements of newborns are approximately proportional; however, it is not exactly known whether such proportions develop by the moment of birth or persist throughout the embryonic development of the foetus. Research has been conducted concerning the body structure of the pregnant woman [1] as well as of the newborn [2]. The author has previously used the results of ultrasound measurements to predict the foetus' weight and to compile various growth curves of body measurements [3].

This paper investigates the interrelations between foetus measurements and their dynamics during pregnancy. The measurements examined are: biparietal diameter of foetus' head, femur length, abdominal breadth and abdominal depth. The foetuses under examination were in most cases measured twice during pregnancy.

As it is difficult to register all measurements during ultrasound examinations, the data contain a large number of blanks, especially in the case of the first ultrasound examination. In order to compensate for it, we predicted the missing values using regression models. Imputation is an essential component of modern applied statistics, as it provides an opportunity to make usable the maximum amount of data instead of a small set of complete measurements. To check the correctness of substitutions, the comparison of combined (containing imputed values) and originally measured variables is applied.

The aims of this paper are:

1. to provide an overview of the distributions and relations of the four main measurements of the foetus (biparietal diameter of head, femur length, abdominal breadth and abdominal depth), bearing in mind the opportunity to predict the missing values of variables using the other measured variables;
2. to find a rule for predicting the missing values of various measurements by means of regression models using the anthropometric data of the foetus and length of pregnancy and to establish combined variables, containing both original and imputed values and forming a complete data-set;

3. to check the adequacy of the complemented data set using comparisons of distribution and correlation parameters between the original and combined variables.

EMPIRICAL MATERIAL AND METHODOLOGY

This survey uses the data of the Women's Hospital of Tartu University. 1930 normal live-born newborns from the years 1995 and 1998, most of whom had registered data of two ultrasound examinations, were surveyed. The study uses the following ultrasound measurements of the foetus: biparietal diameter of head, femur length, abdominal breadth and abdominal depth. In the paper the age of the foetus (ultrasound age) is defined as the number of days from the first day of the last menstruation to the day of the ultrasound examination. Usually the ultrasound age is measured in weeks based on foetus measurements. Thus, in our case a more reliable result is gained compared to the age assessed by a person conducting the examination. For our aims it is also important that the age is assessed independently of ultrasound measurements. Days are used as a unit as foetuses develop relatively fast. The foetuses were measured twice. On average, the first ultrasound measurement (I_US) was carried out on the 140th day and the second one (II_US) on the 240th day (see Table 1). Thus, I or II indicates if the measurement was taken during the first or the second examination. The variable US_BTW_D was calculated as the difference between measurement times (in days). The first ultrasound examination was missing in 423 and the second examination in 429 pregnant women.

For the first ultrasound measurement, more than half of bone measurement values and a quarter of abdominal values were available. In the first half of pregnancy the foetus is too small to be measured properly, especially its abdomen. The second ultrasound measurement lacks a quarter of data; again, more bone measurements are available. Means of the first and the second ultrasound relevant measurements are different, but their maximum and minimum value differences are relatively insignificant. This can be explained by the fact that ultrasound measurements were carried out at different times, while the time intervals of the first measurement and the second measurement partially overlap (see Table 1). While collecting the data, the aim was to study foetus' development throughout pregnancy; therefore the data of the foetuses measured at untypical times were not eliminated.

Table 1. Overview of data used.

Variable	Explanation	Number	*Missing values*	Mean	Stand. deviation	Minimum	Maximum
I_FEMO	I US femur length	1336	594	3.22	1.03	1.00	7.80
I_BIPA	I US biparietal diameter of head	1349	581	4.71	1.17	1.70	10.10
I_ABSY	I US abdominal depth	522	1408	5.11	1.78	2.00	11.70
I_ABL	I US abdominal breadth	523	1407	5.08	1.83	1.60	11.80
II_FEMO	II US femur length	1396	534	6.62	1.03	2.60	9.00
II_BIPA	II US biparietal diameter of head	1418	512	8.56	1.07	4.20	10.60
II_ABSY	II US abdominal depth	1248	682	9.59	1.72	4.00	13.90
II_ABL	II US abdominal breadth	1255	675	9.60	1.66	4.20	13.40
I_US	I US age in days	1507	423	140.08	28.68	40.00	281.00
II_US	II US age in days	1501	429	243.68	35.79	105.00	316.00
US_BTW_D	II US – I US in days	1078	852	104.97	37.68	1.00	225.00
I_USP	complementary I US	1930	0	140.07	25.24	40.00	281.00
II_USP	complementary II US	1930	0	242.96	31.38	117.00	316.00
US_BTW_Dm	Complementary II US – I US	1930	0	102.89	34.86	1.00	225.00

In total, 76 foetuses (3.9% of those measured originally) were left out of the study, as their difference from the rest was so extensive they could be seen as outliers. There could be several reasons: different doctors carried out measurements at different times, data of two different years were used (an insignificant factor, though), errors may have occurred while registering the data, and possible temporary deviations in foetus development cannot be ruled out, although a healthy newborn may have been delivered. Study of possible deviations was not, however, the aim of the present paper, therefore outliers and foetuses with outlier suspicion were left out of further research.

The variables that originally has some values missing were replaced by *combined variables.* The combined variables were formed by replacement of missing values using the following rules.

1. If the true value is available, no replacement takes place.
2. If the true value is not available, but some measurements of the foetus measured at the same time exist, or the time of measurement is known, predictions are made using the available three variables.
3. If the foetus has been measured only once, the second measurement will be created artificially using the time 140 days for the first and 240 days for the second measurement and using rules 1 and 2.

PREDICTION OF MISSING VALUES

The aim of this section is to describe the methodology of prediction of missing values / imputation (step 2 in the previous section). There are four options how to predict.

1. The value of a missing variable is predicted by using the real values of the other three variables (P1) gained at the same examination.
2. If method P1 cannot be applied, the value of a missing variable is predicted by the real values of two or one variables of the same examination (P2).
3. If methods P1 and P2 cannot be applied, the value of a missing variable is predicted by using (earlier estimated) combined values. This methods is applied in the case of abdominal measurements when the missing values are calculated using abdominal measurement models obtained by method P2, replacing femur length and head diameter values by combined (i.e. in some cases predicted) values (P3).
4. If methods P1–P3 cannot be applied, i.e. in case one ultrasound examination is missing completely, then, for the first ultrasound examination, the missing values are predicted using the length of pregnancy. For the second ultrasound examination, the same variable value at the previous examination and time lapse between examinations is used (P4).

PREDICTION OF THE FIRST ULTRASOUND MEASUREMENT VALUES BY MEASURED VARIABLES

Prediction models of the first ultrasound measurements are presented in Table 2.

Table 2. Models to predict the missing values of the first ultrasound examination (P1, P2).

No	MODEL	R^2
(1.1)	P1_I_FEM = – 0.7391 + 0.5066 I_BIP + 0.1972 I_ABS + 0.1195 I_ABL	0.96
(1.2)	P1_I_BIP = 1.0203 + 0.1782 I_ABS + 0.2262 I_ABL + 0.5707 I_FEM	0.96
(1.3)	P1_I_ABS = 0.0627 + 0.1613 I_ABL + 0.5661 I_FEM + 0.4540 I_BIP	0.93
(1.4)	P1_I_ABL = – 0.3263 + 0.3786 I_FEM + 0.6359 I_BIP + 0.1780 I_ABS	0.93
(1.5)	P1_I_FEMk = – 0.3126 + 0.4044 I_ABS + 0.3293 I_ABL	0.94
(1.6)	P1_I_BIPk = 0.8419 + 0.4090 I_ABS + 0.4142 I_ABL	0.95
(2.1)	P2_I_ABS=0.0021+ 0.6436 I_FEM + 0.5764 I_BIP	0.93
(2.2)	P2_I_ABL = –0.3294 + 0.4888 I_FEM + 0.7429 I_BIP	0.93
(2.3)	P2_I_FEM = – 0.8518 + 0.8566 I_BIP	0.92
(2.4)	P2_I_BIP = 1.2788 + 1.0786 I_FEM	0.92

Models (1.1)–(1.4) are the models for finding the missing variable values using the three available variables. The best prediction was gained for bone measurements — head diameter and femur length, see models (1.1) and (1.2). These measurements also made the largest contribution to each other's models. Abdominal measurements, which were predicted by models (1.3) and (1.4), had a 3% lower percentage of description and slightly lower preciseness. The greatest contributions to the model were made by bone measurements.

The best among the models with two variables was the head diameter and femur length value prediction by using abdominal measurements (models (1.5) and (1.6), R^2=0.95, i.e. prediction error is 5% of the variance). The rest, models (2.1.) – (2.4) of the second stage that used two measured values had lower description percentage but showed the strong interrelation between the two measurements. In prediction only bone measurements were used as they yielded the best results. Abdominal depth (model (2.1)) is similarly contributed to by head diameter and femur length. In prediction of abdominal breadth (model (2.2)) influence of head diameter was by about a third larger than that of femur length. Models with one argument (2.3) and (2.4) also yielded a description rate of over 90%.

On the basis of models P1 or P2, the missing values were calculated and combined variables for four measurements of the first ultrasound were compiled; they are presented in Table 3. The first two characters (P1, P2 or P3) of the symbol indicate the model used for imputation. The variables ending in 1 at the end of Table 3 are combined variables in which missing values have been replaced by predicted values.

Table 3. Overview of first ultrasound measurement predictions and combined values.

Variable	Number	Missing values	Mean	Stand. deviation	Minimum	Maximum
P1_I_FEM	467	1463	3.43	1.36	0.91	7.79
P1_I_BIP	471	1459	5.10	1.50	2.36	10.13
P1_I_ABS	474	1456	5.16	1.74	1.89	10.78
P1_I_ABL	469	1461	5.15	1.80	1.74	10.75
P1_I_FEMK	490	1440	3.44	1.34	1.07	8.30
P1_I_BIPK	490	1440	5.05	1.51	2.40	10.49
P2_I_FEM	1349	581	3.18	1.00	0.60	7.80
P2_I_BIP	1336	594	4.75	1.12	2.36	9.69
P2_I_ABS	1284	646	4.81	1.32	1.86	10.84
P2_I_ABL	1284	646	4.76	1.35	1.72	10.99
P3_I_ABS	1403	527	4.77	1.33	1.60	10.84
P3_I_ABL	1403	527	4.73	1.36	1.46	10.99
I_FEM1	1403	527	3.19	1.04	0.78	7.80
I_BIP1	1403	527	4.71	1.17	1.70	10.10
I_ABS1	1403	527	4.77	1.36	1.60	11.70
I_ABL1	1403	527	4.73	1.40	1.46	11.80

So, the available measurements allowed calculating combined measurements of 1403 foetuses for the first ultrasound (among them are also 450 foetuses having all real measurements). The rest, 527 foetuses, did not have any measurements we needed for the first ultrasound and for them the values were calculated using the age (see formulae (5.1)–(5.4) of the paper).

Table 4. Correlations between real (measured) and combined values of first ultrasound measurements of the foetus.

		Real values				Combined values			
		I_FEM	I_BIP	I_ABS	I_ABL	I_FEM	I_BIP	I_ABS	I_ABL
Real values	I_FEM	1	0.94	0.93	0.93	*1*	0.94	0.95	0.94
	I_BIP	0.94	1	0.95	0.95	0.95	*1*	0.96	0.96
	I_ABS	0.93	0.95	1	0.93	0.94	0.95	*1*	0.93
	I_ABL	0.93	0.95	0.93	1	0.93	0.95	0.93	*1*
Combined	I_FEM	*1*	0.95	0.94	0.93	1	0.95	0.95	0.94
	I_BIP	0.94	*1*	0.95	0.95	0.95	1	0.96	0.96
	I_ABS	0.95	0.96	*1*	0.93	0.95	0.96	1	0.95
	I_ABL	0.94	0.96	0.93	*1*	0.94	0.96	0.95	1

Real values were strongly correlated (Table 4) with corresponding combined values (r is between 0.93–0.95 for all values). If we use combined values instead of real values we gain a slightly better model. The difference is not significant, as the difference of relevant correlation coefficients does not exceed 0.02. All correlation coefficients between the real value and the corresponding combined value are equal to one, because when the real value is available, then the combined value is equal to the real one.

PREDICTION OF RESULTS OF THE SECOND ULTRASOUND EXAMINATION BY MEASURED VARIABLES

Prediction models of variables gained as a result of the second ultrasound examination are given in Table 5.

Table 5. Predictions of the second ultrasound examination (P1 and P2).

No	MODEL	R^2
(3.1)	P1_II_FEM = – 0.2549 + 0.5074 II_BIPA + 0.1128 II_ABSY + 0.1533 II_ABL	0.87
(3.2)	P1_II_BIP = 2.3827 + 0.1441 II_ABSY + 0.1245 II_ABL + 0.5447 II_FEMO	0.87
(3.3)	P1_II_ABS = – 2.0956 + 0.1674 II_ABL + 0.5978 II_FEMO + 0.7111 II_BIPA	0.78
(3.4)	P1_II_ABL = – 1.2739 + 0.7189 II_FEMO + 0.5439 II_BIPA + 0.1482 II_ABSY	0.79
(4.1)	P2_II_FEM = – 0.9528 + 0.8850 II_BIPA	0.85
(4.2)	P2_II_BIP = 2.1744 + 0.9644 II_FEMO	0.85
(4.3)	P2_II_ABS = – 2.3677 + 0.7364 II_FEMO + 0.8226 II_BIPA	0.78
(4.4)	P2_II_ABL = – 1.6247 + 0.8280 II_FEMO + 0.6658 II_BIPA	0.78

Models of the second ultrasound examination (3.1) – (4.4) had an up to 15% lower description rate than the first ultrasound examination models (1.1) – (2.4), which may arise from peculiarities in the foetus' growth as during the second half of pregnancy foetuses differ from each other more than during the first half of pregnancy. In general, bone measurements were better described than non-bone measurements, while the difference was slightly larger than in the case of the first ultrasound models – 0.08–0.11.

As compared to the first ultrasound examination results, the model for prediction of the second ultrasound abdominal measurements was considerably less precise, but bone measurements — head diameter and femur length were still more significant. Predicting them reciprocally (see models (4.1) and (4.2)) revealed that 1 cm longer femur length enlarged the head diameter on average by 0.96 cm and the head diameter larger by 1 cm influenced the femur length by 0.89 cm. The ratio was similar to the first ultrasound measurement.

As the ratio of measurements was similar in different examinations, it was possible to claim that mutual ratios of the foetus measurements remained approximately unchanged during whole pregnancy. As the newborns under examination were healthy and normal, it can be assumed that deviation of the foetus measurements from average could also cause differences in birth weight and length.

Similarly to the first ultrasound examination, predicted values of abdominal measurement were calculated with the help of models using combined values of the head diameter and femur length for the second measurement time (see Table 6, values beginning with P3). As a result, second ultrasound measurements for 1449 foetuses were found. These values were predicted for the missing 527 foetuses on the basis of average pregnancy duration in the following section of the paper.

Table 6. Overview of predicted and combined values of the second ultrasound examination.

Variable	Number	*Missing values*	Mean	Stand. deviation	Mini-mum	Maxi-mum
P1_II_FEM	1189	741	6.66	0.92	3.20	8.62
P1_II_BIP	1181	749	8.59	0.95	5.11	10.32
P1_II_ABS	1190	740	9.62	1.54	3.54	12.53
P1_II_ABL	1186	744	9.62	1.46	3.72	12.21
P2_II_FEM	1418	512	6.62	0.95	2.76	8.43
P2_II_BIP	1396	534	8.56	1.00	4.68	10.85
P2_II_ABS	1365	565	9.56	1.60	3.00	12.32
P2_II_ABL	1365	565	9.57	1.53	3.32	12.22
P3_II_ABS	1449	481	9.55	1.53	3.32	12.22
P3_II_ABL	1449	481	9.54	1.60	3.00	12.32
Combined values						
II_BIP	1449	481	8.56	1.07	4.20	10.60
II_ABS	1449	481	9.53	1.77	3.00	13.90
II_ABL	1449	481	9.55	1.69	3.32	13.40
II_FEM	1449	481	6.62	1.03	2.60	9.00

Real and combined values of the second ultrasound examination results were strongly correlated again (see Table 7), although the correlation coefficients were up to 10% smaller than the correspon-ding relationships between the measurements of the first ultrasound examination.

Table 7. Correlations between real and combined values of the second ultrasound measurements of the foetus.

		Real values				Combined values			
		II_FEM	II_BIP	II_ABS	II_ABL	II_FEM	II_BIP	II_ABS	II_ABL
Real values	II_FEM	1	0.91	0.85	0.86	*1*	0.91	0.87	0.88
	II_BIP	0.91	1	0.86	0.86	0.91	*1*	0.89	0.88
	II_ABS	0.85	0.86	1	0.82	0.85	0.86	*1*	0.82
	II_ABL	0.86	0.86	0.82	1	0.86	0.86	0.82	*1*
Combined values	II_FEM	*1*	0.91	0.85	0.86	1	0.91	0.88	0.88
	II_BIP	0.91	*1*	0.86	0.86	0.91	1	0.89	0.88
	II_ABS	0.87	0.89	*1*	0.82	0.88	0.89	1	0.85
	I_ABL	0.88	0.88	0.82	*1*	0.88	0.88	0.85	1

Slightly weaker relationships can be explained by peculiarities of the foetus' growth as older foetuses differ from each other more than younger foetuses both in terms of growth speed and possibly in heredity as well. Correlations between the measured and predicted values differed from mutual correlations of measured values by maximum of 0.03; the same relationship was valid between mutual correlation coefficients of combined values and correlation coefficients of real measurements. It may be inferred that the use of combined values causes inaccuracy of only a few percentage points.

MODELS USING THE RELATIONSHIP BETWEEN FOETUS' ANTHROPOMETRIC DATA AND LENGTH OF PREGNANCY (ULTRASOUND AGE)

Among the data, there were also such foetuses that did not have any measurements from the list we used. To predict the measurements for such cases we studied the relationships between foetus anthropometric data and duration of pregnancy. In some cases we used the artificial measurement times 140 days and 240 days.

A model for the first ultrasound measurement of each variable was the following:

$$variable = intercept + regression\ coefficient \times time$$

where *time* is age in days at the first ultrasound examination; and a model in the second case

$$variable = intercept + regression\ coefficient1 \times time + $$
$$+ regression\ coefficient2 \times earlier\ value\ of\ variable,$$

where the *earlier value of variable* is the value of the corresponding combined variable at the first ultrasound examination and *time* is the number of days between the two ultrasound examinations.

Results of imputations are provided in Table 8.

Table 8. Prediction models of foetus' anthropometric variables through time.

No	MODEL	R^2
(5.1)	I_BIPT – 0.6062 + 0.0376 I_UHP	0.84
(5.2)	I_FEMT= – 1.5322 + 0.0334 I_UHP	0.83
(5.3)	I_ABST= – 1.4288 + 0.0438 I_UHP	0.83
(5.4)	I_ABLT= – 1.5735 + 0.0446 I_UHP	0.83
(6.1)	II_FEMT= 1.6902+ 0.0265 UHVAHPP + 0.6946 I_FEMT	0.84
(6.2)	II_BIPT= 2.6345 + 0.0274 UHVAHPP + 0.6596 I_BIPT	0.82
(6.3)	II_ABST= 0.7352 + 0.0436 UHVAHPP + 0.9070 I_ABST	0.75
(6.4)	II_ABLT= 1.4508 + 0.0414 UHVAHPP + 0.8150 I_ABLT	0.75

Models of the first ultrasound examination (5.5) — (5.4) described all variables similarly — 83–84%. Growth speeds were also similar — 0.3–0.4 mm a day or 2.1–2.4 mm a week. Models of the second ultrasound examination (6.1) — (6.4) described in case of bone measurements similarly – 82% and 84%, but description of abdominal measurements was 8% lower. Growth per day of bone measurements during the second half of pregnancy was almost twice slower than in the first half of pregnancy, in the case of abdominal measurements the same as in the first half. So all measurements grew more or less equally in the first half of pregnancy, but in the second half bone measurements grow more slowly than abdominal measurements.

ANALYSIS OF COMBINED VARIABLES CORRESPONDING TO ULTRASOUND MEASUREMENTS

Models given at the end of the previous chapter yielded the following finite combined variables shown in Table 9.

Table 9. Combined (predicted) values of anthropometric measurements

Variable	Number	*Missing values*	Mean	Stand. deviation	Mini-mum	Maxi-mum
I_FEMc	1930	0	3.16	0.91	0.24	7.80
I_BIPc	1930	0	4.67	1.02	1.05	10.10
I_ABSc	1930	0	4.73	1.19	0.50	11.70
I_ABLc	1930	0	4.69	1.23	0.39	11.80
II_FEMc	1930	0	6.60	0.93	2.60	9.00
II_BIPc	1930	0	8.53	0.96	4.20	10.60
II_ABSc	1930	0	9.50	1.58	3.00	13.90
II_ABLc	1930	0	9.51	1.51	3.32	13.40

Compared to Table 1 in which we had the same indicators of real (measured) values only, it is evident that combined values of the first ultrasound examination had a somewhat smaller mean and standard deviation. Minimums were also different but maximums similar, which may derive from finding combined values for foetuses of very short pregnancy duration (40–60 days). In general, it has little effect on the result.

Another cause of similarity in the last tables is that only about a hundred predictions with time variables were added to 1800 combined values.

Finite combined values of the second ultrasound differed little from real values, only minimal values of abdominal measurements were smaller than real ones.

CONCLUSION

This paper provided methods for using a sketchy data set derived in the course of ultrasound examinations by filling gaps with regression analysis. Relationships between various ultrasound measurements of foetuses, measured twice during pregnancy, and the use of them for imputations models were studied.

Missing values were predicted by using regression models. It is important in the case when these ultrasound measurements will be used to predict newborns' weight, length and other variables.

The methodological part of the study included rules for compilation of combined variables and checking the adequacy of combined values by comparison of distribution parameters and correlations. The comparison showed that combined results, complemented by predictions, were quite close to real values and hence could be well used in further research.

The results obtained enabled us to draw the following conclusions on characteristics of the anthropometric measurements of the foetuses.

- Results of the first ultrasound examination can be predicted more easily.
- Bone measurements — head diameter and femur length — can be more easily predicted by using other variables.
- Bone measurements contribute more to the prediction of other variables.
- During the first half of pregnancy all measurements grow more or less equally.
- During the second half of pregnancy bone measurements grow more slowly than abdominal measurements.
- The average growth of measurements per week is 2–3 mm.

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Papers on Anthropology XII, 2003, pp. 194–201

ANTHROPOMETRIC CHARACTERISTICS OF RECRUITS IN THE NATIONAL ARMED FORCES OF LATVIA

Liana Plavina, Arkādijs Umbraško

National Defence Academy of Latvia

ABSTRACT

Sports and physical activities constitute an integral part of military service and play an important role in the general military training process. The aim of our investigation was to study the influence of military service upon anthropometric parameters of recruits and their physical fitness. The activity of military personnel is connected with a significant daily physical load as well as in stress situation. We analysed anthropometric parameters and the index of 75 recruits at the beginning of their military service and after 10 weeks of the first part of the training programme in the Military Training Centre. We summarised the anthropometric data as height, body mass, body circumferences (chest), and the results of the standard physical exercise (speed, force and endurance). A special attention was paid to general endurance. We determined and evaluated the changes of physical fitness throughout the training programme.

The anthropometric data of recruits indicated the well-developed proportional body constitution, the well-developed thorax and thoraces muscles. Regular sports training and the physical load exerted a beneficial influence upon physical fitness. We fixed positive changes for 60% of recruits. Physical load in the military training programme corresponded to the recruits' abilities.

Key words: anthropometry, recruits, physical training, physical fitness.

INTRODUCTION

A young man at the age of 18 to 26 can be enlisted in the Armed Forces of Latvia. The obligatory military service lasts for 12 months. During that time recruits undergo professional military training of a high physical and psychological load.

Different authors in different countries with various objectives have examined the military personnel: O'Neil R. S. , J.M. Henderson (1994), Kragh F.J., Taylor D. (1995), Haddock et al (1999), Montain et al (1999), James et al (1999) and others. We were interested in the evaluation of the anthropometric characteristics of recruits and estimated the changes during the service time as well as analysed the recruits' sport results in various physical tests that reflected general physical endurance. Social, economic, health conditions are changing from decade to decade which has an influence upon physical development and physical preparedness, anthropometric characteristics and sports results. The improving social life conditions, nutrition opportunities, healthcare system resulted in improving physical development characteristics, but at the same time evoked some negative factors of modern life style such as psychological stress and physical hypoactivity.

MATERIALS AND METHODS

We examined healthy persons (recruits) at the age 19–24. The whole group of examined recruits consisted of 75 persons. They had equal military training, service and social conditions. We the following methods of investigation: anthropometric examination; experimental methods; mathematical methods.

The anthropometric examination included the determination of the main anthropometric parameters (height, body mass, and chest circumference). We measured height with the heightmeter, weight (body mass) with the medical balance. We calculated anthropometric indices:

1) weight-height index ;
2) relative body mass;
3) body mass index;
4) index of body constitution strength;
5) body proportionality index.

The experimental method consisted of two parts:

1. We fixed sports results in various standard physical exercises: sprint (100 m); standing jump; grenade throwing; cross-country race (3000 m); push-ups test; sit- ups test; pull-up to bar.
2. We fixed Harvard step test results. Step test duration — 240s, step height 50 cm, recruits made the step exercise with the speed 120 step per minute.

RESULTS AND DISCUSSION

Our investigation involved 75 recruits at the age of 18 to 23. The examined group was separated according to the age. Examined groups were different: 18-year-old recruits constituted only 5.3% and their body height was 174.6–±4.2 cm. There were 32% of soldiers whose age was 19, the average of body height was 179.2±1.5 cm (Fig.1). 20-year-old recruits formed the largest age group — 34.7%, their body height was 180.7±0.9 cm. The next three age groups were smaller (2I years — 12%, 22 years — 9.3% and 23 years — 4.0%). The average height to these groups was therefore not reliable. The average of the recruit's height was 179.98±0.76 cm. 64% of recruits have height parameters in the interval between 176–185 cm. The analysis of the recruits' body height changes during the last 100 years has shown that the recruit nowadays (the 21st century) is about 16 cm taller than in the 19th century. We took in consideration the data of Derums (1940) about recruits in Riga (Latvia). 1n 1874 the average of height was 167.63±0.12 cm, until 1916 recruits' height increased about 2.9±.0.6 cm and reached 170.53±0.11 cm. Derums (1940) explained such a fact by improved social circumstances, employment conditions, social factors, etc. During World War 1 the economic situation aggravated as well as social problems that caused antropometric characteristics changes — the body height decreased about 1 cm. But later after the crisis period during the time of the first period of independence in the Latvian statehood a new anthropometics characteristic became higher than shown by Derums(1940) the body height increased over 7.5 mm each decade of 10 year period. The recruits' body height in 1920–1922 was 171.34 (the average). According to Backman (1925) the State Institution of Statistics data concerning 1925 the average height was 171.5 cm. A retrospective overview of anthropometric characteristics helps us evaluate data nowadays. We compared our data with the anthropometric characteristics of military personnel in other countries. For example, the recruits' height (age 19.9 years) in the US Army according O`Neil (1994) was 69.47±2.70 pounds (176.53 cm). Montain (1999) pointed out that the height value for 20-year-old soldiers was 173.0±7.0 cm. These data characterized the American continent. In Europe, in the Army the U.K. the military personnel at the age of 22.8 has the height (the average) of 180.3±7.0 cm. In the Baltic region Dadelo (1999) found the body height for the Police Academy students — 180.6±0.52 cm. As we see, the parameters of height in different regions and countries are similar.

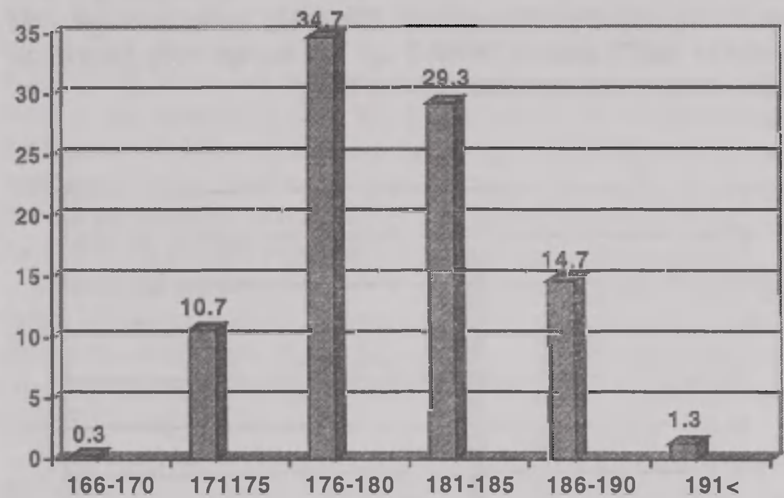

Figure 1. Recruits groups (%) according to height parameters.

One of the anthropometric measurements was the body height in the sitting position. The characteristics of recruits in the examined group were 87.82±1.35 cm. We used the body height data for the calculation of the proportionality index. For 9.3% of recruits the body mass centre was situated in a low position. For 32% of recruits it was placed on the optimal level and for 58.7% the recruit's body mass centre was located in the high position that depends on the height and the length of the extremities. Generally we can see that the body composition of recruits is proportional.

One of the most important anthropometric characteristics is the body mass. There are various external and internal factors that have an influence upon the body mass. The average of the recruits' body mass was 73.82±1,21 kg.. The minimal value of the body mass was 55.0 kg, the highest body mass was 113.3 kg (Fig.2). During the last century the body mass value significantly changed. According to Derums the body mass was 65.41 kg before World War 1. The war situation and the crisis influenced this sensitive anthropometric characteristics — it diminished to 62.13 kg, later after war it slowly increased to 67 kg in 1935. There was a small difference of body mass data in various countries. The average body mass in the US Army according O`Neil was 73.72 (162.39±3.45 pounds). The body mass of 20-year-old recruits in the US army is 78.9±1.7 kg. The average body mass of the Police Academy students was 71.54±0.75 kg.

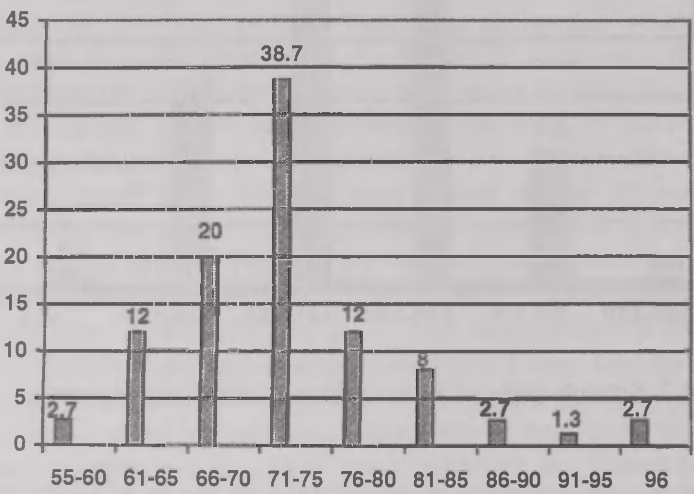

Figure 2. Recruits groups (%) according to the body mass.

The body mass parameters were evaluated by using the relative body mass index. We discovered that the relative body mass index corresponded to the standard for 68%, for 30.7% it exceeds the standard value and only for 1.3% it was below the standard. During ten weeks of a basic training programme the body mass parameters were not the intact characteristics. For 71.7% recruits the body mass changed for 5 kg. We fixed the increase of weight for 60%, but for 11.7% we pointed out the decrease of weight.

The chest circumference is one of the physical development parameters. The average chest circumference in the examined group was 91.4±0.36 cm. During more than a period of hundred years it increased over 15 cm. In 1876 it was 76±0.20 cm, in the war – time the chest circumference decreased over 2 cm. Chest elasticity according to our data, corresponded to the standards and for 41.5% recruits the data exceed the standard.

We used different derived parameters for the evaluation of the body constitution of recruits. One of them was the weight-height index that indirectly indicated the athletic, astenic or hyperstenic body constitution type. We found the average weight-height index — 408.75±5.92 g/cm. We analysed the parameters of weight –height index in the examined group. We found that 53.5% of recruits have the features of athletic body constitution type, 45.3% recruits showed hyperstenic body constitution features and only 1.3% of recruits showed the tendency to the astenic body constitution type. We found that for 73.1% recruits weight-height indexes was over standards.

One of the modern indexes in anthropometry is the Body mass index. The average Body mass index was 23.06±0.49. For 12.2% of recruits the Body mass index was close to the upper limit that indicated a possible overweight problem in future. Such a problem exists in the US Army (Haddock, 1999).

Body constitution strength was evaluated taking into consideration the body mass, the height and the chest circumference. Recruits were divided according to the scale into five groups: weak, middle, good, strong and very strong. The average was 20.4, Table 1 presented the data of body constitution strength before World War 1. The military training results of recruits depended on physical endurance and various physical abilities and working capacity. The main control test in the Army was speed, strength, and endurance test. The development of these features determine the general endurance level.

We fixed sports results in 100 m sprint, standing jump, sit-ups, push-ups, 3000 m cross- country race.

The results of the push-ups test in 10% were negative for the recruits having passed 10 weeks at a basic training course. The average result was (n) 44 that corresponded to the satisfactory result scale.

Table 1. Recruits groups (%) according to the parameters of the body strength index before World War 1 (1913), at the time of World War 1 (1916) and nowadays (2001).

Body strength index scale	Riga – city 1913	Riga – city 1916	Riga –region 1913	Riga –region 1916	Latvia 2001
x–10 very strong	17.2	10.9	34.7	14.7	16
11–15 strong	13.4	11.9	23.0	19.5	34.7
16–20 good	34.1	15.9	23.4	25.2	21.3
21–25 middle	17.2	16.8	13.4	22.9	26.7
25–30 weak	10.8	16.8	4.1	11.9	1.3
30–X very weak	7.3	27.7	1.4	5.8	–

The sit-ups test results were unsatisfactory in 20%, the average number (n) 65. The cross- country race showed that 53% of recruits could not complete the distance in the set time. Results in the Sport test depended on the health category, physical development, the boot quality.

We evaluated the physical endurance according to the Harvard step-test results (Fig.3). The average Harvard step-test index was 78.05±1.65 that corresponded to the middle level of physical preparedness. We divided the recruits according to the Harvard step-test index scale into five groups depending on their physical preparedness: very weak, weak, middle, good, excellent.

There were 59.4% of recruits with middle physical, preparedness, 18.7% of recruits showed a good level of physical preparedness according the Harvard step test index scale and excellent physical preparedness was found in 17.2 5% recruits. During the basic training military programme recruits improved their general endurance and after 10 weeks we saw the Harvard step-test result improving, the average was 80.1±1.1.

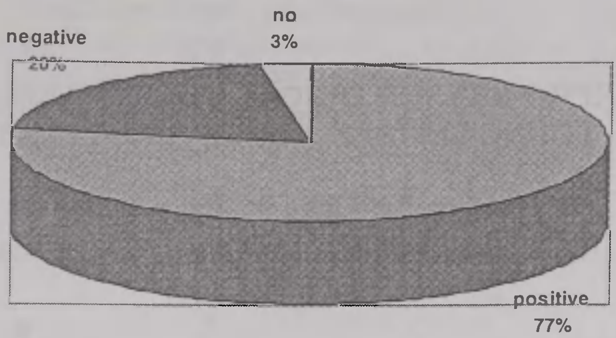

Figure 3. Recruits' Harvard Step-Test index value changes during the basic training course.

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Papers on Anthropology XII, 2003, pp. 202–218

MORPHO-PHYSIOLOGICAL CHARACTERISTICS OF YOUNG FEMALE VOLLEYBALL PLAYERS

M. Prokopec, Padevětová, M. Řemenář, J. Železný

National Institute of Public Health, Prague, Czech Republic

ABSTRACT

Female volleyball players were followed up longitudinally from 8 to 13 years of age in 1974–1980. A set of 42 anthropometrical and physiological traits were ascertained in each participating player twice a year. The numbers of girls varied between 16 and 58 in individual age groups. Some of the measurements were compared with the national standard for children and youths of 1981 (Prokopec-Roth 1987), with the national standard for adult females (Prokopec 1976) and with the Prague Longitudinal Study (Prokopec, 1980). The investigated girls took part in an extensive volleyball and body strengthening training programme five times a week. Their changing physique, body dimensions and proportions through age and training as well as their increasing fitness and power, were followed up year after year by 42 measurements including weight, heights, lengths, widths, circumferences, skin folds, vital capacity, breathing amplitude and hand dynamometry. The female volleyball players were tall, slim, with well developed muscles, with broad shoulders and thus relatively narrow hips, with long upper and lower extremities, with the minimal thickness of subcutaneous fat and relatively low weight, with adequately developed skeletal structures and a relatively high foot arch. These characteristics are considered positive in young females from the standpoint of physical beauty, efficiency and health. Simultaneously the girls developed skilfulness, readiness, elasticity and team spirit, because volleyball as a sports discipline demands and develops all these qualities in participating players. Obviously, it is very difficult to distinguish to what extent the above properties were reached by training only, and in which part genetic endowment and selection played a role. Measurements given in the tables will serve for the comparison with other sports and for the assessment of body development in individual girls of respective ages performing sports, demanding intensive training.

Key words: anthropometry, growth, changing physique through sports, young female volleyball players, longitudinal study.

INTRODUCTION

Young female volleyball players from the LOKOMOTIVA Sports-Club in Prague were investigated anthropometrically regularly at 6-month intervals from 1974 to 1980. The goal of the study was to evaluate the impact of sport (systematic training 5 times a week) on their physical development. Volleyball is a collective sport in which members of the competing teams do not come into direct physical contact — the match is intermediated by the ball, thrown over a high net. This sport involves the whole body, the upper and lower limbs are maximally employed, and readiness, combination and skill are exercised throughout the game.

The girls were not of the same age at the beginning of the study, some of them dropped out in the course of the investigation, others entered. They have been recruited for volleyball training at school, others joined on invitation of the members of the sporting group. Those who left were in part expelled for repeated absence in the training or just left because of loss of interest.

The girls were trained by one of the authors (M.Ř.). Anthropometric measurements were chosen in such a way that information on heights, lengths and circumferences could be obtained and physical properties such as strength, vital capacity, and breathing amplitude could be evaluated.

The exclusiveness of the physique of female volleyball players comes to light only after their measurements are compared with the girls and females who, as a whole, did not specialize in any kind of sport. That is why we have compared the volleyball players with the Czech national standard for children and youths from 1981 [1], with standards for Czech adult females from 1971 (13.5 year old girls only) [2] and with the results of the Prague Longitudinal Study 1956–1980 [3].

MATERIAL AND METHODS

The girls involved in the study were divided into one-year age-groups from 8 to 14 years according to the WHO recommendation [4]. In each age group there are girls from the 1st day of the attained age until the last day before entering the next age group. The numbers of girls in individual age groups from 8.5 to 13.5 years were as follows: In the age group from 8 to 9 years there were 16 girls, in the following age groups there were 45, 58, 42 and 29 girls. On the whole, 238 complete individual assessments and anthropometrical investigations were undertaken. In each of them 42 measurements were taken. Anthropometric measurements were taken according to the recommendations of the International Biological Programme [5] with the exception of the knee height which is measured here to the level of the mid-patella. Skinfolds were measured on 10 sites on the body after Pařízková [6] plus one more skinfold over the biceps, using the Harpenden Skinfold Calliper (the size of the contact plates being 7×14 mm with contact pressure of 10 g per square mm). The way of measuring skinfolds over the biceps, the triceps, under the scapula and above the illiac crest (supracristal) is identical with the IBP recommendation. The sum of the last named 4 skinfolds has been used for calculating the total amount and percentage of fat in the body after Durnin [7]. The breathing amplitude was calculated as the difference between maximum and minimal chest circumferences (measured at a deep inhale and after a maximum exhale). Hand grip was measured by a Collin´s type hand dynamometer by both, right and left hands after each other. The vital capacity was measured by a Hutchinson type of water spirometer. All the measurements were taken by two investigators only (D.P. and M.P.). The trial measurements performed by each of them on the same persons showed none or only insignificant differences

RESULTS AND COMPARISON

The results are shown in Tables 1 and 2 in which the age groups, arithmetical means, standard deviations (SD), the number of persons in each particular age group are given for each of the 42 measurements.

Tables 1 and 2. Anthropometric and physiological measurements of Prague young female volleyball players from 8.5 to 13.5 years (longitudinal follow-up study).

Table 1

Anthropometrical measurements of Prague female volleyball players followed from 8 to 14 years of age

Age (years)	8 -			9 -			10 -		
Mensarement	n	M	SD	n	M	SD	n	M	SD
Sitting Height	16	74,79	3,47	45	76,45	3,32	58	78,90	3,59
Stature	16	141,14	5,20	55	144,67	5,29	58	151,05	5,90
Suprasternal H.	16	113,94	4,61	45	117,57	4,96	58	122,70	5,20
Length of Spine	16	82,86	3,22	45	85,05	3,88	58	88,12	3,89
Acromiale Height	16	113,36	4,36	45	117,15	5,00	58	122,32	5,17
Radiale Height	16	89,10	3,55	45	91,78	4,47	58	96,20	4,74
Dactylion Height	16	53,96	2,66	45	55,62	3,08	58	58,76	3,08
Tibiale Height	16	41,11	2,02	45	42,97	2,25	58	45,66	2,15
Biacromial Diam.	16	29,95	1,01	55	30,76	1,57	58	32,05	1,30
Biiliocris.Diam.	16	20,75	1,05	55	21,12	1,08	58	22,18	1,26
Transverse Chest	16	19,76	1,05	55	20,55	2,00	58	21,24	0,97
Antere-post.Chest	16	13,91	0,84	55	13,83	0,95	58	14,20	1,14
Bicondylar Humer	16	5,45	0,29	55	5,65	0,33	58	5,97	0,30
Bicondylar Femur	16	8,02	0,47	55	8,21	0,41	58	8,58	0,38
Neck Circumferen	16	28,70	1,27	55	29,53	1,16	58	30,55	1,59
Thorax Cir.Relax	16	64,09	3,56	55	66,00	3,32	58	68,42	3,70
Thorax Cir.Maxim	16	69,46	3,74	55	71,44	3,59	58	74,17	3,73
Thorax Cor.Minim	16	62,64	3,74	55	64,32	3,45	58	66,28	3,49
Thigh Cir. Left	16	42,36	3,65	55	43,85	3,18	58	45,49	3,20
Thigh Cir. Right	16	42,17	3,56	55	43,83	3,09	58	45,49	3,10
Calf Circ. Left	15	28,34	2,19	56	29,05	1,82	58	29,90	1,98
Calf Circ. Right	15	28,19	2,13	56	28,67	2,10	58	29,63	1,82
Hand Grip Left	15	16,40	3,18	56	17,45	3,22	58	19,12	3,25
Hand Grip Right	15	15,07	2,71	56	16,52	3,05	58	18,02	3,69
Weight	15	31,26	4,56	56	33,71	4,29	58	37,50	4,96
Vital Capacity	15	1,95	0,26	46	1,97	0,29	44	2,18	0,34
Cheek Skinfold	15	6,99	1,71	56	7,65	1,68	58	7,29	1,58
Chin Skinfold	15	7,01	2,86	56	7,32	2,44	58	6,96	2,22
Thorax I. Skinf.	15	7,21	3,63	56	7,73	3,29	58	7,56	2,83
Thorax II.Skinf.	15	5,85	3,04	56	6,86	3,00	58	6,93	3,34
Supra-Iliac.Sk.	15	7,75	3,64	56	8,42	3,47	58	9,48	3,12
Abdomen Skinfold	15	8,73	6,61	56	9,20	6,05	58	9,38	6,36
Subscapular Sk.	15	7,33	2,48	56	8,04	3,41	58	8,75	3,38
Triceps Skinf.	15	11,55	3,62	56	13,31	4,02	58	12,99	3,82
Thigh Skinfold	15	13,95	3,62	56	13,35	3,66	58	12,38	3,56
Calf Skinfold	15	6,45	2,78	56	6,75	2,57	58	6,90	3,11
Biceps Skinfold	15	6,41	1,79	56	7,42	2,87	58	7,70	2,72
Sphyrion Height	15	7,45	0,56	46	7,89	0,59	58	8,46	0,61
Bitrochanteric D.	15	23,47	1,36	56	24,31	1,94	58	26,25	2,10
Head Circumfer.	15	52,69	1,25	56	52,91	1,06	58	53,31	1,11
Upper Arm Circ.L	15	20,06	1,67	56	21,01	1,42	58	21,67	1,77
Upper Arm Circ.R	15	20,13	1,65	56	21,01	1,57	58	21,72	2,02

Table 2

Anthropometrical measurements of Prague female volleyball players followed from 8 to 14 years of age

Age (years)	11 -			12-			13 -		
Mensarement	n	M	SD	n	M	SD	n	M	SD
Sitting Heigh	42	82,46	3,95	48	84,74	3,81	29	87,97	3,09
Stature	42	158,94	6,34	48	163,74	6,06	29	169,37	4,26
Suprasternal H.	42	129,84	5,50	48	134,10	5,90	29	138,74	3,93
Length of Spine	42	93,10	3,67	48	95,66	3,87	29	99,27	2,79
Acromiale Height	42	129,50	5,76	48	133,60	5,12	29	138,66	3,75
Radiale Height	42	101,97	4,44	48	104,89	3,62	29	108,55	3,18
Dactylon Height	42	61,93	3,04	48	64,23	2,55	29	66,13	2,54
Tibiale Height	42	48,05	2,01	48	48,84	2,06	29	49,87	1,66
Biacromial Diam	42	33,66	1,37	48	34,78	1,48	29	36,37	1,02
Biiliocris.Diam.	42	23,80	1,57	48	24,82	1,64	29	25,88	1,08
Transverse Chest	42	22,07	1,13	48	23,20	1,34	29	24,33	1,18
Antero-post Chest	42	15,19	1,06	48	15,96	1,15	29	16,84	1,83
Bicondylar Humer.	42	6,20	0,30	48	6,30	0,25	29	6,43	0,25
Bicondylar Femur	42	8,89	0,37	48	8,90	0,33	29	9,06	0,34
Neck Circumferen.	42	31,76	1,74	48	32,53	1,56	29	33,84	1,30
Thorax Cir.Relax	42	72,39	3,86	48	75,14	4,12	29	80,39	2,36
Thorax Cir.Maxim.	42	78,16	4,31	48	80,79	4,60	29	85,70	3,04
Thorax.Cir.Minim.	42	69,72	3,60	48	72,21	3,88	29	76,52	2,44
Thigh Cir.Left	42	48,05	3,18	48	50,00	3,37	29	53,19	2,28
Thigh Cir.Right	42	47,79	3,30	48	49,71	3,40	29	53,41	2,33
Calf Circ.Left	42	31,02	3,46	48	32,55	2,20	28	34,08	1,77
Calf Circ.Right	42	30,80	3,30	48	32,17	1,95	28	34,68	1,80
Hand Grip Left	42	21,98	4,29	47	24,83	4,48	27	28,04	6,82
Hand Grip Right	42	21,00	4,54	48	23,88	4,96	27	26,74	5,50
Weight	42	43,15	5,70	48	47,56	6,33	28	54,21	4,15
Vital Capacity	29	2,62	0,54	48	2,85	0,52	27	3,00	0,48
Cheek Skinfold	42	7,62	1,85	48	7,81	1,48	28	8,91	1,35
Chin Skinfold	42	7,34	2,05	48	6,90	1,68	28	7,42	1,80
Thorax I.Skinf.	42	7,62	2,34	48	7,41	2,78	28	7,59	2,21
Thorax II.Skinf.	42	7,10	3,15	48	7,27	2,98	28	8,21	2,35
Supra-Iliac.Sk.	42	10,99	4,71	48	11,34	5,01	28	13,83	4,28
Abdomen Skinf.	42	10,39	5,82	48	10,65	4,32	28	12,79	3,63
Subscapular Sk.	42	8,78	2,88	48	8,81	2,92	28	10,04	2,93
Triceps Skinf.	42	13,22	3,76	48	13,98	3,95	28	14,43	4,45
Thigh Skinfold	42	10,81	2,73	48	11,83	3,28	28	11,40	3,33
Calf Skinfold	42	6,66	2,30	48	8,28	2,95	28	9,00	2,38
Biceps Skinfold	42	7,19	2,06	48	7,45	2,28	28	8,14	2,21
Sphyrion height	42	8,64	0,44	48	8,72	4,41	28	8,81	4,67
Bitrochant.D.	42	27,66	2,20	48	28,78	1,73	28	30,12	1,96
Head Circumfer.	42	53,79	1,17	48	54,10	1,32	28	54,89	1,53
Upper Arm Circ.L	42	21,97	1,42	48	22,69	1,56	28	23,95	1,38
Upper Arm Circ.R	42	22,13	1,37	48	22,62	1,46	28	23,99	1,29

By comparing the average body measurements in individual yearly age groups, a steady quantitative increase in lengths, widths, circumferences and body weight year by year may be observed. The heights and lengths increase during the observed period, i.e. from the age of

8.5 to 13.5 years relatively linearly. The increments in weight, hand grip and vital capacity are the biggest after the age of 10 years. A slightly irregular increase was observed in average skin folds. Biepicondylar humerus and femur, characterizing skeletal growth and also the bicristal width and ankle height reveal a slowing down trend of yearly increments after 11 years of age. Their average yearly increments before the age of 11 were bigger than afterwards. The age group of 11.5 years showed most likely higher averages in the majority of measurements than we would presume, most likely because of the adolescence spurt already being present in some of the girls. This is, for example, apparent in the mean vital capacity, in the mean height, in the sum of four skinfolds, as well as in the circumferences and in the width measurements. The differences in the mean circumferences between the right and left extremities and between the right and left hand grips were statistically insignificant.

COMPARISON OF HEIGHT AND WEIGHT WITH THE NATIONAL STANDARD

The basic measurements, body height and weight, when compared with the national standard of 1981 classified the volleyball players as tall, and slim. Their mean height falls into the middle of the 2nd height channel of the chart PROKOPEC-ROTH (Fig.1) which marks the 90th percentile. Not even the smallest girl fell below the medium channel III. The tallest one exceeded the 97th percentile. Their mean body proportion puts them between channel C and D at below 10 years of age, and later into the upper part of channel D which means that they were slim in comparison with the standard. The female volleyball players had, without a single exception, slim and tall figures, and an elegant, elastic gait.

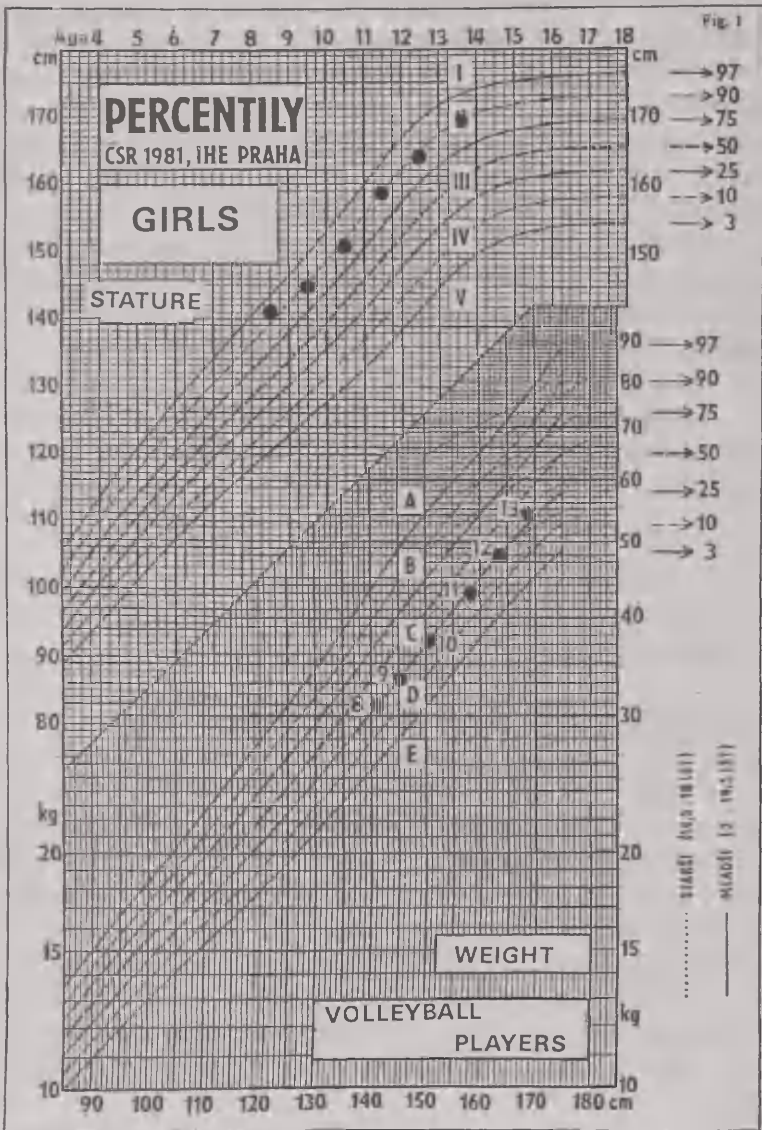

Figure 1. The mean heights and weights of young female volleyball players of 8.5 to 13.5 years plotted onto a chart for the assessment of the child and adolescent growth of Prokopec and Roth. The volleyball players are tall, their mean heights coincide with the 90th percentile level, and slim. Their body proportionality dots lie on the border between D and C channels on the 25th percentile level.

COMPARISON OF THIRTEEN-AND-A-HALF-YEAR-OLD VOLLEYBALL PLAYERS WITH 20 TO 49 YEARS OLD AVERAGE CZECH FEMALES

In comparison with average adult females (Fig. 2) [2] the young female volleyball players at the age of 13.5 years are on average taller (1.54 Z-score), all body heights and lengths are also larger (jugulare height 1.5 Z-score, total arm length 0.72 Z-score). The height of the ankle (sphyrion) reveals the difference 2.4 Z-score, showing thus a higher foot arch in the young sporting group. The sitting height shows a difference of only plus 0.96 Z-score which points to the relatively longer lower extremities in the young volleyball players. The biepicondylar humerus and femur widths and the biacromial width in the volleyball players do not differ from the adult standard. The transverse and saggital thorax, the bicristal width and the bitrochanteric width is narrower in the volleyball players than in adult females by minus 0.7 and minus1.5 Z-scores. The body weight as well as the circumferences of the thorax, thigh and calf are smaller by minus 1 to minus 1.5 Z-score. The neck circumference differs only by minus 0.3 Z-score. Hand-grip strength in the 13.5 year old volleyball players is smaller only by minus 0.3 Z-score than the adult female standard and their vital capacity is in them higher by 0.85 Z-score..

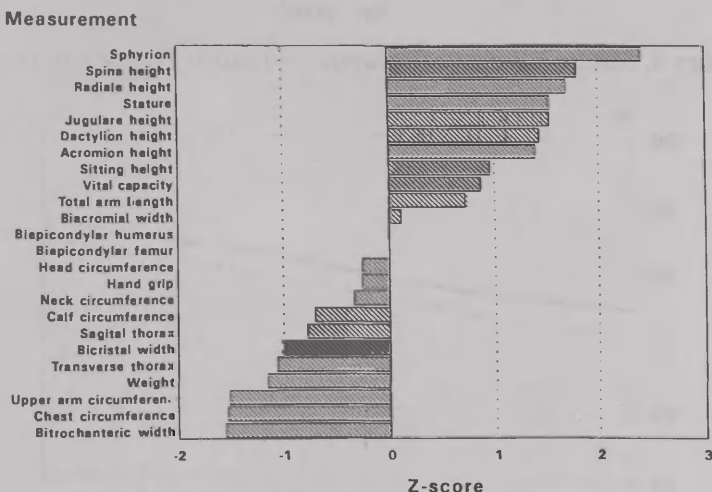

Figure 2. Comparison of selected body measurements of 13.5 year-old volleyball players with those of adult Czech females 20–49 years old in Z-score.

COMPARISON WITH THE PRAGUE LONGITUDINAL STUDY

The selected body measurements of the volleyball players were compared with those of the Prague Longitudinal Study. Young female volleyball players exceed the Prague girls of the same age in body height, (Fig. 3), sitting height (Fig. 4), weight (Fig. 5), femur and humerus widths (Fig. 6), in biacromial width but NOT in bicristal width (Fig. 7), chest circumference (Fig. 8) and in total body fat (Fig. 9). In Figures 3 to 9 the full line represents volleyball players, the interrupted line the girls from the Prague longitudinal study.

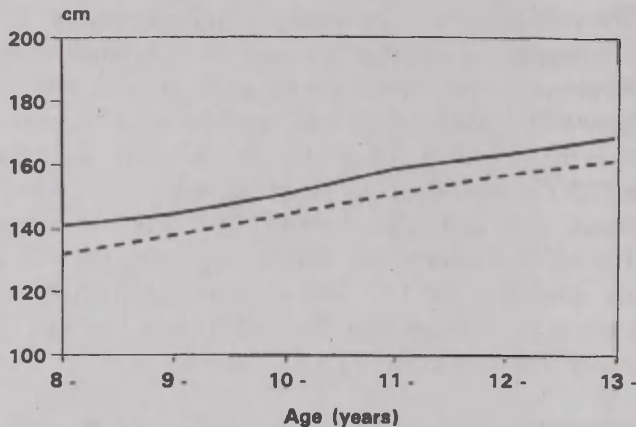

Figure 3. Stature in volleyball players (—) and in Prague girls (- -).

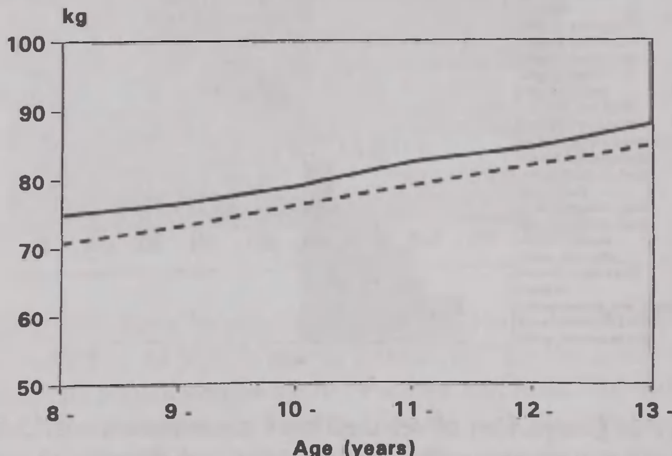

Figure 4. Sitting height in volleyball players (—) and in Prague girls (- -).

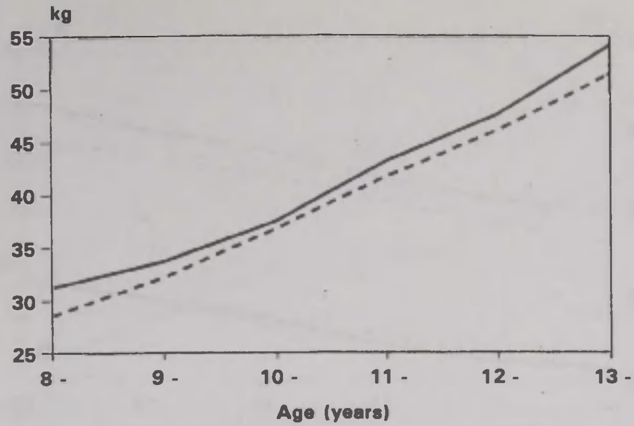

Figure 5. Body weight in volleyball players (—) and in Prague girls (- -).

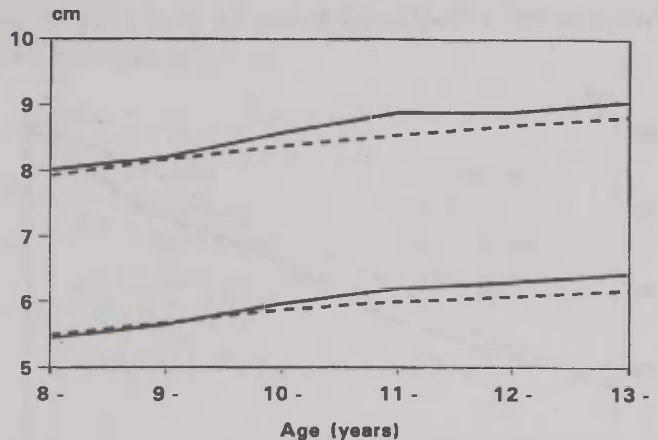

Figure 6. Biepicondylar femur and humerus in volleyball players (—) and in Prague girls (- -).

The comparison of eight selected measurements of volleyball players with the Prague Longitudinal Study (taken as standard) is shown in Fig.10: Individual measurements are expressed in Z-scores. The biggest deviation from the standard in the positive sense shows biacromial width (broad shoulders) and the biggest deviation in the negative sense the subscapular skin fold.

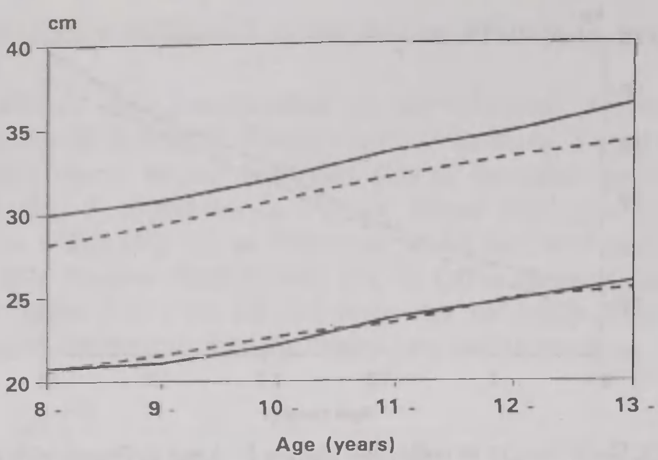

Figure 7. Biacromial (above) and bicristal (below) widths in volleyball players (—) and in Prague girls (- -).

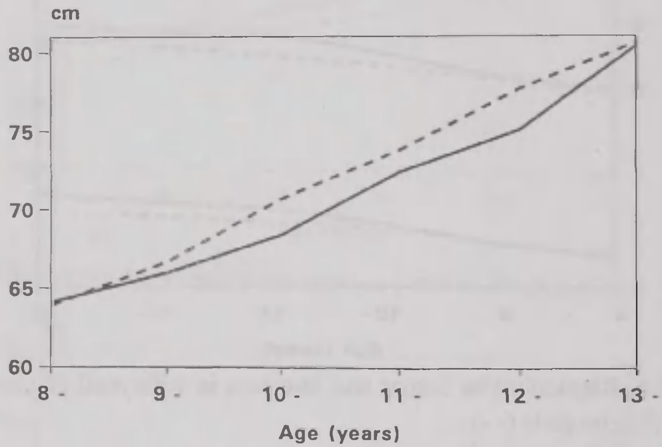

Figure 8. Chest circumference in volleyball players (—) and in Prague girls (- -).

The comparison of the mean sum of four skinfolds and the average percent of body fat is shown in Tab. 3. It shows clearly that the volleyball players have thinner skinfolds and a smaller percentage of fat when compared with the Prague girls. The increase of the average breathing amplitude is also shown in volleyball players from 8.5 years to 13.5 years which amounts to 2.4 cm.

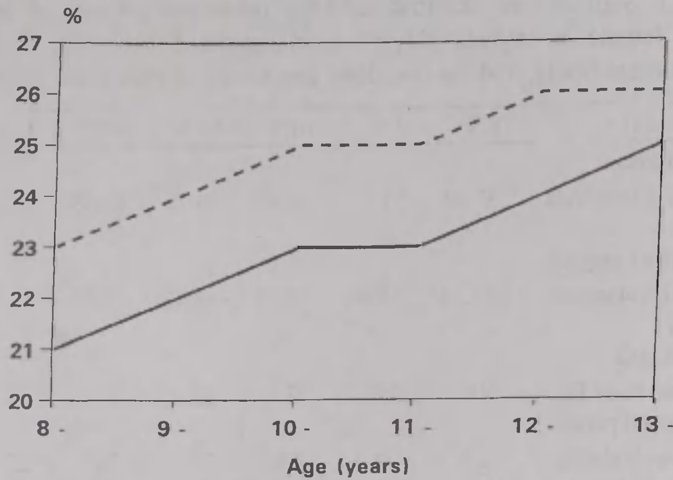

Figure 9. Total body fat percentage of weight in volleyball players (—) and in Prague girls (- -).

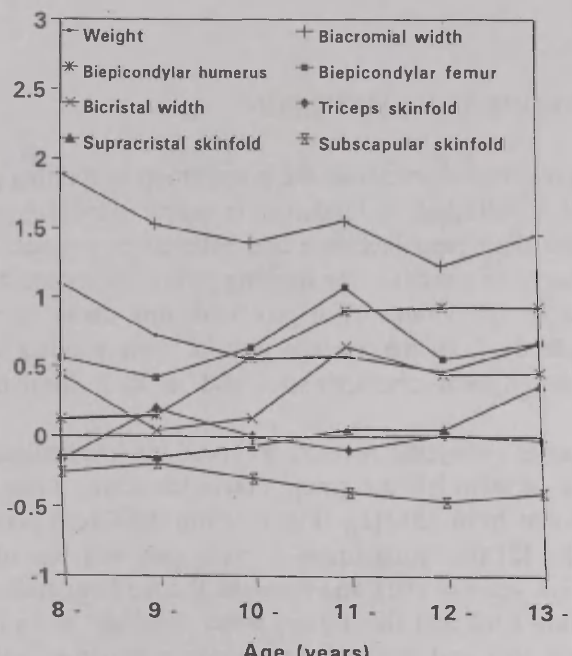

Figure 10. Differences of the selected measurements of female volleyball players from Prague girls (standard) in Z-sore.

Table 3. Sum of four skinfolds and the mean percentages of fat in young female volleyball players in comparison with the Prague Longitudinal Study, and the breathing amplitude of volleyball players.

Age (years) >	8.5	9.5	10.5	11.5	12.5	13.5
Measurement:						
Sum of 4 skinfolds in mm Volleyball players	33.04	37.19	38.92	40.18	41.58	46.44
Sum of 4 skinfolds in mm Prague girls	37.53	40.45	45.54	44.42	47.99	48.45
Per cent body fat Volleyball players	21	22	23	23	24	25
Per cent body fat Prague girls	23	24	25	25	26	25
Breathing Amplitude (cm) Volleyball players	6.82	7.12	7.89	8.44	8.54	9.18

CONCLUSIONS AND DISCUSSION

The data presented characterize the given group of sporting girls who specialized in volleyball and indulged in intensive training for several years during their prepubescence and pubescence periods. The data may also serve as standards for sporting girls of European descent of the respective age groups. The group of girls under investigation differs evidently from the average girls of corresponding ages (not sporting) in physical characteristics and in their lifestyles (daily regimen).

The Prague volleyball players, followed-up longitudinally for 6 years (some of them left the group, others joined it), differ from the Czech standard from 1981(1), (Fig 1), from the Czech standard for adult females [2] (the comparison is made only with the oldest age group — 13.5 years of age), and from the Prague Longitudinal Study [3]. They have a tall and slim figure, broad shoulders and a relatively narrow pelvis, long and slim upper and lower extremities, well arched feet and a narrow, flat thorax. In relation to their body weight they had bigger hand-grip strength and vital capacity and a thinner subcutaneous fat layer (thinner skin folds). Their body characteristics (physique) coincide with those which are appreciated by present-day young females.

It is evident that the volleyball players as a group represents a selection of girls which became still tougher by hard training through years and those for whom the training was too demanding. (In some cases, of course, there might have also been other reasons for leaving the group). Some girls from other volleyball clubs who were evidently successful in sports joined the LOKOMOTIVA club in the course of the research period. A relatively small upper arm circumference and relatively broad biacromial width show that the volleyball players have a thinner fat layer on their arms than non-sporting girls of their age and that volleyball apparently does not demand great strength of the biceps and triceps muscles in comparison with the deltoid, pectoral and dorsal muscles. It is this combination of muscle groups which helps to develop an undeformed and harmonious physique in girls. Movements demanded by playing volleyball model the girl's body a little like that of a boy because it produces or prefers a tall stature, broad shoulders and relatively narrow hips.

It is very difficult, indeed, to distinguish how far this is caused by exercise and training and to what extent it was caused by selection and genetic endowment. It is sure, that the above-described types do well in volleyball and that we do find them among successful players. Other types, not possessing the qualities just mentioned, are found in minority among the players or they just do not tend to join the club. When they do, it is likely that they will leave it in due time.

The personal experience of one of the authors (M.P.) from meeting some of the volleyball players in their adulthood, many years after finishing the above study, was that the beneficial effect of playing volleyball on the development of their physiques was long-lasting, even if they were playing volleyball intensively for a limited number of years during their period of growth. A good example of a positive effect of playing volleyball intensively since early school age on the development of physique is L.B. who was followed-up longitudinally from 3 to 18 years of age. Her heights and weights were plotted against the Czech standard [19, (Fig. 11) and her photographs at the ages of 10, 11 and 15 years are shown in Fig.12.

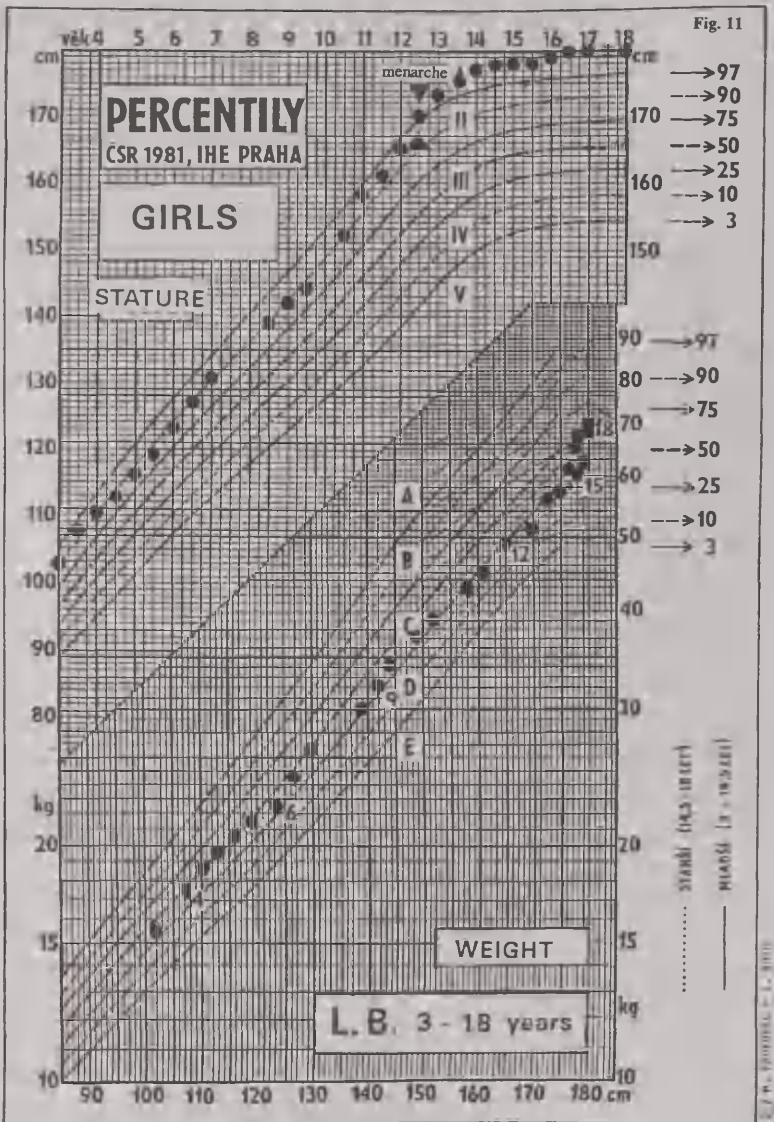

Figure 11. Growth data (heights and body proportionality) of a female volleyball player L.B. plotted into a growth chart from 3 to 18 years of age.

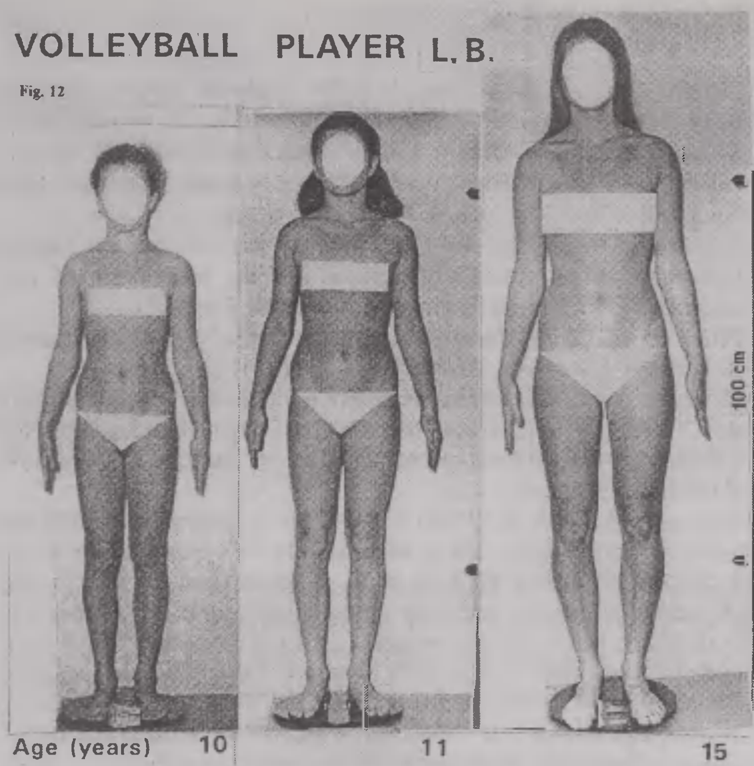

Figure 12. Photograph of volleyball player L.B. at 10, 11 and 15 years of age. Photo: Courtesy National.Institute of Public Health, Prague.

ACKNOWLEDGEMENT

The author is indebted to Dr Med. Pavel Chýle, CSc for the revision of the English text and to Marcela Havlínová for creating Figures 2 to 9.

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Papers on Anthropology XII, 2003, pp. 219–228

ANTHROPOMETRIC ASSESSMENT OF ELDERLY MEN AGED 64–69 IN RELATION TO SOME ATHEROGENIC METABOLIC INDICES (EPIDEMIOLOGICAL STUDY IN TALLINN 2002–2003)

Merileid Saava, Peeter Laane, Jelena Abina, Naima Villo

Estonian Institute of Cardiology, Tallinn, Estonia

ABSTRACT

The cross-sectional epidemiological study of the random sample from the Estonian Population Register of the freely living population of elderly men of Tallinn was carried out in 2002–2003. In this paper results are presented of 139 men, aged 64–69, examined by means of standard epidemiological methods on cardiovascular diseases, including anthropometrical parameters (height, weight, skinfold thickness and hip, waist, arm, calf circumferences), arterial blood pressure, lipids (TC, HDL-C, TG), glucose, albumin, creatinine and homocystine in plasma.

Overweight by BMI (BMI≥25kg/m³) was registered in 70.4% among elderly men, in 22.5% it was estimated as obesity (BMI≥30kg/m³). The opposite, the underweight (BMI≤20kg/m²), was established only in 4.9%. The malnutrition status (MNA≤17 points) estimated by MNA (Mini Nutritional Assessment) was established in 2.4% and the risk to malnutrition (MNA 17–23.5 points) — in 18.4%, well-nourished (normal and overweight) constituted 78.9%. So the comparison of MNA results with BMI values showed that more often MNA detected the risk of malnutrition.

No significant correlation was found of anthropometrical parameters with blood pressure, the highest correlation coefficients were found for diastolic blood pressure with subscapular skinfold thickness and BMI values.

Hypercholesterolemia (TC> 5.2mmol/l) was found in 70%, low levels of HDL-C (hypo-HDL-cholesterolemia, HDL-C < 1 mmol/l) in 29.5%, hypertrigyceridemia (TG > 1,6 mmol/l)- in 34%.

Correlations between anthropometrical parameters and blood plasma lipids assured that the total cholesterol had no correlation to anthropometrical data. At the same time HDL-cholesterol had statistically significant negative correlation to many anthropometrical data: weight, fat (kg), hip and waist measures, BMI and height. Triglycerides, glucose and creatinine in plasma had positive correlation with the same indeces: fat (%, kg), skinfolds' thickness, waist, hip, W/H ratio, weight and BMI. That means that atherogenic changes in the metabolism of lipids (decrease of HDL-cholesterol, increase of triglycerides and glucose) are connected with the excess of fat in the body and especially in the abdominal region of the body.

The correlation between biochemical data showed that total cholesterol was in positive relationship with triglycerides and glucose concentration, at the same time HDL-cholesterol had negative correlation to triglycerides and creatinine in plasma. The levels of triglycerides and glucose both had the same associates with anthropometrical data, especially with fat mass in the body and with the parameters that show fat accumulation (skinfolds, waist, hip and arm circumferences).

Key words: anthropometry, body fat monitoring, BMI, MNA-test, blood lipids, glucose, the elderly

The materials used in this paper form a part of the epidemiological investigation of the main risk factors of atherosclerosis in the elderly in Tallinn which was started in 2002.

The aims of this study are to assess the main common anthropometrical indices in the random sample of men aged 64–69 years and find out the prevalence of the main risk factors and whether there are any associations of the anthropometrical parameters with some atherogenic metabolic indices (lipids, glucose in blood plasma) and blood pressure. The comparison of the present data with our previous investigations on younger population age-groups [1] shows the trends of risk factors and their interaction in the ageing of population.

A number of anthropometrical assessment instruments have been developed for identifying those elderly who would suffer under malnutrition and could benefit from the early detection of that situation and get dietary intervention. It is known that rapid weight loss or malnutrition are independent predictors of increased mortality in older age. The early detection of malnutrition or the risk to it are very important because it is difficult to correct the nutritional status in older age.

The body composition studies have shown that the main change developing with age is the loss of muscle. Sarcopenia may occur in many elderly without a significant weight loss, suggesting that the muscle is being replaced by fat. The body composition changes are important and can not be estimated by body weight or the calculation of the body mass index (BMI) alone. Because of that the MNA-test (The Mini Nutritional Assessment) was worked out and validated [2].

One of the aims of this paper is to use the Mini-Nutritional Assessment test (MNA) in the population of the elderly and to compare the MNA results with the BMI (kg/m²) values and other anthropometrical indices as tools for the nutritional assessment.

There are already data for the institutionalised elderly in the Merivälja nursing home which were obtained by us in our investigation in 1999–2000. The data showed a better outcome detecting the risk to undernutritional status in the elderly by the MNA-test in comparison with BMI [3]. Now it is interesting to know how often malnutrition or the risk to it can be detected by MNA in the epidemiological selection of the elderly.

MATERIAL AND METHODS

The cohort of population for study comprised of men born in 1933–1937 living in Tallinn, the random sample was selected from the Population Register. Among those who participated in the study there were 139 men aged from 64 to 69 (the average age 66.5 years) that provided a sufficient response rate (over 70 per cent).

The examination was done at the department of preventive cardiology by certified investigators on the methods of epidemiological investigation. The examination included medical, social, psychological, nutritional data gathering, which took about 2 hours of contact with the participant, beginning from blood tests, ECG, special standardized questionnaires on the main risk factors. Height (H) was measured with common anthropometre to the nearest 0.5 cm and weight (W) with medical wages to the nearest 0.1 kg. Body fat (in % and in kg) was assessed by Omron BF body fat monitor. Hands' muscle-power measurement was done with a dynamometer (±0.2kg). The circumferences of the right calf and of the right upper arm (±0.1cm) were measured. Skinfold thickness (on the right upper arm over the triceps and subscapular) were measured twice (T and S, ±0.2mm) and the mean of the two measurements and the sum of T+S were used in the study.

The body mass index was calculated. The criteria for the Body Mass Index = Weight/ Height² (kg/m²) were as follows: BMI≥25 to 29.9 light overweight, BMI≥30 real overweight, ≥ 35 obesity; 20–24.9 normal range and BMI < 21 undernutrition.

Nutritional assessment was estimated by the Mini Nutritional Assessment (MNA) [2]. The MNA-test is composed of simple measurements and some questions performed in 10 minutes. The MNA consists of: some anthropometric measurements(weight, height, BMI, the weight loss during the last 3 months; mid arm and calf circumference); a short dietary questionnaire (related to the number of meals, the food and fluid intake, the autonomy of feeding); questions related to lifestyles, medication and mobility; the subjective assessment of self-perception on the health and nutritional status.

The sum of scores of each part of the MNA based on the points system allows a score of 30 points being as the maximum. The criteria for estimating the MNA: ≥24 points are normal, not at risk for malnutrition, 17 to 23.5 are at the risk and <17 points are malnourished.

Blood pressure (BP) measurements were made twice on the right arm with a mercury sphygmomanometer, systolic blood pressure (SBP) was recorded for the Korotkoff's first phase and diastolic pressure for the fifth (DBP) phase. The mean of the two measurements was used in the analysis (±2mmHg).

Venous blood samples were taken from the antecubital vein after a fast of 12 hours. Biochemical analyses of total cholesterol (TC, mmol/l), high density lipoprotein cholesterol (HDL-C, mmol/l) and triglycerides (TG, mmol/l), glucose (Glu, mmol/l), albumin (Alb, g/l), creatinine (Cre, u/mol/l) were performed in EDTA-plasma with enzymatic and routine clinical methods in the Diagnostic Centre of Tallinn on the KONE-Dynamic analyser. Homocysteine (Hcy, umol/l) was determined in the central laboratory of the Tallinn Central Hospital on the IMMUNOLITE 20000 analyser by the chemist A.Kuulberg under the quality control of dr. E. Valdre, PhD. The data were computed using the SPPS statistical package. Means, standard deviations, percentile values and correlation coefficients were calculated.

RESULTS AND DISCUSSION

The means and medians of data together with their percentiles are presented in Table 1 and frequencies of BMI and MNA values with the criteria of over- or undernutrition are in Table 2.

Overweight by BMI (BMI≥25kg/m³) was registered in 70.4% among elderly men, in 22.5% it was estimated as obesity (BMI≥30kg/m³). The opposite, the underweight (BMI≤20kg/m²) was established only in 4.9%. In 1999–2000 in younger men population (50–54-year-olds) the prevalence of overweight was lower — 64.9% and obesity 15.8% [4, 5].

Estimated by MNA, the malnutrition status (MNA≤17 points) was estimated in 2.4% and the risk to malnutrition (MNA 17–23.5 points) — in 18.4%. It is important to mention that the MNA-test already gives one point less to BMI≤23 and BMI≤21 two points less in calculating of the overall score. The conclusion of these comparisons is that BMI gives overestimated results for the normal and the overweight status of elderly people and so the risk to malnutrition is non-existing. For the real assessment of the nutritional status in older age it is better to use the MNA-test, as it is validated and recommended, because the MNA takes into account more parameters than BMI.

Dynamometric measurement showed that the mean strength of hands was 39–43 kg and variations were from 24 to 58 kg with no significant differences between the right or the left hand.

The criterion of hypertension was taken SBP/DBP≥140/80 mmHg. By this criterion in the present study of the elderly population aged 64–69 hypertension represents a great risk (in 66.2%) and compared with previous studies it has remained on the same high level (BP was elevated in 61.4% of men aged 50–54 investigated in Tallinn in 1999–2000) [4, 5]. No significant correlation was found of anthropometrical

Table 1. Anthropometric, blood pressure and biochemical data (mean, standard deviation and procentiles) of the population sample of men aged 65–69 in Tallinn 2002–2003.

Variables	Mean	SD	Procentiles						
			5	10	25	50	75	90	95
Height (cm)	173.3	6.49	161	164	169	174	771	181	184
Weight (kg)	83.2	15.36	58.7	63.0	71.8	83.0	92.9	103	111
BMI (kg/m²)	27.6	4.39	20.2	22.0	24.0	28.0	30.0	34.0	35.0
Waist circum-ference(cm)	95.8	12.27	75	80	88	96	1.4	110	118
Hip circumference (cm)	103.5	8.25	91	94	98	103	108	115	118
Waist/Hip	0.93	0.068	0.80	0.84	0.88	0.93	0.98	1.00	1.00
Upper arm circum-ference (cm)	31.7	3.35	27	28	29	32	34	36	38
Calf circumference (cm)	36.3	3.08	30	33	35	36	38	41	42
Tricepc skinfold (mm)	20.8	7.88	7.5	10.5	14.5	21.0	26.5	30.0	33.0
Subscapular skinfold (mm)	24.6	9.47	9.5	11.5	17.0	24.5	32.0	36.5	41.0
Skinfolds' sum (mm)	45.4	16.28	19.5	24.5	32.0	45.0	59.5	66.5	70.0
Body fat (%)	27.7	5.08	18.9	20.6	24.1	28.9	31.6	34.2	35.8
Body fat mass (kg)	23.3	7.78	11.5	13.9	17.3	22.9	28.5	35.0	37.8
MNA score	26.1	3.52	18.9	20.5	24.5	27.0	29.0	29.7	30.0
Dynamometry (kg)									
Right hand	43.2	8.84	29	31	38	42	49	54	58
Left hand	39.1	8.84	24	28	34	39	44	49	56
Heart rate (per min)	69.8	11.99	52	58	64	68	75	84	92
Blood pressure (mmHg)									
Systolic BP	156.2	67.1	117	123	134	148	162	184	200
Diastolic BP	87.7	12.8	68	72	79	87	96	104	110
TC (mmol/l)	5.79	1.01	4.1	4.6	5.1	5.8	6.4	7.2	7.6
HDL-C (mmol/l)	1.35	0.47	0.8	0.9	1.0	1.2	1.5	2.0	2.4
TG (mmol/l)	1.67	1.52	0.64	0.80	1.00	1.40	2.00	2.7	3.0
Glucose (mmol/l)	6.17	1.23	4.9	5.1	5.4	5.8	6.5	7.6	8.3
Albumine (g/l)	44.9	4.56	37	39	42	45	48	50	53
Creatinine (umol/l)	82.0	15.08	60.5	63.0	70.2	80.5	91.0	100	106
Homocysteine (umol/l)	10.8	6.77	5.9	6.3	7.4	9.3	11.5	14.7	20.6

Table 2. Frequency of overweight and malnutrition by several anthropometrical measures and biochemical data in comparison with BMI and MNA values.

Parameter	Class	Criteria for estimation	Frequency (%)
BMI (kg/m^2)	Severe undernutrition (UN)	<18.5	1.4
	High risk to undernutrition	≤19	2.8
	Beginning risk to underweight	≤21	7.0
	Normal weight range	21–25	24.5
	Overweight	≥ 25	70.4
	Obese class I	>30	22.5
	Obese class II	>35	4.5
Waist (cm)	Increased	>95	49.6
	Substantially great	>100	35.5
Waist/Hip ratio	Increased	>0.96	34.2
	Very high	>1.00	9.1
MNA score	Malnourished	≤ 17	2.3
	Risk to undernutrition	17–23.5	18.8
	Well-nourished	≥24	78.9
Very low albumine	Undernourished	≤36 g/l	3.4
(10% percentile point)	Risk to undernutrition	≤40 g/l	14.2
Low creatinine	Risk to undernutrition	≤70 umol/l	25
(5% percentile point)	Undernourished	≤60 umol/l	4.7

parameters with blood pressure in that age-group, the highest correlation coefficients were found for diastolic blood pressure with subscapular skinfold thickness and BMI values (r=+0.190 and +0.183), then followed weight, waist and upper arm circumferences and the fat mass (kg). In 13% of the participants the heart rate reached 80 and more beats per minute; the significant correlation of the heart rate to total cholesterol and the glucose level in blood and with diastolic blood pressure appeared.

The comparison of the data of blood plasma lipids with normal ranges showed that the mean levels of TC and TG in elderly men were high (average 5,8 mmol/l, 1.67 mmol/l); HDL-cholesterol level was 1.35 mmol/l. The mean of glucose was 6.17 mmol/l (normal under 6 mmol/l). Hypercholesterolemia (TC> 5.2mmol/l) was in 70%, low levels of HDL-C (hypo-HDL-cholesterolemia, HDL-C < 1 mmol/l) in 29.5%, hypertrigyceridemia (TG > 1,6 mmol/l) — in 34%.

The correlations between anthropometrical parameters and blood plasma lipids presented in Table 3 assured that total cholesterol had no correlation to anthropometrical data. At the same time HDL-cholesterol in plasma had negative correlation to many anthropometrical data: weight, fat (kg), hip and waist measures, BMI and height. Triglycerides, glucose and creatinine in plasma had positive correlation to the same indices: fat (%, kg), skinfolds' thickness, waist, hip, W/H ratio, weight and BMI. That means that atherogenic changes in the metabolism of lipids (decrease of HDL-cholesterol, increase of triglycerides and glucose are connected with the excess of fat in the body and especially in the abdominal region of the body. The correlation between biochemical data shows that total cholesterol is in positive relationship with triglycerides and glucose concentration, at the same time HDL-cholesterol had negative correlation to triglycerides and creatinine in plasma. Triglycerides' correlation to the glucose was the highest (r=+0.45) among all the metabolic interactions and because of that the triglycerides and glucose levels both had the same associates with anthropometrical data, especially with the fat mass in the body and connected parameters that show fat accumulation (skinfolds, waist, hip and arm circumferences).

In conclusion, anthropometrical parameters together characterized as overweight and obesity, fat accumulation in the body, especially in the abdominal region of the body have a certain impact on blood plasma lipids, glucose and diastolic blood pressure, that is why they are the main risk factors for atherosclerotic heart diseases, hypertension and diabetes.

BMI is not very adequate for estimating the nutritional status in the aged people. MNA is a better tool for this purpose, because MNA detects malnutrition risks more often. A certain part (20%) of elderly men of freely living population are at risk to be undernourished and have to be under special medical follow-up and nutritional care.

Table 3. Correlation coefficients between anthropometrical parameters, blood pressure, plasma lipids and other biochemical indices of men aged 65–69 years (p≥0.01* ; p≥0.001**).

Variables	Coefficients of correlation						
	TC	HDL-C	TG	Glu	Cr	SBP	DBP
Height	–0.16	–0.25*	+0.06	–0.00	+0.08	–0.02	+0.00
Weight	–0.05	–0.31*	+0.17	+0.24*	+0.24*	–0.04	+0.17
BMI	+0.02	–0.24*	+0.17	+0.29**	+0.26*	–0.04	+0.18
Waist circumference	+0.15	–0.27*	+0.26*	+0.31**	+0.30**	–0.04	–0.16
Hip circumference	–0.04	–0.30**	+0.14	+0.31**	+0.24*	–0.06	+0.15
Waist/Hip	+0.10	–0.15	+0.25*	+0.20	+0.33*	+0.01	+0.14
Arm circumference	–0.03	–0.20	+0.24*	+0.18	+0.18	+0.02	+0.17
Calf circumference	+0.00	–0.28*	+0.09	+0.12	+0.13	+0.06	+0.11
Tricepc skinfold	+0.01	–0.04	+0.19	+0.11	+0.10	–0.02	+0.07
Subscapular skinfold	+0.04	–0.04	+0.24*	+0.15	+0.17	+0.02	+0.26*
Skinfolds' sum	+0.02	–0.04	+0.23*	+0.14	+0.15	+0.00	+0.14
Body fat (%)	–0.02	–0.21*	+0.26*	+0.31**	+0.08	–0.14	+0.12
Body fat mass (kg)	–0.02	–0.29*	+0.27*	+0.32**	+0.19	–0.10	+0.14
MNA score	–0.02	–0.19	+0.11	+0.11	+0.13	–0.09	–0.10
Heart rate (per min)	+0.24*	–0.01	+0.21	+0.28**	+0.02	+0.02	+0.26*
Systolic BP	+0.05	+0.03	–0.03	+0.03	+0.02	1.0	+0.30*
Diastolic BP	+0.28**	+0.06	+0.18	+0.03	+0.02	+0.30*	1.0
TC (mmol/l)	1.0	+0.16	+0.35**	+0.26*	+0.01	+0.05	+0.28*
HDL-C (mmol/l)	+0.16	1.0	–0.25*	–0.02	–0.32**	–0.03	+0.06
TG (mmol/l)	+0.26*	–0.25*	1.0	0.45**	+0.13	–0.03	+0.18
Glucose (mmol/l)	+0.24*	–0.02	+0.45**	1.0	+0.10	+0.03	+0.03

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Papers on Anthropology XII, 2003, pp. 229–239

COMPARATIVE ANALYSIS OF AGE-DEPENDENT PROCESSES

R. Stupnicki, J. Dobosz, K. Milde, P. Tomaszewski

Academy of Physical Education, Warsaw, Poland

ABSTRACT

Comparing various groups (e.g. social categories) with respect to one or more variables over a wide age range presents serious difficulties when the given variable is to be represented by a single value. The aim of the study was to design a method of comparing developmental processes, recorded cross-sectionally for various groups of subjects and free of constraints like linearity and/or homogeneity of variances. The effects of mothers' education and of residence town size on body height and running test results (50 m distance) of boys served as a model. Data from 1989 National Youth Survey, which included boys aged 7–20 years (n = 1547) from fatherless families, were used. Boys of the same age range, inhabiting large cities (above 100,000 inhabitants), whose fathers had higher education, served as control group (n = 1158). The procedure consisted of transforming variables in order to normalise their distributions. Means and standard deviations, fit as polynomial functions of age, served to standardise transformed variables. Normality of distributions of standardised variables validated the procedure.

Both factors (mothers' education and town size) significantly affected body height; boys from large towns, whose mothers had higher education, did not differ from the control group. On the other hand, boys from small and medium-size towns, whose mothers had higher education, exhibited a significantly higher running velocity than control subjects; boys from other categories did not differ significantly from controls. It was concluded that standardisation of variables against time-functions of means and standard deviations, determined for wide age-ranges, enables comparing social categories with respect to given variable globally, irrespectively of age. Moreover, a lack of correlation of the standardised variable with age and symmetrical distribution of data outside the ±2 SD interval, may serve as validation criteria for the entire procedure.

Key words: age-related processes; standardisation of variables; social categories

INTRODUCTION

Socio-anthropological studies often involve cohorts in a wide age range and classified into diverse categories for comparative purposes. In order to facilitate age-based comparisons, the subjects are usually grouped in several age classes. However, when studying e.g. growth processes, the intra-class scatter usually varies with age, making it non-uniform, like in the case of body height. Therefore, social categories cannot be directly compared as a whole over a wide age range. In a simplified approach, the categories are compared by the same age classes (cf. e.g. [6]), thus rendering a large number of comparisons (contrasts) instead of just one for any two categories. The number of contrasts is sometimes reduced by subdividing the entire age range (e.g. from 7 to 19 years) into three periods: pre-pubertal, pubertal and post-pubertal [3]. Although such a procedure may give insight into the consecutive phases of development, a single value representing a given social category may prove useful. The obvious way to achieve this is to standardise variables, but the non-uniformity of variances along age presents a serious obstacle. Standardising against empirical values was used by Przewęda and Dobosz in their study on regional differences in somatic and physical fitness variables [4].

Another approach, presented by Cauderay et al. [1], consisted of computing a set of multiple regressions, which might be useful to describe the process, but comparing groups would remain difficult.

The aim of the study was to design a method of comparing developmental processes, recorded cross-sectionally for various groups of subjects, and free of constraints like linearity and/or homogeneity of variances.

MATERIAL AND METHODS

The analysis was performed on cross-sectional data on growth and motor development of boys from fatherless families, brought up by mothers (n= 1547). The data were selected from a large cohort of boys studied in a socio-anthropological survey project (n=37,690) conducted in 1999 by Przewęda and Dobosz [4].

The boys were classified by mothers' education (three categories: elementary, secondary, higher) and by the residence town size (three categories: localities up to 10,000 inhabitants, towns up to 100,000 inhabitants, larger towns). The numbers of subjects in all nine categories are presented in Table 1.

Table 1. Numbers of boys from fatherless families classified according to mothers' education and town size.

Mothers' education \ Town size	<10K	10–100K	>100K	Total
Primary	415	177	145	737
Secondary	216	237	141	594
Higher	59	85	72	216
Total	690	499	358	1547

Boys, whose fathers had higher education and inhabited large towns (over 100,000 inhabitants), were also selected from that large cohort and served as a reference group (n = 1158). They were grouped in age classes, one-year wide.

For the purpose of this study, two variables were selected: body height and 50 m run. Processing details will be presented in the Results section. Standard Excel procedures and functions were employed.

RESULTS

Body height. For every age class means and standard deviations were computed and smoothed by moving average as described elsewhere [5]. Smoothed values were then approximated with fifth degree polynomials by using standard Excel function; these polynomials were named f_m and f_s for the mean and standard deviation, respectively. Next, individual standardised z-values were computed from the formula: $z_i = (x_i — f_m)/f_s$, where x_i were individual body height values. The observed and smoothed values are presented in Figure 1.

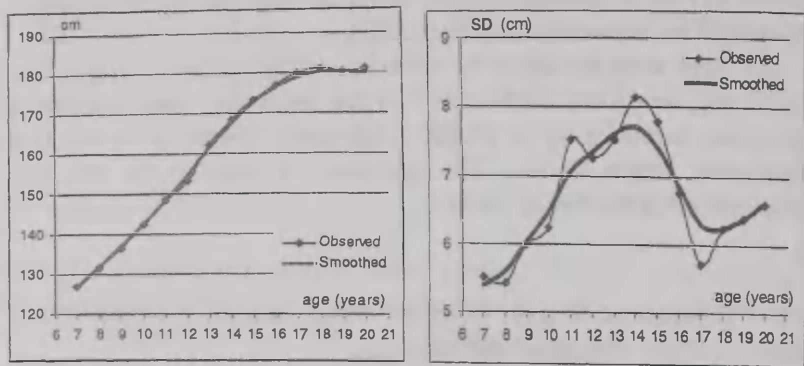

Figure 1. Mean body heights (above) and standard deviations (below) of boys (total n=1158) from big cities; fathers with higher education. Raw values and smoothed ones by fitting five-degree polynomial. Cross-sectional study from 1999.

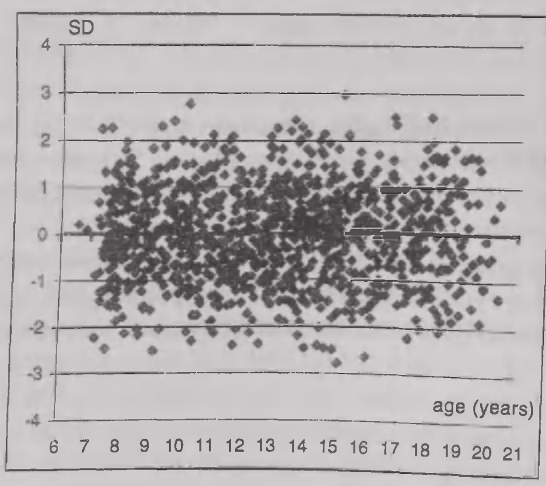

Figure 2. Individual, standardised values of body height of boys. Standardisation against five-degree polynomials computed for smoothed means and standard deviations (for details see Figure 1.).

In order to verify the correctness of standardising, standardised values were plotted against age (Figure 2.). The points are uniformly scattered along age and the total numbers of points exceeding the 95% interval are identical and amount to 26 each, vs. the expected 29 (2.5% of 1158).

Fifty-meter run. Three approaches were used to process these data:

1. Raw values,
2. Square root transformation,
3. Reciprocal transformation (strictly speaking, the time measurements were transformed to velocities, i.e. 50/time).

In all instances, the means and standard deviations for yearly age classes were smoothed, then polynomial functions and standardised values were computed as described for body height. The distributions of standardised values proved right-skewed for (1) and (2) and nearly normal for velocities (3), as shown in Figure 3. Quadratic and linear fits for running velocity means and standard deviations, respectively, are shown in Figure 4, and the standardised values vs. age plot in Figure 5.

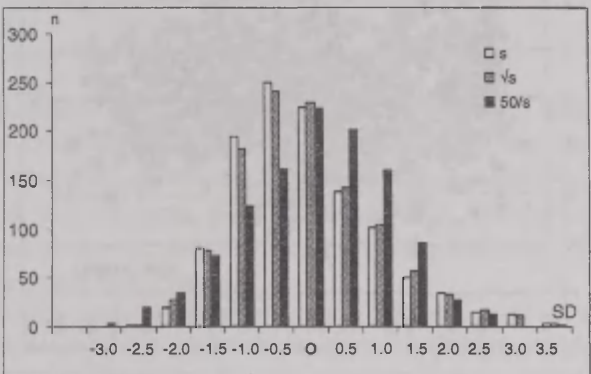

Figure 3. Distributions of standardised values of 50 m run results: running time, square root of running time, and running velocity. Results recorded in boys presented in Figure 1.

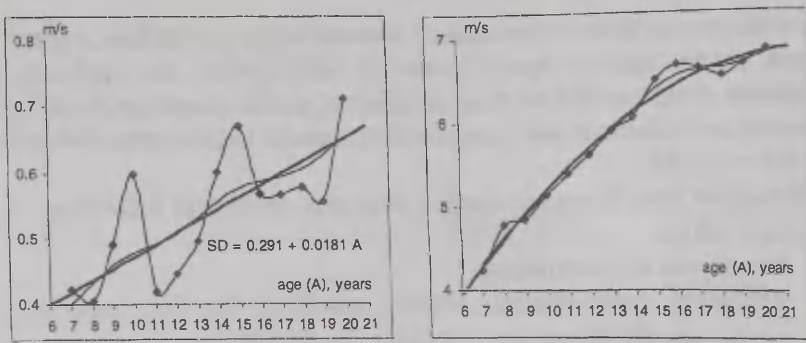

Figure 4. Mean velocities of running 50 m distance (upper) and standard deviations (lower) of boys. Raw values (line with points), smoothed ones by moving average technique (dotted line), and approximated by equations shown (for details see Figure 1.).

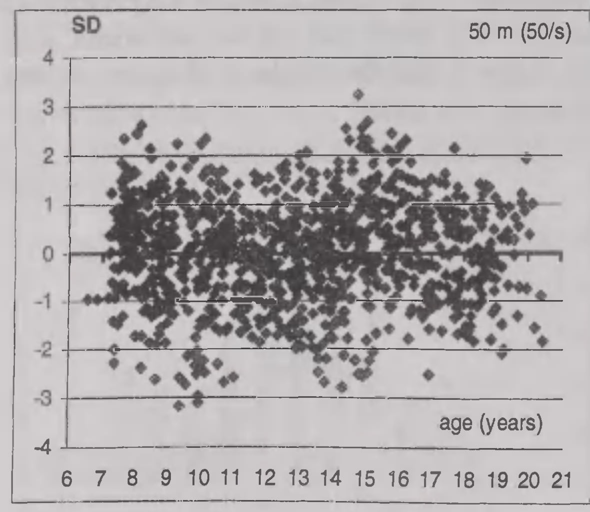

Figure 5. Individual, standardised values of running velocity of boys at 50 m distance. Standardisation against equations presented in figure 4, computed for smoothed means and standard deviations (for details see Figure 1.).

The total numbers of points exceeding the 95% interval amounted to 41 (lower end) and 28 (upper end). The observed excess in the former vs. the expected number was non-significant ($\chi^2 = 1.13$).

Mean standardised values for body height and running velocity were computed for boys from all social categories of fatherless families. Mean values, together with standard errors (SE), are presented in Figures 6 and 7.

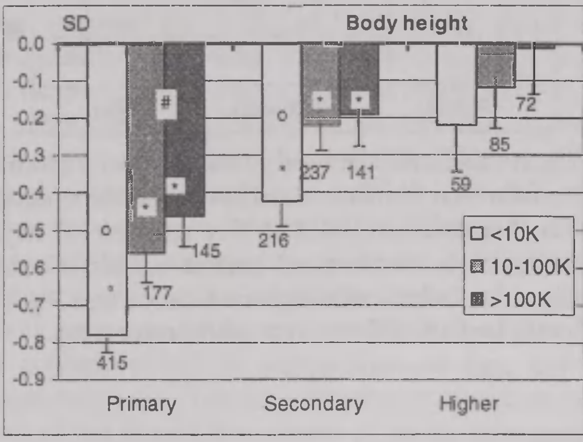

Figure 6. Mean (±SE), standardised body height of boys aged 7–20 years (total n = 1158) from fatherless families, classified by mothers' education and town size (in thousands inhabitants). Numbers of boys in each category given under the bars. Standardised against polynomial equations computed for boys from big cities, fathers with higher education (see Figure 1.).

Significantly ($p<0.05$) different from: * reference group; ° medium-size town, same mother's education category; # respective categories, secondary mother's education.

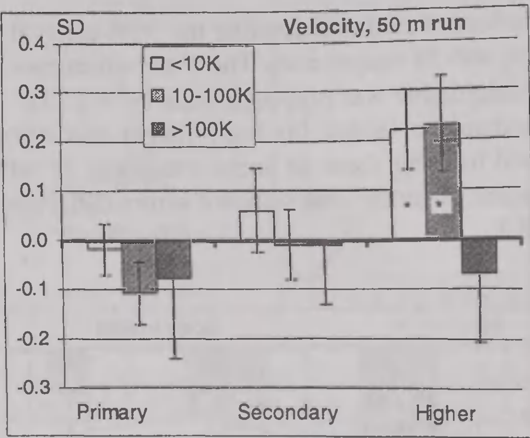

Figure 7. Mean (±SE), standardised running velocity (50 m distance) of boys from fatherless families, classified by mothers' education and town size (in thousands inhabitants). For numbers of boys in each category see figure 6. Standardised against equations computed for boys from big cities, fathers with higher education (see Figure 4.).

* Significantly ($p<0.05$) different from the reference group.

DISCUSSION

The approach used here, i.e. standardising individual data against mean and standard deviation defined as functions of age, seems to be an alternative to other means of reducing a set of data to a single value. There are no limitations as to the choice of fit — the polynomial function used here is easy to apply but might render unreliable values at the ends of the range studied; it may be difficult to obtain a stable value corresponding to the terminal growth. Therefore, spline functions might provide a good solution, especially for e.g. body height [2], but the end portion of body height curve may still require an asymptotic segment, or a linear one in form of age-defined condition (i.e. above a given age the function becomes a constant).

However, the growth curve in cross-sectional studies may not show a constant terminal stature, due to the fact that subjects who terminated their growth at the time of the study, i.e. at the age of 18 — 20 years, could not benefit from improved living conditions, in contrast to their juniors. This would not apply to populations whose living standard was high and steady for two decades or more.

At any rate, the presented approach is superior to standardising against empirical means and standard deviations for individual age categories. In that latter case, standard deviations presented in Figure 4 would produce great scatter in standardised values between age categories without any justification for such a phenomenon. Therefore, the scatter in standard deviations was considered random, and linear fit for standard deviations vs. age was applied.

The functions used in standardising may be obtained directly from the entire set of data, from unweighted moving means and standard deviations computed for 'rolling-on' sets of e.g. 50 values, or from means and standard deviations, either raw or smoothed ones, computed for consecutive age classes, e.g. by the weighted five-point moving average technique (cf. [5]). Besides, raw data may require some preprocessing prior to standardisation, e.g. transformation (square root, reciprocal, log, truncation etc.).

An important step is validation of the entire procedure, consisting of plotting individual standardised values of a given variable against age (Figures 2 and 5). This should be done for the set of reference data, which served to produce standardising functions. Two criteria may be applied: a lack of dependence on age, and normal-like distribution across age. The latter may be evidenced by no significant deviations of the observed numbers of points below and above the 95% range from the expected ones (cf. Figures 3 and 5).

Apart from methodological considerations, the results obtained by our approach should also be commented upon. Body height of boys from the lowest social category (mothers with primary education, living in villages) exhibits the greatest deviation, by nearly 0.8 SD, from the reference group. The deficit in body height decreased with the education level of mothers and, to a lesser degree, with the town size. In general, mean, standardised body height of boys from medium and large towns did not differ significantly between categories, but both differed from village boys. Boys from those two categories, whose mothers had higher education, did not differ significantly from those from the reference group. It may be concluded that lone mothers with higher education are capable of providing their sons as good living standard as full families of the same education level.

Running velocity at 50-m distance may be regarded as an indicator of speed/strength fitness. Interestingly, boys from fatherless families, whose mothers had either primary or secondary education, did not differ significantly from the respective reference categories. On the other hand, boys from the higher education category of mothers exhibited a significantly higher fitness than the reference group, but only those from villages or medium-size towns. Boys from the highest category resembled those from the lowest ones. On the whole, no category of studied boys proved worse than the boys from the reference group. Naturally, no conclusion can be drawn as to the overall fitness of boys studied from a single test only, but the principal aim was to present an approach to a global assessment of variables in a population.

CONCLUSIONS

1. Standardisation of variables against time-functions of means and standard deviations, determined for wide age-ranges, enables comparing social categories with respect to given variable globally, irrespectively of age.
2. A lack of correlation of the standardised variable with age and symmetrical distribution of data outside the ±2 SD interval may serve as validation criteria for the entire procedure.

ACKNOWLEDGEMENTS

The study was supported by project No. DS-40. Thanks are due to Professor R. Przeweda for making available the data from project No. 3P05D02422 used in this study.

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Papers on Anthropology XII, 2003, pp. 240–250

IDENTIFICATION AND PREVALENCE OF WHITE COAT HYPERTENSION IN ADOLESCENTS

Lagle Suurorg

Estonian Institute of Cardiology,
Department for Children's Preventive Cardiology

ABSTRACT

Ambulatory blood pressure monitoring (ABPM) is widely utilized for the evaluation and management of hypertension in adults but has not been routinely used in children and adolescent care. Objectives: 1) to determine how the choice of threshold limits for defining ambulatory hypertension affects the determination of "white-coat hypertension" (WCH) in adolescents; 2) to find whether the severity of office hypertension predicts the occurrence of WCH in adolescents; 3) to identify the prevalence of WCH in adolescents of different sex. Patients and methods. Seventy-one adolescents (mean age 15 years) with elevated blood pressure were investigated using ambulatory blood pressure monitoring. Blood pressure was assessed according to two widely quoted limit sources: the Task Force for High Blood Pressure in Children and published normative ambulatory BP data from a multicentre study. The new blood pressure index was used for assessment of the severity of hypertension. Results. The results of the current study confirm the importance of the choice of threshold BP limits used to define ambulatory hypertension and WCH in adolescents. To determine whether the likelihood of hypertension was affected by choice of the threshold values, the BP indices (BPI) were calculated. Effect of the difference in threshold values on the calculation of BP load the blood pressure index was determined by Task Force patient-specific 95th threshold limits or by ambulatory blood pressure threshold values. These data suggest that using Task Force threshold limits in assessment of ABP data may lead to overdiagnosis of ambulatory hypertension in children.

INTODUCTION

Blood pressure (BP) elevation is a well-established risk factor for cardiovascular morbidity and mortality in adults. More recently, it has been established through autopsy studies using noninvasive techniques that BP elevation is also a risk factor for the develepment of atherosclerosis in childhood and adolescence. If cardiolvascular disease morbidity and mortality are to be prevented, then children with elevated BP must be identified and appropriately treated [1]. A review of the past 20 years studies stated that hypertension is an under-recognized entity in children [2]. Ambulatory blood pressure monitoring (ABPM) has been introduced into the study of hypertension and has become a useful tool in making clinical decisions. The advantages of ABPM over its office counterpart have been studied in children to observe the relationship between BP measurement and early markers of organ damage. The clinical use of ABPM has permitted to identify a number of phenomena in hypertension that would otherwise not have been discovered (strength of evidence B–C). Ambulatory measurement is of benefit in excluding "white coat hypertension" (evidence strength C) [3]. ABPM seems to be an effective and well-tolerated tool in evaluating blood pressure in children and adolescents, helping to identify those who need careful checkup and treatment [4] or to avoid unnecessary diagnostic tools or even treatment in children and adolescents [5]. The phenomenon of "white coat hypertension" (WCH) has been defined as mean office BP readings being in the hypertensive range while 24-hour ambulatory blood pressure (ABP) readings are in the normal range. The phenomena of WCH in children have been discussed in literature since 1990 [6, 7]. WCH has been recognized in children and, depending on the choice of threshold values for normalcy, its prevalence seems to be higher (44–88%) [5] than in the adult population (7.1%–53%) [8, 9]. This wide range in the study of WCH in adults may be related to the choice of threshold limits used to define ambulatory hypertension [9] or to the severity of office hypertension [10]. Due to the continuous development of children, pediatric patients require a separate standard of blood pressure normality in each stage of physical maturity that must be continually redefined throughout childhood. Still the Task Force on High Blood Pressure in Children [11] values are used as a standard for assessment of office auscultatory blood pressure and also for the assessment of ambulatory oscillometric blood pressure measurements. Some authors have expressed doubts about the validity of application of these threshold limits for the assessment of ambulatory oscillometric blood pressure. The normally wide variation of blood pressure during childhood prevents the expression of the relative severity of office blood pressure simply by ranges of blood pressure values as outlined in the hypertension staging criteria by the Sixth Joint National Committee [12].

The issue of white coat hypertension (WCH) in children and adolescents has been addressed in few pediatric studies, and no consensus has been found in determination of this phenomenon [5, 6].

OBJECTIVE

The objectives of this study were: 1) to determine how the choice of threshold limits for defining ambulatory hypertension affects the determination of WCH in adolescents; 2) to find whether the severity of office hypertension predicts the occurrence of WCH in adolescents; 3) to identify the prevalence of WCH in adolescents of different sex.

PATIENTS AND METHODS

The subjects were adolescents, both male and female, referred to the Department for Children's Preventive Cardiology of the Estonian Institute of Cardiology from November 2001 to April 2003. In all patients hypertension had been identified by primary health care or school health care personnel. To obtain office blood pressure, the measurement of BP was performed twice before ABPM using a calibrated mercury sphygmomanometer according to *Guidelines for identification of risk factors of non-communicable diseases in children* [13]. Family history and life-style, including smoking, alcohol and exercise, were documented using an investigator-completed questionnaire. Demographic data included gender, age (years), height (centimeters) and weight (kilograms). Quetelet' body mass index (BMI) was calculated (kg/m²) and body fat percentage (BF%) was measured using the method of biolectrical impedance with body fat analyzer BF-905 (MALTRON®, UK). Ambulatory blood pressure was recorded over a 24-hour period using an MOBILOGRAPH® recorder (I.E.M.

GmbH, Germany) and appropriate cuff size. The data were recorded while the patients went about their usual daily activities. A diary card was used to detail the activities during the recording period, in particular the awake and asleep time that facilitated data interpretation.

To determine how the choice of threshold limits affected the determination of WCH, ABPM data of the 24-hour period were compared using two widely quoted limit sources: the Task Force for High Blood Pressure in Children [11] and normative ambulatory BP data from a multicentre study [14]. As the Task Force (TF) data include no measurements of night-time BP, no upper threshold values exist for normal night-time BP by TF criteria. Therefore, the analysis of ABP for the current study was restricted to daytime BP measurements only. Based on TF criteria, office hypertension was defined as mean SBP or DBP higher than the 95th percentile by gender, age and height. On the basis of ABP criteria, ambulatory hypertension was defined as 24-hour mean daytime SBP or DBP higher than the ambulatory daytime 95th percentile by gender and height. For each threshold limit source, WCH was defined as office BP hypertension with ambulatory normotension. The daytime BP load was calculated for ABP as percentage of daytime BP readings that exceeded the patient-specific TF 95th percentile. A daytime SBP and/or DBP load = 30% was classified as hypertension [15]. To analyze the relative severity of hypertension, the new blood pressure index (BPI) was used among patients [16]. Office BPI was calculated by dividing the average office BP by the TF-defined 95th percentile BP specific for each patient (BPI-TF). Ambulatory BP index (BPI-ABP) was calculated by dividing the average daytime ABP and DBP by the ABP age and gender specific 95th percentile. Calculated in this manner, an index 1.1–1.2 would correspond to BP that was 10–20% above 95th percentile and BPI =1.3 would correspond to BP that was 30% or more above the 95th percentile of chosen threshold limits and which were estimated as hypertension.

STATISTICS

The SPSS 8.0 for Windows statistic package was used. The determination of mean data and standard deviation, Spearmen correlation and pair-wise t-test were used. A P value of 0.05 was considered the threshold for statistical significance [17].

RESULTS

The sample included seventy-one 11–19-year-old adolescents (mean age 15.2 years) from among 78 persons who passed succesful ABPM (91%). There were 44 boys (62.9%) and 26 girls (37.1%). More than half of adolescents (52.1%) had a positive family history of cardiac disease or hypertension. Nine of them (13.2%) were smokers, among boys the smoking habit occurred 3.5 times more often (7 persons) than among girls (2 persons).

Baseline demographic and anthropometric data for the 71 patients included in the analysis are shown in Table 1.

Table 1. Demographic and anthropometric data of patients

Gender	Age(years)	Weight (kg)	Height (cm)	BMI (kg/m^2)	BF (%)
Boys(n=44)	15.5	73.3*	175.1*,	23.4	26.8
SD	2.0	14.4	9.5	4.9	9.8
Girls (n=26)	14.7	61.6	164.2	22.9	33.1
SD	2.1	15.2	8.3	5.8	11.9

SD — standard deviation; * $p<0.05$ difference between boys and girls

A statistical difference in weight and height was noticed between boys and girls ($p<0.05$). A tendency of BMI increase with age was found ($p=0.051$), and older adolescents were taller than younger ones ($p=0.000$). No correlation was found between BMI, BF % and age. The mean blood pressure data by gender are shown in Table 2.

Table 2. The mean blood pressure data according to office and 24-hour blood pressure measurements

Gender	Mean office SBP (mmHg)	Mean ABPM SBP (mmHg)	Mean office DBP (mmHg)	Mean ABPM DBP (mmHg)
Boys	141.0* ?	130.7*?	72.7	71.4
SD	10.2	8.0	12.5	6.9
Girls	131.7*	124.3	74.1	71.4
SD	13.2	7.1	9.2	5.1
Total	137.9?	128.4?	73.2	71.4
SD	13.7	8.4	11.5	6.3

SD — standard deviation; * $p<0.05$ difference between boys and girls; ? $p<0.05$ difference between office and 24-hour mean blood pressure

24-hour mean blood pressure data were lower than office BP and the gender difference in SBP was defined in both measurement patterns.

The prevalence of high blood pressure in two measurements was identified, and the data are shown in Table 3.

Table 3. Prevalence of increased office and daytime 24-hour blood pressure by Task Force 95% percentile patient-specific threshold

Gender	Increased office SBP	Increased office DBP	Increased 24-hour mean daytime SBP	Increased 24-hour mean daytime DBP
Boys	75.6%*	22.2%	55.6%*	95.6%
Girls	47.8%	13.0%	76.9%	96.2%

*p<0.05 difference between boys and girls

Boys had more often increased office BP readings than girls, but 24-hour ABP data were opposite — girls had more often increased mean SBP than boys. DBP data did not differ by gender in both investigation patterns.

The severity of hypertension has been defined by blood pressure load. In adolescents the blood pressure load 30% has been identified as hypertension. The analysis of blood pressure load was restricted only to comparing ABPM daytime BP data with Task Force 95th patient-specific percentile. Figure 1 shows the gender difference of blood pressure load = 30%.

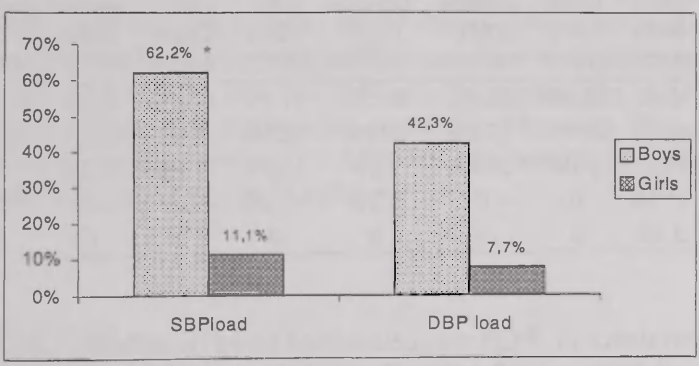

Figure 1. The prevalence of ambulatory daytime blood pressure load by gender.

* p<0.05 difference between boys and girls

SBP load = 30% was found to be a sufficiently frequent symptom, which occurred more often in boys than in girls ($p=0.02$). To find the prevalence of WCH, the office and 24-hour BP data were compared. Among the 68 patients identified as having office systolic hypertension by Task Force criteria, 19 (27.9%) were normotensive by ABP criteria. Among patients with office diastolic hypertension by Task Force threshold values, 12 (17.6%) had normal ABP values.

To diagnose more precisely the characteristics of hypertension, Task Force and ABP limit source were compared to determine the difference between the patient-specific 95th percentile threshold limits for each source. Pair-wise analysis of the patient-specific 95th percentile threshold limits showed that ABP threshold values were lower than the Task Force limits for both SBP (127.4±3.6 vs. 130.4±4.7; $p<0.05$) and DBP (77.4±2.4 vs. 83.2±3.5; $p<0.05$). Corresponding to these lower limits, there was a need to find new tools to determine hypertension and /or WCH in adolescents.

To determine whether the likelihood of hypertension was affected by the choice of the threshold values, the BP indices (BPI) were calculated and are shown in Table 4.

Table 4. Blood pressure indices by two threshold limits: the Task Force 95th and ABP normative 95th percentile by respondents' gender

BPI	Gender							
	Boys				Girls			
	Office SBPI/ TF95%	Office DBPI/ TF95%	Daytime SBPI/ ABP95%	Daytime DBPI/ ABP95%	Office SBPI/ TF95%	Office DBPI/ TF95%	Daytime SBPI/ ABPP95%	Daytim DB DBPI /ABP95%
=0.9	4.4%	68.8%	20.0%	66.7%	17.4%	60.8%	11.5%	65.3%
1.0	42.2%	24.4%	55.6%	28.9%	52.2%	30.4%	65.4%	26.9%
1.1	37.8%	6.7%	24.4%	2.2%	13.0%	8.7%	23.1%	7.7%
1.2	13.3%	0	0	2.2%	17.4%	0	0	0
=1.3	2.2%	0	0	0	0	0	0	0

The prevalence of WCH was determined based on differing threshold values of SBP or DBP index. For SBP index, WCH was present in 51.1% of boys and 30.4% of girls (SBP index was 1.1.–1.2 , i.e. SBP 10%–20% above the 95th TF percentile) compared to 46.6% when the index was = 1.0 in boys and 69.6% in girls, respectively. For DBP index, WCH was present in 6.7% in boys and 8.7% in girls when BPI was 1.1–1.2 by patient-specific 95th TF percentile. The prevalence of WCH based on SBP index by ABP threshold values was 24.4% in boys and 23.1% in girls when BP index was 1.1–1.2. For DBP index, WCH was present in 4.4% in boys and 7.7% in girls when BPI was 1.1–1.2 by patient-specific 95th percentile ABP threshold limits.

As BPI based on either limit source did not correlate with gender, the indices were also calculated independently of gender, and the data are shown in Table 5.

Table 5. Prevalence of blood pressure indices according to two different threshold limits

BPI	SBPI-TF95%	DBPI-TF95%	SBPI-ABP95%	DBPI-ABP95%
=1.0	54.4%	92.7%	76.1%	74.4%
1.1	29.4%	7.4%	23.9%	4.2%
1.2	14.7%	0	0	1.4%
=1.3	1.5%	0	0	0

Among 44.1% of patients identified as having office hypertension (BPI 1.1–1.2) by TF 95% criteria, only 23.9% found to be hypertensive by ABP 95% criteria which was lower by 20.2%.
The effect of the different threshold values on the calculation of BP load was determined. Systolic BP load = 30% by patient-specific TF 95% threshold was discovered in 52.3% of respondents and diastolic BP load = 30% in 9.4% of them. By BP index, systolic blood pressure load = 30% (SBPI) above the TF 95th percentile was identified only in 1.5% of respondents and in none of the patient by ABP 95th percentile. These data suggest the possibility that using Task Force threshold limits in assessment of ABP data may lead to overdiagnosis of ambulatory hypertension in children.

DISCUSSION

The results of the current study confirm the importance of the choice of threshold BP limits used to define ambulatory hypertension and

WCH in adolescents. Although an evidence-based definition of WCH in children is still absent, a substantiated interpretation of ABPM data to define WCH in adolescents must still rely on the use of an internally consistent set of criteria. The published studies found WCH prevalence in 44% of children when defining ambulatory hypertension as mean 24-hour BP above Task Force 95th percentile [6]. These data differ from the current study where only daytime 24-hour BP data were used. The current study showed that prevalence of systolic WCH decreased from 44.1% by Task Force 95th threshold limits to 23.9% by ABP 95th threshold limits. The current study differs from a recent study where WCH prevalence was found more often by normative ABP criteria than by Task Force criteria. [5]. J. M. Sorof and colleagues [13] found that ABP limits were significantly higher than the corresponding Task Force limits data. The current study identified that ABP threshold 95th percentile was lower than Task Force patient-specific 95th percentile. The difference in the data of this study and the study by J. M. Sorof (2001) could be explained by demographic and anthropometric differences of the adolescents, which could be the reason for different patient-specific 95th threshold values. The analysis of blood pressure load was restricted only to comparing ABPM daytime BP data with Task Force 95th patient-specific percentile. By Task Force criteria about the half of investigated adolescents had systolic blood pressure load = 30%.

To determine whether the likelihood of hypertension was affected by the choice of the threshold values, the BP indices (BPI) were calculated. The effect of the different threshold values on the calculation of BP load — by Task Force patient-specific 95th threshold limits or by blood pressure index — was determined. These data suggest the possibility that using Task Force threshold limits in assessment of ABP data may lead to overdiagnosis of ambulatory hypertension in children. There is a need for blood pressure norms for Estonian children and adolescents.

The study was supported by the Estonian Science Foundation (Grant 4683).

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VYACHESLAV AFANASYEV, HONORARY DOCTOR OF THE UNIVERSITY OF TARTU

Maie Toomsalu

Institute of Pharmacology, University of Tartu, Estonia

Vyacheslav Afanasyev was born in the province of Orlov into a family of nobility on 15 January 1859. He received his secondary education at the classical *gymnasium* of Orlov, from which he graduated in 1877 with a gold medal. Thereafter he entered the Medical Surgical Academy (later Academy of Military Medicine), from which he graduated *cum laude* in and, after participating in a competition, was allowed to continue his education at the so-called institute of professors for three years. During these three years, he worked at the laboratory of Prof. N. P. Ivanovski at the Department of Pathological Anatomy. In 1884 he passed the exams of a commune physician and Doctor of Medicine, and in 1885 he defended his doctoral thesis *О патолого-анатомических изменениях в тканях животного организма при отравлении бертоллетовой солью* (On pathological and anatomical changes in animal organism in the case of Berthollet salt poisoning). On 11 May 1885 he was awarded the degree of Doctor of Medicine. In February 1886 the conference of the academy entrusted him with the duties of assistant at the Department of Pathological Anatomy. Along with pathology, anatomy, histology and dissection techniques, he also dealt with bacteriological studies under Prof. Ivanovski and studies of kefir bacteria under Professor Kostychev of the Forestry Institute.

From March 1887 to July 1890 he served in the 130th infantry regiment in Kiev and thereafter as a department head at Kiev Military Hospital. From 1888–1889 he worked at the University of Kiev under Prof. V. V. Podvysotski and as a result published two papers: *К патологии Addison'овой болезни* (On the pathology of Addison's disease) and *К патологии остраго и хронического алкоголизма* (On the pathology of acute and chronic alcoholism).

In July 1890 the Learned Council of the Academy of Military Medicine decided to send V. Afanasyev abroad at public expense for a year to extend his knowledge of pathology and bacteriology. V. Afanasyev participated in the 10^{th} International Medical Congress and, for a month and a half, improved his knowledge of pathology at dissections at the Institute of Prof. Virchow in Berlin. From there he proceeded to Tübingen where he, within seven months, worked on pathological anatomy and bacteriology under Prof. P. Baumgarten. He also published the paper *Experimentelle Untersuchungen über einige Mikroorganismen aus der Gruppe der sogenannten Septikaemia haemorrhagica.* In Tübingen he also listened to Prof. Liebermeister's clinical lectures and Prof. Vierordt's lectures on heart diseases. Thereafter he spent four months in Paris, studying pathological anatomy under Prof. Cornil and bacteriology at Pasteur Institute in the laboratories of P. P. E. Roux and Prof. I. Mechnikov's laboratory. There he wrote the paper *О гистогенезе экспериментального бугорка в легких кролика* (On histogenesis of experimental tubercles in rabbit lungs) in which he showed that in the case of tuberculosis giant cells form in blood vessels as Mechnikov's macrophages merge. In Paris he also attended the lectures of Professors Bauchard, Hayem, Charcot, Fournier, Brouardel and Strauss as well as Prof. Mechnikov's lectures on comparative pathology of inflammations. We can conclude that Afanasyev substantially extended his education. The choice of supervisors, however, may seem somewhat surprising if we consider that P. Baumgarten repeatedly and forcefully argued against the universality of Mechnikov's theory of phagocytosis; Afanasyev, however, became and ardent supporter of Mechnikov's views.

After his return to homeland, V. Afanasyev was appointed as prosector of Nikolayevski Miliatary Hospital in St. Petersburg; thereafter he was elected as prosector of the Department of Pathological Anatomy at the Academy of Military Medicine. He occupied this post until 10 April 1894. He also worked as prosector of St. George's parish in St. Petersburg.

On 7 May 1890 V. Afanasyev was elected, after delivering two demonstration lectures, *Privatdozent* of Pathological Anatomy at the Academy of Military Medicine and from 1891–1894 he lectured on pathological histology and conducted practical classes with third-year students of the academy.

On 10 May 1894 V. Afanasyev was appointed Professor of General Pathology and Pathological Anatomy at the University of

Tartu. His appointment was one of the manifestations of Russification policy in Tsarist Russia. When V. Afanasyev had to take over the department with a glorious past, the knowledge of Russian among greater part of students was still poor and professors had a certain prejudice against Russian scholars. On the one hand, Afanasyev was pressed by the obligation to keep up the high standards of research; on the other hand, he was limited by poor technical equipment. A. Valdes wrote in 1924, "The research atmosphere at the Institute attracted eager scholars from elsewhere — doctoral students to write their dissertations and others for solving some scientific problems..." [10: 66]

In the summer of 1896 V. Afanasyev worked on practical bacteriology at Prof. Rubner's Institute of Hygiene in Berlin. After his return, Afanasyev restarted the laboratory of bacteriology at the Institute of Pathology in the New Anatomical Theatre of the University of Tartu and was the first to deliver a systematic course of bacteriology for students. He taught this course as an optional subject from 1896–1905.

V. Afanasyev also lectured at Rostovtsev's private university.

The students' opinion about V. Afanasyev as a lecturer was favourable. A. Valdes has noted that V. Afanasyev's lectures were excellent, students attended them willingly, and he achieved great respect among students. H. Normann, historian of medicine, Professor of Propedeutics of Internal Diseases and head of department from 1944–1950, has written in his memoirs, "A new subject was general pathology. This is lectured by the Dean, Vyacheslav Alekseyevich Afanasyev, a likeable bald-headed old gentleman with brownish teeth; his lectures are fascinating and substantial" [6: 34].

V. Afanasyev's research interests included tuberculosis, sepsis, alcoholism, atherosclerosis, etc. In A. Valdes' estimation the most productive period in Afanasyev's scientific career was before World War I. His students were the later Moscow phthisiologist Rubinstein, Baku pathological anatomist Shirokogorov, Riga pathological anatomist R. Adelheim and Tartu pathological anatomist A. Valdes. V. Afanasyev also played an essential role in the completion of N. Burdenko's doctoral dissertation as the necessary experiments were conducted by Burdenko under the supervision of pathological anatomist V. Afanasyev and physiologist V. Kurchinski.

Sometimes Prof. Afanasyev delivered public lectures, e.g. *О лечении дифтерита кровяной сывороткой* (On treatment of diphtheria with blood serum, 1895) and *Проказа прежде и теперь*

(Leprosy in the past and now, 1897). At the meetings of the Scientific and Literary Society of the University of Tartu (Yuryev) he presented reports on the 80th birthday of R. Virchow in 1901 and about V. I. Dal's doctoral dissertation. (R. Virchow, 1821–1902, German writer, editor, politician and statesman, anthropologist, ethnologist, archaeologist and pathologist; Professor of Pathological Anatomy in Würzburg, 1849–1856. V. V. Dal (Dahl), 1801–1872, student of the Medical Faculty of the University of Tartu 1826–1829, talented writer, renowned ethnographer and folklorist, renowned naturalist, corresponding member of St. Petersburg Academy of Sciences, entered Russian cultural history with his four-volume explanatory dictionary of the living Russian language)

On the centenary of St. Petersburg Academy of Military Medicine, V. Afanasyev was elected corresponding member of the academy on 18 December 1898.

V. Afanasyev worked in Tartu for 24 years. He supervised ten papers on pathological anatomy by G. R. Rubinstein, N. Panov's paper *Круглая язва желудка* (Round gastric ulcer), which won a gold medal, Panov's doctoral dissertation and 15 other doctoral dissertations. From 1912–1918 he was Dean of the Faculty of Medicine.

During World War I, after Riga had fallen to Germans in 1917, the Russian government decided to evacuate the University of Tartu to Voronezh in Central Russia. When the university was evacuated in 1918, V. Afanasyev also left for Voronezh, where he worked as a professor of Voronezh University until 1930. Although he retired in 1930, he continued working in 1934 as professor extraordinary at Voronezh Medical Institute and at the pathological laboratory of Voronezh Oncological Institute.

In 1932 V. Afanasyev was elected honorary professor of the University of Tartu.

V. Afanasyev perished in the bombardment of Voronezh on 12 June 1942.

V. AFANASYEV'S WORKS

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FACTOR ANALYSIS OF ANTHROPOMETRICAL VARIABLES, SOMATOTYPE COMPONENTS AND SEXUAL MATURATION SIGNS OF 12–15-YEAR-OLD CHILDREN

Gudrun Veldre[1] *and Toivo Jürimäe*[2]

[1] Institute of Zoology and Hydrobiology / Centre for Physical Anthropology,
[2] Institute of Sport Pedagogy, University of Tartu, Estonia

ABSTRACT

The aim of the study was to investigate the factor structure of physique in adolescent boys and girls. In addition, the factor structure of anthropometric variables, Heath-Carter somatotype components and sexual maturation in different genders was studied. Factorial types of physique were determined by principal component analysis with varimax rotation. The study was carried out on a sample of 745 healthy 12–15-year-old students (356 boys and 389 girls).

The number of significant factors was different in boys and girls, two and three respectively. Two factors represented 80.7% of the total variance of anthropometric parameters in boys, and three factors represented 77% in girls. The fatness factor was a separate factor in both sexes. The size factor that was the first factor in boys was split into two unrelated factors — the longitudinal factor and the massiveness factor — in girls.

When besides anthropometric and sexual maturation parameters the somatotype components were included in the analysis, endomorphy was highly associated with the fatness factor in both girls and boys. In boys an additional mesomorphy factor was formed besides the general size factor and the fatness factor. In girls the sexual maturation signs formed a separate factor. In both sexes these additional principal components described a relatively small part of the total variability of parameters. In boys the factor that was associated with the general size was also highly correlated with sexual maturation parameters. The results of factor analysis pointed out the differences in relationships between sexual maturation and body physique in different genders.

Key words: anthropometric parameters, endomorphy, mesomorphy, ectomorphy, sexual development, adolescent boys and girls

INTRODUCTION

Physique is a term that "encompasses the whole body" [18]. Sometimes "body type" has been used as synonymous to physique [23]. Physique is believed to consist of three distinct, yet interrelated components: body size, structure and composition [1]. All these components of physique can be characterized by anthropometric parameters. Human physique can be established by examining the factor structure of essential anthropometric parameters. In pubertal period the increase of body dimensions runs in parallel to sexual maturation. Several hypotheses have been formulated about associations between physical and reproductive maturation [7, 8]. Most probably, primary sexual maturation in females is deferred until appropriate physical scale for successful reproduction is attained [6]. In females the achievement of an appropriate size is important for successful parturition [8], or size is important in the co-ordination of physical and reproductive maturation [6]. In males early initiation of reproduction may be favoured on the one hand, and the increased competitive ability that comes with greater size and maturity on the other [6]. On the basis of previous studies [11, 12, 19] we can expect that in the studied age range persons with greater body dimensions are more advanced in their sexual maturation.

Factor analysis of the whole set of anthropometric parameters was used to extract the valuable factors. Boys and girls were studied separately to see if the factors are related to the same measurements in both genders. We expected in our analysis that sexual maturation signs and most important anthropometric parameters are associated with the same factor. Relying on earlier studies [2, 4, 14], although they used different sets of anthropometric variables to identify the factorial structure of physique, we expected that at least two from three somatotype components are related to factors that approximately correspond to the main components of body composition.

The aim of our study was 1) to find the factor structure of anthropometric parameters; 2) factor analysis of Heath-Carter somatotype components, anthropometric variables and sexual maturation; 3) to explain whether different blocks of variables are related and which anthropometrical variables are connected with different somatotype components and sexual maturity signs.

This is the first study that simultaneously uses for factor analysis a large set of anthropometric parameters, sexual maturation signs and somatotype components.

MATERIAL AND METHODS

The study was carried out on a cross-sectional sample of 745 students (356 boys and 389 girls) of Tartu (about 100,000 inhabitants), Estonia. All the subjects, Estonian in origin, were in the age range from 12 to 15 years. Children's parents or guardians and children themselves gave their oral permission for voluntary testing. The study was approved by the Medical Ethics Committee of University of Tartu (Estonia).

All anthropometric variables were measured according to the protocol recommended by the International Society for Advancement of Kinanthropometry [10]. Pubertal status of the subjects was assessed according to the descriptions of stages given by Tanner [15, 17] and performed by the self-assessment method [5].

Three somatotype components — endomorphy (ENDO), mesomorphy (MESO) and ectomorphy (ECTO) were assessed according to the Carter and Heath [3] anthropometric somatotyping method modified for children (i. e. height-corrected endomorphy was used). The means and standard deviations of anthropometric parameters of the same group have been published in previous articles [20, 22], the means and standard deviations of somatotype components and sexual maturation signs are published in the current collection of papers [21], and to save space they are not included in this article.

Factor analysis (principal component method with varimax rotation) was used to determine:

1) the factorial structure of physique on the basis of anthropometrical parameters, and
2) the factorial structure of physique, sexual maturation and somatotype components.

In addition, exact chronological age was included in the list of the analysed variables.

A factor was accepted as meaningful if the corresponding eigenvalue was 1.0 or greater.

All the calculations were done with the SAS statistical package [13].

RESULTS

Rotated factor loadings of anthropometric variables are presented in Table 1 for both boys and girls. Two main factors could be identified in boys. The first factor could be levelled as the size factor as it was characterised by high loading on body weight, height, girths and breadths. This factor was also highly correlated with chronological age. The second factor, possibly defined as the fatness factor, represented mostly skinfolds and some girths (arm, thigh, waist). The first factor accounted for 47.9% and the second accounted for 32.8% (Table 1). These two factors together described 80.7% of the total variability of anthropometric parameters in boys.

In girls, three main factors could be identified on the basis of anthropometry: (1) the fatness factor; (2) the longitudinal factor (or linearity factor) that was highly correlated with body height, body lengths and moderately with chest breadths. It was also the only factor in girls that was correlated moderately with chronological age. (3) The factor of massiveness that was characterized by high loading of BMI, girths and breadths (including humerus and femur width). These three relatively equal factors together accounted for 77% of the total variability of anthropometric parameters in girls — for 32.1%, 25.0% and 20.0% respectively (Table 1).

Table 1. Factor loading after varimax rotation (only anthropometrical variables were included).

Variable	Boys			Girls			
	Factor 1	Factor 2	Communalities	Factor 1	Factor 2	Factor 3	Communalities
mass (kg)	**0.82**	0.55	0.974	0.63	0.48	0.59	0.975
height (cm)	**0.97**	0.06	0.948	0.16	0.89	0.33	0.935
BMI (kg/m²)	0.47	**0.83**	0.908	0.75	0.11	0.61	0.954
Skinfolds;							
triceps	-0.05	**0.92**	0.858	**0.86**	0.10	0.29	0.836
subscapular	0.12	**0.92**	0.863	**0.90**	0.14	0.21	0.869
biceps	-0.06	**0.86**	0.747	**0.86**	0.07	0.11	0.758
iliac crest	0.08	**0.92**	0.851	**0.88**	0.18	0.21	0.854
supraspinale	0.10	**0.91**	0.844	**0.91**	0.16	0.18	0.879
abdominal	0.12	**0.93**	0.876	**0.89**	0.17	0.18	0.860
front thigh	-0.06	0.90	0.810	0.82	0.08	0.27	0.754
medial calf	0.02	**0.88**	0.777	0.77	0.15	0.23	0.662
mid-axilla	0.07	**0.91**	0.828	**0.89**	0.09	0.17	0.830
Girths:							
head	**0.61**	0.34	0.485	0.32	0.40	0.48	0.489
neck	**0.78**	0.43	0.797	0.52	0.41	0.56	0.746
arm relaxed	**0.61**	**0.71**	0.870	**0.73**	0.20	0.59	0.922
arm flexed and tensed	**0.69**	**0.63**	0.870	**0.70**	0.22	0.61	0.921
forearm	**0.77**	**0.52**	0.866	0.58	0.33	0.65	0.879
wrist	**0.77**	**0.50**	0.831	0.46	0.31	0.71	0.811
chest	**0.75**	**0.58**	0.896	**0.64**	0.38	0.57	0.886
waist	**0.59**	**0.74**	0.868	**0.76**	0.28	0.46	0.867
gluteal	**0.73**	**0.63**	0.934	0.61	0.45	0.58	0.911
thigh	0.56	**0.77**	0.912	**0.67**	0.31	**0.61**	0.918
thigh mid trochanter	**0.61**	**0.71**		0.63	0.28	**0.63**	
tibiale laterale			0.878	[illegible]			0.868
calf	**0.69**	**0.61**	0.843	**0.53**	0.33	0.69	0.868
ankle	**0.72**	0.43	0.708	0.37	0.38	**0.65**	0.701

Variable	Boys Factor 1	Boys Factor 2	Boys Communalities	Girls Factor 1	Girls Factor 2	Girls Factor 3	Girls Communalities
Lengths:							
acromiale-radiale	0.90	0.002	0.810	0.15	0.83	0.24	0.761
radiale-stylion	0.88	0.10	0.780	0.22	0.78	0.21	0.706
midstylion-dactylion	0.92	0.06	0.844	0.08	0.74	0.40	0.718
iliospinale height	0.93	0.05	0.861	0.15	0.92	0.15	0.901
trochanterion height	0.91	0.01	0.834	0.14	0.92	0.13	0.863
trochanterion-tibiale-laterale	0.82	-0.05	0.672	0.19	0.78	0.08	0.652
tibiale laterale to floor	0.85	0.06	0.724	0.14	0.85	0.08	0.753
tibiale mediale-sphy.tibiale	0.83	0.02	0.682	0.04	0.81	0.10	0.670
Breadths/Lengths							
biacromial	0.88	0.12	0.783	0.21	0.57	0.44	0.561
biiliocristal	0.84	0.29	0.788	0.40	0.59	0.43	0.688
foot length	0.88	0.11	0.787	0.04	0.67	0.42	0.622
sitting height	0.92	0.11	0.850	0.18	0.69	0.47	0.721
transverse chest	0.77	0.38	0.744	0.54	0.38	0.54	0.727
A-P chest	0.66	0.51	0.695	0.54	0.29	0.48	0.603
humerus	0.82	0.22	0.723	0.16	0.41	0.62	0.578
femur	0.74	0.36	0.676	0.37	0.31	0.60	0.592
AGE	0.74	-0.15	0.574	0.13	0.45	0.25	0.283
Percentage of variance	47.86	32.83	Total CE 33.89	32.07	25.00	20.02	Total CE 32.38

When all the studied variables (anthropometrical parameters, sexual maturation signs and somatotype components) were included, three main principal components were found in boys: (1) the size and sexual maturation factor; (2) the fatness factor that was characterized by high loading of skinfolds and somatotype components, especially endomorphy; and (3) the mesomorphy factor that was correlated moderately with some girths, BMI; positively and highly with mesomorphy; and negatively and moderately with ectomorphy. These three factors accounted for 80.2% of the total variability of all the measured parameters in boys, respectively for 42.8%, 29.9% and 7.5% (Table 2).

Table 2. Factor loading after varimax rotation (all studied variables were included).

Variable	Boys				Girls				
	Factor 1	Factor 2	Factor 3	Communalities	Factor 1	Factor 2	Factor 3	Factor 4	Communalities
mass (kg)	**0.80**	0.50	0.01	0.976	0.63	0.48	0.46	0.36	0.974
height (cm)	**0.99**	0.05	0.30	0.978	0.15	**0.86**	0.16	0.41	0.957
BMI (kg/m²)	0.40	0.77	0.46	0.967	0.77	0.12	0.54	0.26	0.963
Skinfolds:									
triceps	-0.04	**0.95**	0.01	0.895	**0.87**	0.11	0.21	0.17	0.844
subscapular	0.14	**0.92**	0.08	0.868	**0.90**	0.14	0.13	0.16	0.874
biceps	-0.04	**0.89**	-0.04	0.787	**0.87**	0.09	0.06	0.05	0.768
iliac crest	0.09	**0.93**	0.04	0.872	0.88	0.17	0.14	0.18	0.851
supraspinale	0.13	**0.92**	0.02	0.869	0.91	0.16	0.11	0.13	0.884
abdominal	0.15	**0.94**	0.02	0.908	**0.90**	0.17	0.11	0.12	0.861
front thigh	-0.05	**0.90**	0.06	0.824	**0.83**	0.09	0.22	0.12	0.753
medial calf	0.04	**0.90**	-0.02	0.816	**0.77**	0.17	0.18	0.08	0.664
mid-axilla	0.10	**0.91**	0.02	0.841	**0.89**	0.11	0.12	0.07	0.832
Girths:									
head	0.60	0.30	0.18	0.479	0.32	0.41	0.38	0.27	0.484
neck	0.74	0.36	0.42	0.847	0.52	0.38	0.42	0.42	0.760
arm relaxed	0.55	0.64	0.45	0.915	0.74	0.21	0.50	0.28	0.923
arm flexed and tensed	0.64	0.56	0.46	0.927	0.71	0.23	0.52	0.29	0.923
forearm	0.72	0.45	0.41	0.895	0.60	0.36	0.57	0.28	0.881
wrist	0.71	0.45	0.40	0.856	0.48	0.38	0.64	0.19	0.819
chest	0.73	0.52	0.34	0.913	**0.64**	0.34	0.43	0.45	0.911
waist	0.56	0.70	0.31	0.892	**0.76**	0.30	0.39	0.20	0.867
gluteal	0.71	0.58	0.29	0.932	0.61	0.42	0.42	0.45	0.928
thigh	0.53	0.73	0.33	0.919	0.68	0.31	0.49	0.35	0.921
thigh mid trochanter tibiale laterale	0.57	0.67	0.34	0.889	0.64	0.28	0.53	0.32	0.871
calf	0.63	0.56	0.39	0.862	0.54	0.34	0.60	0.32	0.873
ankle	0.68	0.40	0.28	0.702	0.39	0.44	0.59	0.17	0.717

Variable	Boys				Girls				
	Factor 1	Factor 2	Factor 3	Communalities	Factor 1	Factor 2	Factor 3	Factor 4	Communalities
Lengths:									
acromiale-radiale	**0.92**	0.03	-0.06	0.846	0.14	**0.78**	0.12	0.33	0.759
radiale-stylion	**0.90**	0.12	-0.05	0.829	0.22	**0.76**	0.13	0.22	0.696
midstylion-dactylion	**0.91**	0.03	0.12	0.843	0.09	**0.77**	0.30	0.20	0.728
iliospinale height	**0.96**	0.08	-0.11	0.949	0.15	**0.91**	0.08	0.19	0.902
trochanterion height	**0.95**	0.06	-0.15	0.928	0.14	**0.91**	0.06	0.19	0.883
trochanterion-tibiale-laterale	**0.87**	-0.04	-0.10	0.768	0.18	**0.75**	-0.002	0.23	0.646
tibiale laterale to floor	**0.89**	0.11	-0.16	0.827	0.14	**0.87**	0.06	0.05	0.784
tibiale mediale-sphy.tibiale	0.88	0.06	-0.18	0.816	0.04	**0.81**	0.06	0.12	0.675
Breadths/ Lengths									
biacromial	0.86	0.07	0.21	0.783	0.21	0.54	0.31	0.37	0.566
biiliocristal	0.84	0.27	0.12	0.791	0.39	0.55	0.26	0.44	0.710
foot length	0.88	0.12	0.03	0.791	0.07	**0.75**	0.39	-0.02	0.722
sitting height	0.90	0.06	0.19	0.856	0.17	0.63	0.24	0.57	0.801
transverse chest	0.75	0.33	0.30	0.757	0.54	0.37	0.41	0.35	0.724
A-P chest	0.64	0.46	0.27	0.690	0.55	0.32	0.40	0.18	0.607
humerus	0.77	0.20	0.30	0.726	0.19	0.49	0.61	0.06	0.645
femur	0.71	0.36	0.21	0.672	0.40	0.40	0.59	0.02	0.673
AGE	0.74	-0.19	0.19	0.619	0.09	0.29	0.01	0.74	0.640
MA	0.70	0.03	0.34	0.614	0.21	0.24	0.19	0.73	0.670
PH	0.72	-0.07	0.20	0.562	0.12	0.30	0.14	0.76	0.698
AX	0.54	-0.03	0.37	0.423	0.20	0.15	0.04	0.75	0.628
OIGARCHE/ MENARCHE	0.40	-0.09	0.30	0.258	0.23	0.16	0.07	0.76	0.666
GEN	0.57	0.01	0.22	0.373					
ENDO	-0.05	0.98	0.05	0.962	0.96	0.06	0.15	0.15	0.964
MESO	-0.10	0.62	0.68	0.846	0.51	-0.40	0.71	-0.12	0.934
ECTO	0.07	-0.78	-0.56	0.936	-0.73	0.22	-0.55	-0.17	0.912
Percentage of variance	42.75	29.90	7.54	Total CE 40.10	31.78	22.08	13.29	11.92	Total CE 38.74

In girls, the analysis of all the studied variables detected four main factors: (1) the fatness factor (or endomorphy factor); (2) the longitudinal factor that from new variables correlated slightly negatively only with the mesomorphy component; (3) the massiveness factor that is highly positively loaded with the mesomorphy component and moderately negatively with ectomorphy; and (4) the sexual maturation factor that, besides high correlations with sexual maturation variables and age, from body parameters correlated moderately only with sitting height. This fourth factor had only slight correlations with biiliocristal breadth and chest and hip girths and body height. Four factors together represented 79.1% of total variance in girls, respectively 31.8%, 22.1%, 13.3% and 11.9% (Table 2).

In conclusion, a different number of valuable factors were identified in boys and in girls. Both in boys and girls, these main factors represented ca 4/5 of the total variance in all cases. Based on the factor analysis of anthropometric parameters, somatotype components and sexual maturation variables, it can be concluded that:

(1) The fatness factor was a separate factor in both sexes. When somatotype components were included in the analysis, endomorphy was also highly associated with the fatness factor in both girls and boys.

(2) When somatotype components were included in the analysis, an additional mesomorphy factor was formed in boys besides the general size factor and the fatness factor.

(3) In girls, sexual maturation signs formed a separate factor. In boys, one factor was associated with general size as well as sexual maturation parameters.

DISCUSSION

Factor analysis, a type of multivariate analysis, which helps to reduce a large number of intercorrelated anthropometrical variables to a small number of independent factors, is one way of classification of human body physique [16]. We were interested in observing how many valuable factors of physique could be detected, and if these separate factors of body physique were related to the same anthropometrical measurements in both sexes.

Usually, most results of factor analysis are similar: a general factor is followed by several group factors [4, 16] depending on the set of included variables. If skinfold measurements are included in the analysis, a fat factor can be distinguished [2, 4, 14].

Our analysis revealed a different number of significant principal components in different genders of adolescents. This is different from the results of factor analysis of body physique in adults [14], although comparison is difficult because the set of variables was broader in our analysis. On the other hand, all the measurements that were used by Susanne et al. [14] were also included in our analysis, and the data of Buday [2] suggest that factor structure remains the same if the other body measurements were taken into account, although their loadings would change a little. This observation of Buday was also confirmed by our results of two factor analysis.

In boys two significant factors represented 80.7% of the total variance of anthropometrical parameters, and in girls three main factors represented 77%. The variance explained by main factors was similar to that reported by other authors [2, 4, 14]. The first factor — the size factor — that in boys described almost half (47.9%) of the variability, was in girls split into two unrelated factors — the longitudinal factor and the massiveness factor. The fatness factor turned to the first place in girls. In both boys and girls the fatness factor decribed 1/3 from the total variability of body physique determined by anthropometric parameters.

Secondly, the factor structure was studied where, besides anthropometric variables, sexual maturation parameters and somatotype components were taken into account. The factor structure remained the same, although an additional factor was added in both sexes. In boys the additional factor can be defined as the mesomorphy factor as it consists primarily of the mesomorphy component; it is also correlated negatively with ectomorphy and slightly positively with some girths and BMI. Correlations of the mesomorphy component with anthropometric measurements, even those that were used in the equation of mesomorphy calculation (for example humerus and femur breadth and calf girth) were relatively low.

In girls the additional factor includes high loadings for the sexual maturation signs and age. The only anthropometrical measurement that was significantly related to this sexual maturity factor was sitting height, although slight correlations were also found with height, biiliocristal breadth and with chest and gluteal girths, i.e. with body dimensions that reflect appropriate physical status or skeletal maturity necessary for normal parturition in females.

In both sexes these additional principal components still described a relatively small part of total variability of parameters (in rotated pattern 7.5% in boys and 11.9% in girls). In boys the general size factor was highly correlated with sexual maturation parameters, indicating how closely the body size in boys is connected with sexual maturation. In girls the sexual maturity signs remained relatively distinct from most anthropometric parameters.

As regards the somatotype components, similarily with other studies [4, 14], endomorphy was highly associated with the fatness factor in both girls and boys.

Differently from results on adult females [14], our analysis did not reveal separate factors for trunk and limb fatness for 12–15-year-old girls. The revealed factors were more general in this age period when differences between individuals are most pronounced.

Mesomorphy in boys was represented by a separate factor (the mesomorphy factor) but also had high loading on factor 2 (the fatness (endomorphy) factor). This is understandable as in both sexes the fatness factor also represented girths that consisted of both fat layer and muscles. In girls mesomorphy was correlated besides positive correlations with the fatness (endomorphy) factor and the mesomorphy factor slightly negatively with the longitudinal factor. This seems to reflect the well-known differences in muscular development of different genders in pubertal years. Like other reports [4, 14] had pointed out, our results showed that ectomorphy was not an independent factor. The ectomorphy component was not highly correlated with the longitudinal factor in girls or with the general size factor in boys, although in adults ectomorphy and the longitudinal factor are highly correlated [14]. The reason for this could be the fact that in the studied age the skeletal dimensions, including lengths, are greater in early maturers, who tend to be more endomorphic, differently from later maturers who tend to be more ectomorphic.

In conclusion, our results suggested that the factor structure of physique of different genders was quite similar in adolescents, although the number of factors was different in boys and girls. Substantial gender differences appeared in relationships of sexual maturation and somatotype components with body physique.

In boys the same factor was highly loaded with general body size and sexual maturity signs, indicating how closely all body dimensions are related to sexual maturity signs and stressing the importance of body size in attainment of appropriate sexual maturation in boys.

In girls sexual maturation variables remained relatively distinct from body measurements, except from sitting height, less from biacromiale and biiliocristale breadth and hip girth. This could be viewed as support to the hypothesis [6] that in girls sexual maturity is connected with attainment of skeletal maturity that is important in reproduction success. It is well known that immature teenage mothers have increased the infant low birth-weight risk that in its turn is a leading cause of neonatal and infant mortality and associated with childhood morbidity [6, 8].

From Heath-Carter somatotype components, endomorphy had the highest concordance with the fatness factor in both sexes. The other somatotype components were described by two factors of physique.

These results suggested that factor analysis could be successfully used in assessing main sex-specific body physique and sexual maturation relation differences in adolescents.

ACKNOWLEDGMENTS

We would like to thank Prof. E.-M. Tiit for her helpful comments and advice on statistics.

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Papers on Anthropology XII, 2003, pp. 271–285

RELATIONSHIPS BETWEEN BODY SIZE, SOMATOTYPE COMPONENTS AND SEXUAL MATURATION IN ESTONIAN ADOLESCENTS

Gudrun Veldre[1] *, Toivo Jürimäe*[2]

[1] Institute of Zoology and Hydrobiology / Centre for Physical Anthropology,
[2] Institute of Sport Pedagogy, University of Tartu, Estonia

ABSTRACT

The aim of this cross-sectional study was to investigate how body size (height, weight) and somatotype components are linked with sexual maturation in Estonian adolescents. In total, 745 randomly selected 12–15-year-old students (356 boys and 389 girls) from Tartu (about 100,000 inhabitants) were studied. Their body height and weight were measured and the somatotype components (endomorphy, mesomorphy, ectomorphy) were determined according to Carter and Heath [8]. Pubertal stages (self-assessed pubic hair, axillar hair and breast stages) were determined according to the method described by Tanner [35, 36]. In boys, left testis was used for the measurement of testicular volume using a Prader orchidometer. Data about the occurrence of menarche and oigarche were also collected. Separately in boys and girls, the sexual maturity variables were subjected to principal component analysis (PC1), which was used as a "global" sexual development index. Regression analysis demonstrated that somatotype components explained 3.68% ($R^2 \times 100$) of the total variance of PC1 in boys. In girls, somatotype components described 31.18% ($R^2 \times 100$) of the total variance of PC1. In both genders, body height and weight together accounted for more (in boys 53.28% and in girls 46.30%) in PC1 than somatotype components. It was concluded that somatotype components contributed a relatively small but significant amount to the variance in PC1. Contribution of body height and weight to the variance in sexual maturity index seems to be more important than contribution of somatotype components, and this is more evident in boys.

Key words: height, weight, endomorphy, mesomorphy, ectomporphy, sexual development, adolescents

INTRODUCTION

In puberty, which is associated with the development of the sexual function, there are great variations in sexual maturation, expressive variations in physique and body size in adolescents of the same age and gender. One way to deal with differences in physique is to use the method of somatotyping, and presently the Heath-Carter anthropometric somatotyping method appears to be the most often used [23, 34]. The Heath-Carter anthropometric method [8, 18] gives an overview of the total physique, which is independent of size [9]. Many studies have investigated somatotypes of children in pubertal years [9, 10, 13, 14, 19, 30] and peculiarities of sexual maturation [4, 12, 21, 22, 24, 25] typically in terms of pubertal stages described by Tanner [35]. The association between sexual maturation and somatotype has not been very carefully investigated [1, 8]. Data about the relationship of sexual maturation with individual somatotype in boys are scarce and controversial [3, 8, 20, 28, 31]. It is not clear whether dominant mesomorphy (MESO), endomorphy (ENDO) or even ectomorphy (ECTO) can be associated with advantages in maturation, or there are no differences [28] in maturation stages between boys with different somatotypes. In girls, different authors have suggested that the higher ENDO component is connected with earlier sexual maturity [2, 3, 28]. Some studies have shown that linearity of body build is associated with late maturity in girls [29, 35]. Our hypothesis is that there are substantial sexual differences in relation of sexual maturation to somatotype components and body size.

The aim of the present cross-sectional study was to investigate how the body size (height, weight) and somatotype components are linked with sexual maturation in Estonian adolescents.

MATERIALS AND METHODS

Subjects

The cross-sectional sample consisted of 745 randomly selected adolescents from different schools of Tartu (about 100,000 inhabitants), Estonia. All subjects (356 boys and 389 girls) were in the chronological age ranging from 12 to 15 years. They were all Estonians in origin. The parents or guardians of children and children themselves gave their consent to voluntary testing. The study was approved by the Medical Ethics Committee of the University of Tartu.

Anthropometry and somatotype assessment

Body height was measured using a Martin metal anthropometer in cm (±0.1) and body weight with medical scales in kg (±0.05). For girth and breadth measurements, the Rosscraft Centurion Kit (Canada) instrumentation was used. The skinfold thicknesses were measured using a Holtain (UK) skinfold caliper.

The series of all anthropometric measurements (body height, body weight, 4 skinfolds: triceps, subscapular, supraspinale and medial calf, 2 girths: flexed and tensed upper arm and calf, and 2 breadths: biepicondylar humerus and femur), which is necessary for somatotype components calculations, were taken by one of the authors (G. V.) to reduce systematic errors (previously assessed test-retest reliability was $r>0.90$). The mean of two trials was used in the analysis.

Three somatotype components — ENDO, MESO and ECTO — were assessed according to the Carter and Heath [8] anthropometric somatotyping method modified for children (i.e., height-corrected endomorphy).

Sexual maturity

The pubertal status of the subjects was assessed according to Tanner [35]. Self-assessment [12, 26, 33] of pubic hair and axillar hair development stage and additionally breast development stages in girls were used. Each subject was asked to observe photographs [24, 25] of the stages of secondary sex characteristics and to read the descriptions of stages. The subjects were asked to view the photographs carefully and make a decision about the stage that most closely reflected their current status.

Left testis was used for the measurement of testicular volume according to Prader orchidometer (ovoids with 1, 2, 3, 4, 6, 8, 10, 12, 15, 20 and 25 ml) in boys. The girls were asked about the onset of menarche, the boys about oigarche (0 = no; 1 = yes). Assurance of confidentiality and anonymity of subject information was stressed, as was the right to refuse consent.

Statistical analysis

All data were analyzed by using the SAS [32] statistical package (version 6.12; SAS Institute Inc, Cary, NC). Standard statistical methods were used to calculate mean ($\overline{X}$) and standard deviation (±SD). Analyses of variance (ANOVA's) were performed to assess differences between boys and girls. Pearson product-moment and partial correlation coefficients were used to determine the relationships between dependent variables. Principal component analysis [17] was used to estimate the feasibility of selecting one or another combination of sexual maturity indicators. A factor was accepted as meaningful if its eigenvalue was 1.0 or greater. The procedures FIT and also multiple regression and ANOVA were used to evaluate associations among different variables by multiple regression analysis. Equations were controlled over ordinary parameters of the model fitting (first of all, R-square and adjusted R-square, but also for tolerance as a measure of multicollinearity and condition index, etc.). The level of significance for all analyses was set at $p \leq 0.05$.

RESULTS

The overall descriptive data of boys and girls are presented in Figures 1–4. There was no statistically significant difference between boys and girls in chronological age and body weight (Fig. 1). The somatotype components (Fig.2) and sexual maturation stages (Fig.3) were significantly different between boys and girls. In boys the occurrence of oigarche increased from 3.2% at the age of 12 to 53.4% at the age of 15 (Fig.4). In girls the occurrence of menarche increased from 12.2% at the age of 12 to 87.0% at the age of 15 (Fig.4).

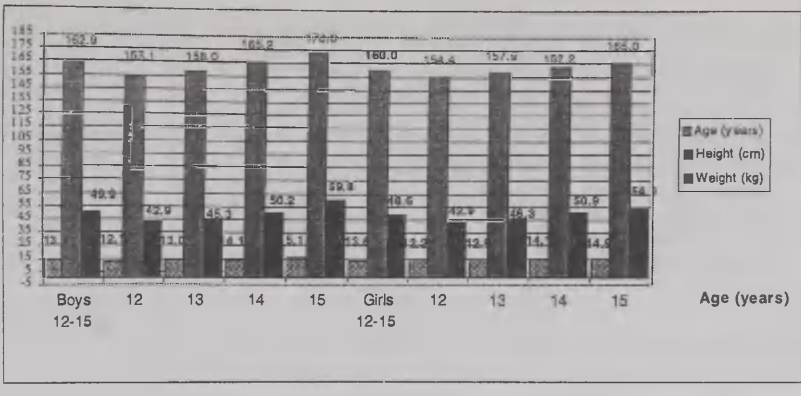

Figure 1. Age, height and weight in 12–15-year-old children studied.

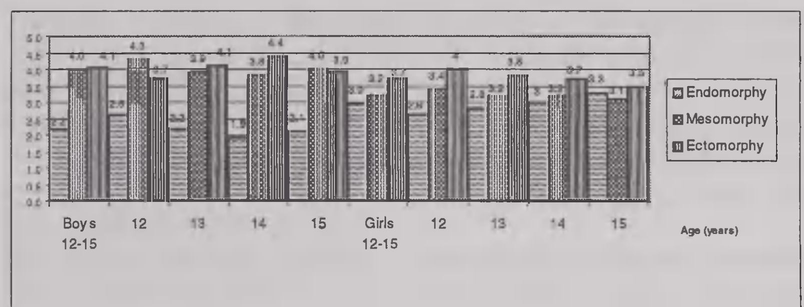

Figure 2. Somatotype component ratings in 12–15 year-old boys and girls.

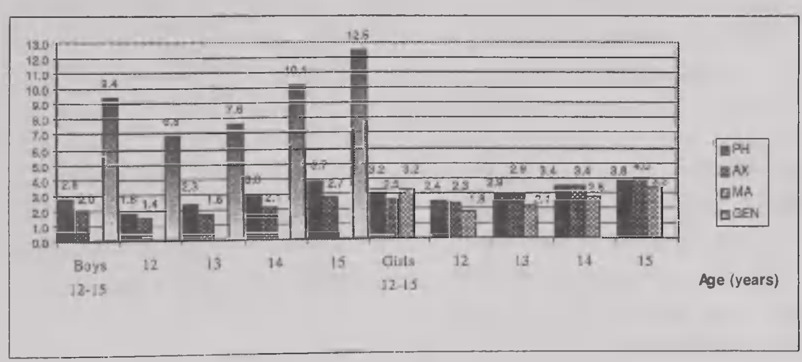

Figure 3. Sexual maturation variables in 12–15-year-old children.
(PH — pubic hair development stage, AX — axillar hair, MA — breast development stage, GEN — genital size (ml)).

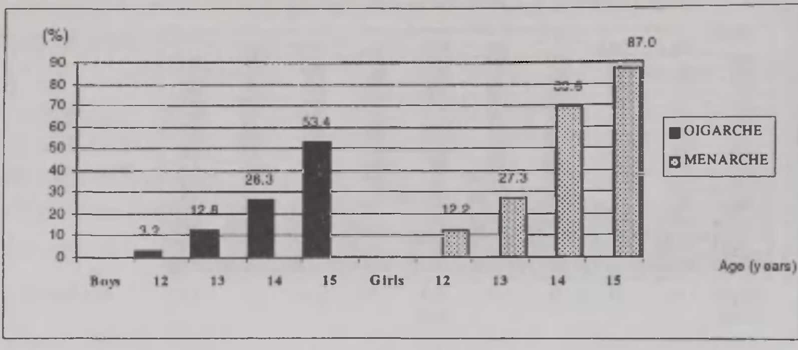

Figure 4. Occurrence of oigarche and menarche (%) in 12–15-year-old children.

Table 1 summarizes the factor structure of the used sexual maturation variables in boys and girls. The first principal component — PC1 (used as a "global" index of sexual development), the only factor with an eigenvalue more than 1.0, was able to explain 56.42% of variance in boys and 70.56% in girls (Table 1).

Table 1. Factor structure of sexual maturation variables of boys and girls and variance explained for the first principal component (PC1) in both sexes.

Boys (n=356)		Girls (n=389)	
Variable	PC1	PC1	Variable
		0.85	MA
PH	0.86	0.88	PH
AX	0.77	0.81	AX
OIGARCHE	0.66	0.82	MENARCHE
GEN	0.70		
Variance explained for the PC1	2.26 56.42%	2.82 70.56%	Variance explained for the PC1

PH — pubic hair development stage
AX — axillar hair
MA — breast development stage
GEN — genital size

Pearson correlation coefficients and partial correlations are presented in Tables 2 and 3. Relationships between PC1 and chronological age were significant and similar for both sexes (r=0.67 for boys and r=0.69 for girls). In boys, there were no significant relationships between PC1 and somatotype components (Table 2). In girls, PC1 correlated significantly with two somatotype components: positively with ENDO (r=0.23) and negatively with ECTO (r=–0.13) (Table 3). Both in boys and girls, PC1 correlated significantly with body height (r=0.72 and r=0.63, respectively) and weight (r=0.65 and r=0.64, respectively). There were significant negative partial correlations between PC1 and ENDO (r=–0.20) in boys and between PC1 and ECTO (r=–0.15) in girls when the influence of height and weight was eliminated (Table 2 and 3).

In predicting sexual maturation (PC1), using multiple regression and ANOVA analysis, all somatotype components, height and weight and chronological age were used as independent variables. Only statistically significant variables were left in the PC1 predicting equations (Table 4). In predicting PC1, also interactions of variables were tested. Moderate multicollinearity was found between variables, but this did not turn the equations unreal as equations with transformed variables showed.

In boys and girls, most of the PC1 predicting equations (Table 4) were similar despite the different sexual variables and the fact that PC1 in girls explained more variance than in boys. Firstly, all three somatotype components were used to predict PC1, which explained 31.18% of the total variance in girls and only 3.68% in boys (Table 4). In the PC1 regression equations of different sexes, the signs of estimates of ENDO were dissimilar: in boys negative and in girls positive. Secondly, chronological age alone explained 45.45% and 47.78% of the total variance in PC1, respectively, in boys and girls. Thirdly, body height and weight were used to predict PC1. In boys and in girls, body height and weight respectively explained 53.28% and 46.30% of the total variance in PC1 (Table 4).

Table 2. Pearson correlation coefficients and partial correlations between somatotype ratings, chronological age (AGE), sexual development index (PC1) and height and weight in boys (n=356).

	ENDO	MESO	ECTO	AGE	PC1	Height	Weight
ENDO	1.00						
MESO	**0.61**	1.00					
ECTO	**–0.77**	**–0.88**	1.00				
AGE	**–0.17**	–0.06	0.08	1.00			
PC1	0.01	0.06	–0.10	**0.67**	1.00		
Height	0.01	–0.03	0.01	**0.54**	**0.72**	1.00	
Weight	**0.47**	**0.46**	**–0.55**	**0.71**	**0.65**	**0.82**	1.00

When *height and weight* were eliminated

	ENDO	MESO	ECTO	AGE	PC1
ENDO	1.00				
MESO	**–0.23**	1.00			
ECTO	–0.03	**–0.43**	1.00		
AGE	**–0.28**	0.05	0.06	1.00	
PC1	**–0.20**	0.01	–0.07	**0.36**	1.00

When *chronological age* was eliminated

	ENDO	MESO	ECTO	AGE	Height	Weight
ENDO	1.00					
MESO	**0.62**	1.00				
ECTO	**–0.78**	**–0.88**	1.00			
PC1	**0.17**	**0.14**	**–0.22**	1.00		
Height	**0.19**	0.01	–0.08	**0.46**	1.00	
Weight	**0.68**	**0.59**	**–0.71**	**0.45**	**0.73**	1.00

When *sexual factor (PC1)* was eliminated

	ENDO	MESO	ECTO	AGE	Height	Weight
ENDO	1.00					
MESO	**0.62**	1.00				
ECTO	**–0.79**	**–0.88**	1.00			
AGE	**–0.23**	**–0.15**	**0.21**	1.00		
Height	0.01	**–0.13**	**0.12**	**0.44**	1.00	
Weight	**0.62**	**0.55**	**–0.64**	**0.18**	**0.66**	1.00

Statistically significant (P<0.05) correlations are in bold

Table 3. Pearson correlation coefficients and partial correlations between somatotype ratings, chronological age (AGE), sexual development index (PC1) and height and weight in girls (n=389).

	ENDO	MESO	ECTO	AGE	PC1	Height	Weight
ENDO	1.00						
MESO	**0.57**	1.00					
ECTO	**–0.78**	**–0.84**	1.00				
AGE	**0.23**	–0.10	**–0.13**	1.00			
PC1	**0.39**	0.03	**–0.32**	**0.69**	1.00		
Height	**0.27**	**–0.23**	–0.05	**0.53**	**0.63**	1.00	
Weight	**0.75**	**0.41**	**–0.69**	**0.45**	**0.64**	**0.74**	1.00

When *height and weight* were eliminated

	ENDO	MESO	ECTO	AGE	PC1
ENDO	1.00				
MESO	**–0.20**	1.00			
ECTO	0.07	**–0.19**	1.00		
AGE	0.06	–0.04	**–0.17**	1.00	
PC1	0.10	–0.04	**–0.15**	**0.39**	1.00

When *chronological age* was eliminated

	ENDO	MESO	ECTO	PC1	Height	Weight
ENDO	1.00					
MESO	**0.68**	1.00				
ECTO	**–0.80**	**–0.90**	1.00			
PC1	**0.23**	0.13	**–0.19**	1.00		
Height	0.08	**0.60**	**0.18**	**0.15**	1.00	
Weight	**0.77**	**–0.26**	**–0.72**	**0.25**	**0.53**	1.00

When *sexual factor (PC1)* was eliminated

	ENDO	MESO	ECTO	AGE	Height	Weight
ENDO	1.00					
MESO	**0.68**	1.00				
ECTO	**–0.79**	**–0.90**	1.00			
AGE	–0.07	**–0.15**	0.11	1.00		
Height	0.03	**–0.30**	**0.23**	**0.17**	1.00	
Weight	**0.76**	**0.59**	**–0.71**	–0.01	**0.50**	1.00

Statistically significant (P<0.05) correlations are in

Table 4. Results of multiple regression and ANOVA in predicting first principal component (PC1) from somatotype components, chronological age and from weight and height in boys and girls.

	Predicting equations in boys	R^2x100 (%)	P	Predicting equations in girls	R^2x100 (%)	P
1	PC1= 3.04–0.19*ENDO–0.25*MESO–0.40*ECTO	3.68	0.006	PC1= 4.21+0.16*ENDO–0.76*MESO–0.61*ECTO	31.18	0.0001
2	PC1= –8.39+0.61*AGE	45.45	0.0001	PC1= –8.88+0.66*AGE	47.78	0.0000
3	PC1= –9.78+0.06*HEIGHT+0.02*WEIGHT	53.28	0.0001	PC1= –9.14+0.05*HEIGHT+0.04*WEIGHT	46.30	0.0001
4	PC1= –9.89+0.03*HEIGHT+0.02*WEIGHT+0.32*AGE	59.14	0.0001	PC1= –10.49+0.02*HEIGHT+0.03*WEIGHT+0.44*AGE	61.32	0.0001
5	PC1= –10.85–0.10*ENDO–0.18*ECTO+0.05*HEIGHT+0.29*AGE	60.04	0.0001	PC1= –10.62–0.19*MESO–0.31*ECTO+0.04*HEIGHT+0.40*AGE	63.17	0.0001

When total variance of PC1 was predicted from body size (body height, weight) and chronological age, the $R^2 \times 100$ were 59.14% and 61.32% respectively. Finally, all variables (somatotype components, body height, body weight and chronological age) were used to predict PC1. The addition of somatotype components did not give much better results, although some somatotype components were significant. In addition, interaction of studied variables did not produce significant changes in R^2. Equations where intercourse of body height and body weight with age were independent variables made it possible to avoid multicollinearity of variables, but these variables also explained approximately 2/3 of PC1 variance.

DISCUSSION

It is well known that the anthropometrical parameters of adolescents increase rapidly during puberty. Our results indicated that it is sufficient to use only simple anthropometry to characterize sexual maturation — the "global" index of sexual development (PC1) was better characterized by height and weight than by somatotype components (see Table 4). The possible explanations for this are: 1) the anthropometrical parameters used to calculate somatotype components significantly correlate with body weight [34], and 2) the equation for calculation of MESO includes height and the equation for calculation of ECTO includes both height and weight.

Using the Heath-Carter [18] somatometric system for presenting the adolescents' physique, our results indicated that the mean ENDO, MESO and ECTO values were similar to other European adolescents of the same age [13, 14, 15]. However, the tendency to have a slightly smaller ENDO and expressed ECTO values seems to be characteristic of Estonian adolescents of both sexes in comparison with some other studies [7, 30]. MESO, however, does not appear to be as well developed in Estonian adolescents as in European adolescents of the same age [13, 30].

Secondary sexual development (breast, pubic hair, axillary hair, testicular volume, menarche, oigarche) reflects functional maturity. It has been suggested that the use of combined summarized signs of puberty should be used to describe "global" sexual maturity [27]. In our study, the results of principal component analysis showed that only one principal factor had an eigenvalue more than 1.0. This is in accordance with similar analysis of sexual maturity indicators in a tri-ethnic sample of USA adolescents in the Heartfelt Study [27] where only three main variables of sexual maturation were assessed. The percentage of variance accounted for by the PC1 in our study was in the range of variance that Mueller et al. [27] found in their study for different age groups.

In our study, PC1 was highly correlated with body height and weight (Tables 2 and 3). It is understandable because more mature children are taller and their body weight is higher. However, the relationships between sexual maturation (PC1) and somatotype components are not so clear. In girls, only two components: ENDO and ECTO correlated significantly with PC1. In boys, PC1 did not correlate significantly with somatotype components.

Previous studies have indicated that ENDO and MESO components could be more closely related to advanced maturation in children [8]. In contrast, late maturation is closely linked to ECTO [6, 11, 29], and this is in accordance with the results of our study where relationship between PC1 and ECTO was negative but low (see Tables 2 and 3).

Multiple regression analysis (Table 4) indicated that PC1 is closely related (31.18%, $R^2 \times 100$) to all three (ENDO, MESO, ECTO) somatotype components in girls but weakly in boys (3.68%, $R^2 \times 100$). Multiple regression equations also indicated that ENDO was associated with PC1 positively in girls and negatively in boys. Previous research has indicated that higher ENDO is closely connected with greater skeletal maturation in boys [5]. In girls, higher ENDO value is typical of early matured girls [2, 3, 29]. However, in our study, we did not select our subjects by earlier or later sexual maturation groups.

Our results indicated that body size parameters — body height and weight — were stronger predictors of sexual maturation (PC1) than somatotype components. In our study, height and weight characterized 53.28% of the total variance in boys and 46.30% in girls (Table 4). The model where chronological age was added characterized about 60% of total variance in both boys and girls. The final model where somatotype components, height, weight and chronological age were all used as independent variables was not a stronger predictor of sexual maturity. These results highlight that body height and weight, which explain about 60% of variance in PC1 have a significant impact on sexual maturation changes. This is indirectly in conformity with the well-known data that extreme body dimensions are associated with sexual maturation disorders [16], and in the case of many diseases both body size and maturation (as well as the reproduction system) are affected, and also the physique can differ from the normal, especially in boys [7].

It can be concluded that somatotype components have a small but significant impact on the "global" parameter of sexual maturation (PC1). In boys, somatotype components described a smaller part of PC1 variance than in girls. In both sexes, body size (body height and weight) was a stronger predictor of PC1 than somatotype components.

ACKNOWLEDGMENTS

We are most grateful for the helpful comments of Prof. E.–M. Tiit and T. Möls.

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Papers on Anthropology XII, 2003, pp. 286–290

LONGITUDINAL ASSESSMENT OF PEAK HEIGHT VELOCITY IN ESTONIAN GIRLS

Anne Volver

Institute of Exercise Biology, University of Tartu

ABSTRACT

The study was aimed at detecting the peak height velocity (PHV) in Estonian girls using the longitudinal measurement of height after every 4 months. During a two-year period anthropometrical measurements and assessment of breast development stages by Tanner took place in 48 healthy girls. PHV was convincingly detected in 30 girls from 11years 9 months to 13 years 1 month, the mean ±SD was 12 years and 6±11.7 months, the median 12 years and 0.5 months. The mean value of the PHV was 11.9±5.9 cm/year. The PHV most frequently related to breast developmental stage 2.

Key words: adolescents, age, breast developmental stages, growth spurt.

INRTODUCTION

According to the generalization of Marshall and Tanner [4] the adolescent growth spurt begins in girls at about the age of 10.5 and in boys at about 12.5 years. The maximum of the velocity of height increase (peak height velocity) appears on average 1.5 years after the onset of the adolescent growth spurt. However, the time and the value of PHV varies from the child to another. The mean values of the PHV has been found for girls 9.0±1.03 cm/year [2] and for boys 10.3±1.54 cm/year [3].

In Estonia, Silla and Teoste [5] found the average PHV in girls at the age from 11 to 12 and in boys from 14 to 15 years. The values of PHV were 6.57 and 7.14 cm/year, respectively. Due to individual differences in the growth pattern, as well as due to the fast decrement of the growth rate after the PHV, detection of PHV requires a longitudinal study whereas the height should be measured after 3 to 6 months [1,4]. Silla and Teoste [5] performed height measurements after the periods of a year. The present study is aimed at checking up these results measuring the height in Estonian girls after every four months.

METHODS

A longitudinal study was conducted in 48 healthy girls of the age range from 126 to 168 months (10,2–14,0 years). During a two-year period, anthropometrical measurements and the assessment of the breast development stages (by Tanner's scale [6]) were performed every four months. In this paper, the dynamics of height was analyzed for the detection of PHV. For each girl a 4-months period was found during which the height increase per month was the highest. The individual age of the PHV was considered to be at the middle of the 4-months period. This period was considered to be the PHV period if the height rate per 4 month was at least 2 cm. The results were summed up for computing the curve of the distribution of individual data and for detecting the mean and median values.

RESULTS

According to the above mentioned criteria, the PHV was established in 30 girls. In the remaining 18 girls, the obvious increase of growth velocity was not found during the two-year-period. PHV was mainly established in girls who where 10–12 years old and at breast development stages I or II. The PHV was not established in the majority of the girls at the age of 12–14 years and at stages II and III (Table 1).

Table 1. Distribution of girls by chronological age and breast development stages at the onset of observations.

	Breast development stages				Chronological age (years)			
	I	II	III	IV	10,2–11	11,1–12	12,1–13	13,1–14
PHV was found (n=30)	16	14	1	0	6	14	6	4
PHV was not found (n=18)	0	8	9	1	0	4	5	9

In 70% of girls the PHV was detected at the age range from 11 years 9 months to 13 years 1 month. During the 4-month-period when PHV was observed, the breast developmental stage II dominated: 6 girls reached stage II, 12 remained at stage II and 4 transferred to stage III (Table 2).

Table 2. Breast developmental stages at the onset and end of the 4-months period of PHV.

Stages of breast development		No of girls
At the onset of the period	At the end of the period	
I	I	7
I	II	6
II	II	12
II	III	4
III	III	1

The mean age at PHV (± SD) was 12 years 6±11.7 months. The median age 12 years 0.5 months. The discrepancy between the mean and median values was related to 3% girls of late PHV (in the age range 14 years 2.5 months and 14 years 6 months). Two of them reached during the 4-month-period of PHV the breast developmental stage II and one remained at stage II.

The mean value of PHV was 3.98 ± 1.98 an per 4 months (11.9± 5.9 cm per years).

DISCUSSION

The obtained results indicate that the PHV reveals mostly at age the of 12 years (Fig. 1). It is in good accordance with the generalization of Marshall and Tanner [4]: in girls adolescent growth spurt begins at about 10.5 years and the PHV appears 1.5 after, that is in age 12 years. In Estonia girls Silla and Teoste [5] found the PHV at age 11 to 12 years. The value of these data should be highly appreciated, because their longitudinal study extended to the period from 7 to 18 years. However, the measurements only once per year are not sufficient for the precise detection of the PHV.

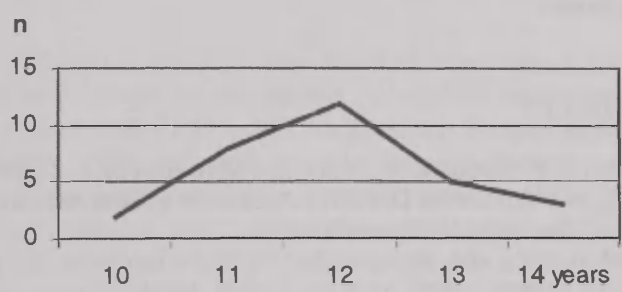

Figure 1. Distribution of PHV time by chronological ages (indiented by years).

A questions arises whether the lack of the detection of PHV in 18 girls might influence the results of the present study. PHV was not found mainly in the girls who were at the onset of the observation 12 to 14 years old and were in breast development stages II or III. Therefore, plausibly they had PHV before the participation in the investigation. Nevertheless, the present results are in good accordance with those presented by Marshall and Tanner [4].

The PHV was related to the breast developmental stage II. Marshal and Tanner [4] indicated that in most cases PHV reveals either in stage III, whereas in a number of cases PHV reveals either in stage II or IV. The present results also indicated on individual variability in the relationship between PHV and the stages of sexual maturation. In 21% of girls the PHV was found even before the onset of the puberty (stage I). PHV at the stage IV was not observed. However, in three cases of late PHV, also the sexual development was restricted. These girls of the age 13–14 years were only at breast developmental stages II or III.

Both PHV as well as gender- specific development of reproductive organs (including breast glands) are triggered and controlled by sex hormones. The mentioned three cases of late PHV in the associations of restricted breast development point on a general reason that is, plausibly, a low production of female sex hormones, those stimulate both the growth rate via the secretion of growth hormone and the sexual development. However, the appearance of PHV before the onset of puberty in 21% of girls suggests that individual differences may exist in the susceptibility of growth and sexual development on sex hormones.

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Papers on Anthropology XII, 2003, pp. 291–299

PRENATAL DEVELOPMENT OF TWINS IN THE MIRROR OF FAMILIAL BACKGROUND

Annamária Zsákai, Éva B. Bodzsár, Kristóf Jakab

Department of Biological Anthropology, Eötvös Loránd Univiversity, Budapest, Hungary

ABSTRACT

In obstetrics the developmental status of new-borns is assessed by using birth weight as an indicator of impaired development. Only 10–20% of total birth weight variance can be attributed to foetal genotype while maternal environment and intrauterine factors, such as placentation, have a much more important role [1]. Placental features were found to have important bearing on foetal development, and inhibited placental growth affected foetal and neonatal development considerably [2].

Many studies have reported on the association between birth weight and socio-economic background. It has been generally assumed that poor maternal socio-economic environment impairs foetal growth and neonatal maturation status [3, 4]. However, almost no research has been published on whether socio-economic factors have any significant effect on birth weight either directly or indirectly through the placenta.

The purpose of this study was to quantify the influence of socio-economic factors on the foetoplacental unit in twins. Birth weight and placental weight of 1580 twin pairs grouped by birth order and factors of socio-economic background (parental occupation, parental age,) and maternal "body linearity" as an indicator of maternal nutritional status were analyzed. Our results evidenced that maternal age, body linearity and parental occupation had significant effects on placental weight and, indirectly, also on birth weight. Between 18 and 40 years of maternal age placental and neonatal birth weights were found to grow with maternal age and ectomorphy, parental occupation and associated level of education.

Key words: Twin study, Foeto-placental unit, Prenatal development, Socio-economic familial background

INTRODUCTION

In obstetrics the developmental status of newborns is assessed by using birth weight as an indicator of neonatal development [5,6]. Only 10–20% of total birth weight variance can be attributed to foetal genotype while maternal environment and intrauterine factors, such as placentation, have a much more important role [1]. Placental features, as placental weight, type of placentation, length of umbilical cord, type of cord insertion on the placenta, were found to have important bearing on foetal development in our previous study [2].

Many studies have reported on the association between birth weight and socio-economic background and nutritional status of the mother, respectively. Namely, extremely poor maternal socio-economic environment was found to impair foetal growth and neonatal maturation status [3, 4]. The foetus seems to be essentially protected against maternal nutritional deficits and other adverse environmental effects by the intrauterine milieu. Multiple pregnancy, when two or more foetuses compete for space in the uterus, and adverse socio-economic factors are additive in their effect, twinning could enlarge the differences in foetal development among social groups.

The main purpose of this study was to quantify the influence of socio-economic factors and maternal nutritional status on the foetoplacental unit in twins. Inhibited placental growth was evidenced to affect foetal and neonatal development considerably. On the basis of this connection our hypothesis was that the socio-demographic factors would influence placental development and their effects appear indirectly in the neonatal development. Practically, birth weight differences among social groups can be originated in the socio-demographic variation of placental development. To check the validity of this hypothesis: we studied [1] the role the socio-demographic factors of the family and maternal nutritional status in birth weight, and [2] the part played by the placenta in it.

SUBJECTS AND METHODS

By the order of Health Department of the Budapest City Council multiple births have been recorded by the Budapest Twin Register since 1970 [7]. The Budapest Longitudinal Twin Study based on the Twin Register also started in 1970 to meet the recommendations of WHO [8]. Information on pregnancy outcome and socio-economic factors was available for more than 1500 twin pairs born between 1970 and 1980. The distribution of the twins by birth weight can be seen in Table 1.

Table 1. Distribution of twins by birth weight.

Birth weight (g)			n	%
	–	1000	27	0.9
1001	–	1500	218	7.1
1501	–	2000	744	24.3
2001	–	2500	1124	36.6
2501	–	3000	747	24.4
3001	–	3500	179	5.8
3501	–	4000	27	0.9
4001	–		1	0.0
		Total:	3067	100.0

Birth weight and placental weight were recorded in the maternity wards, data on socio-economic background and parental body size were collected from the gynaecological records. Social, environmental and biological characteristics regarded as potential risk factors for impaired neonatal development included parental occupation, maternal age at birth, parental body size and maternal body linearity. Parental occupation was considered by using the combination of the following categories of the maternal and paternal occupational statuses: intellectual worker, skilled worker, non-skilled worker, casual worker. Maternal "body linearity" as an indicator of maternal nutritional status was estimated by dividing body height in cm by the cube root of body weight in kg. The total birth weight of twins was used to estimate the physical development of neonates born from the same pregnancy. Total birth weight expressed in units of placental weight, what we termed placental index was used to estimate the development of foetoplacental unit as a whole. Gestational age was expressed in completed weeks of the interval between the last menstrual period and birth. The centiles 3, 10, 25, 50, 75, 90 and 97 of birth weight were estimated by Cole's LMS method [9].

All differences and coefficients were tested at the 5% level of random error in the computations [10].

RESULTS AND DISCUSSION

Because of the uterine cavity's limited space, twin placentas frequently collide during their expansion. This may restrict their growth, retarded growth of the placentas had considerable influence on foetal and neonatal development. Placental weight and total birth weight were positively correlated (Pearson's coefficient was 0.6, Figure 1), so birth weight of twins increased with placental weight in this study.

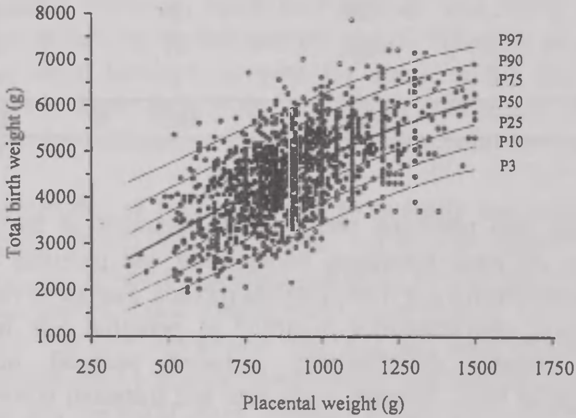

Figure 1. Relationship between birth weight and placental weight.

Birth weight increased with higher parental occupational status, twins whose parents had jobs associated with a higher level of education were born with greater weight than twins of parents with lower occupational status (Figure 2). Neonatal birth weight grew with maternal age. It could be stated that maternal age at birth had significant effect on birth weight; compared to mothers giving birth below 18 years of age, mothers aged between 18 and 40 years delivered heavier twins. Weak correlation was observed between maternal body linearity and birth weight, coefficient was –0,128, the last figure in this transparency evidences that birth weight decreased with increasing maternal body linearity.

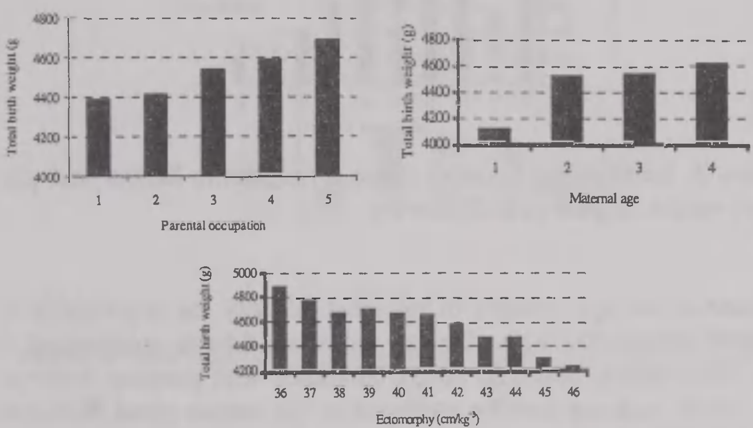

Figure 2. Relationship between socio-demographic factors and birth weight.

Parental occupation

1: both parents are unskilled worker, 2: one parent is skilled worker, the other is unskilled, 3: both parents are skilled worker, 4: one of the parents is intellectual worker, 5: both parents are intellectual worker

Maternal age

1:-18.0 years, 2: 18.1-24.0 years, 3: 24.1-30.0 years, 4: 30.1-40.0 years

Placental weight was greater in twins of parents with higher occupational status than twins of families where both parents were employed as unskilled workers (Figure 3). An increased risk of impaired placental development was found to associate with low maternal age could be found in this study. Maternal body linearity had significant influence on placental growth, placental weight decreased with increasing maternal ectomorphy.

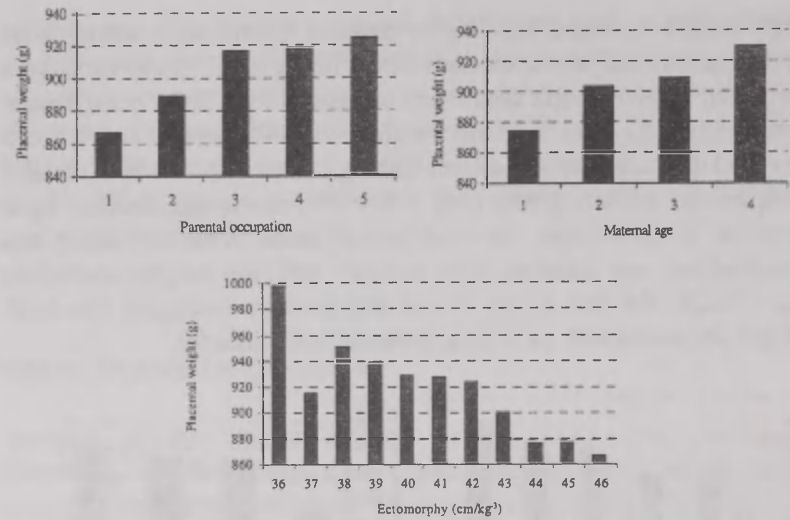

Figure 3. Relationship between socio-demographic factors and placental weight. (Abbr.: as in Figure 1)

Because of the age changes of maternal linearity the relationship of maternal ectomorphy with placental index could be as pronounced as was found before. Maternal height decreased with growing maternal age, which tendency may be attributed to the secular trend described in adult body height of successive generations of the last century (Figure 4). The largest difference in stature was found between mothers younger than 18 years of age at birth/delivery and older than 40 years of age, on the average mothers in the youngest age group were more than 7 cm taller than mothers belonged to the oldest age group. Maternal body weight increased with advancing maternal age, which phenomenon could be explained with the gradual age changes of body weight observed in adult women aged between 25 and 60 years of age (Figure 4). Age changes in maternal body linearity reflected these parallel changes of body height and weight.

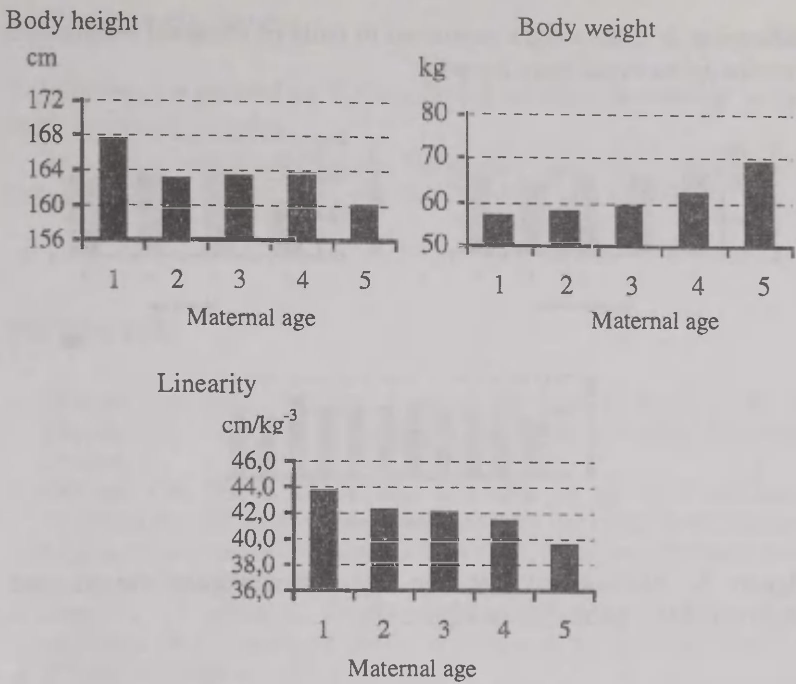

Figure 4. Maternal body dimensions by age. (Abbr.: as in Figure 1)

The associations between the studied socio-demographic variables and placental weight, respectively birth weight, showed the same tendencies (Figure 2–3). Parental occupation, maternal age and maternal nutritional status had significant bearing on the development of the foetoplacental unit in this study. Birth weight may reflect the relationship between socio-demographic differences and placental development.

This kind of placental index has been used in Hungarian obstetric practice as a very simple, but a very important indicator of foetoplacental development. Parental occupation had no influence on placental index, since the latter did not vary significantly by categories of parental occupation (Figure 5). It could be also stated that maternal age at birth had no significant impact on the placental index. And as you can see in this figure, maternal nutritional status had no considerable influence on placental index either; and there were no differences in birth weight expressed in units of placental weight as a function of maternal body linearity.

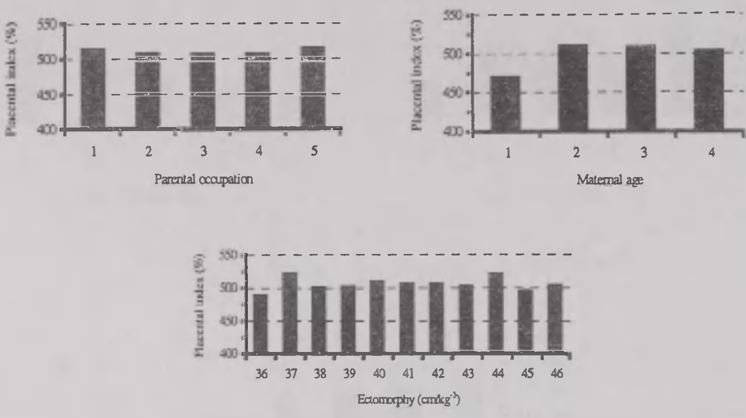

Figure 5. Relationship between socio-demographic factors and placental index. (Abbr.: as in Figure 1).

CONCLUSIONS

Foetal development was found to associate with the features of placenta; linear correlation was found between placental development and birth weight. This time we conducted a study to evaluate the evidence for the hypothesis that socio-economic factors and maternal nutritional status are potential factors for the development of foetoplacental unit. Our results evidenced that maternal age, body linearity and parental occupation had significant effects on placental weight and, through the placenta, indirectly, also on birth weight. The better the socio-economic background of the family and the better the maternal nutritional status, the better foetoplacental development was found. These observations suggest that parental occupation, maternal age and maternal body linearity would affect birth weight and placental weight in a similar way, and would not placental index significantly. So the conclusions are: [1] the studied socio-economic and maternal factors show relationship with placental development, and [2] in turn, placental development is significantly related to foetal development, [3] accordingly socio-economic factors on placental growth are therefore reflected in foetal development.

ACKNOLODGEMENTS

The authors are grateful to T. Cole for his courtesy in granting access to his computer program.

This paper was funded by the Hungarian National Foundation for Scientific Research (OTKA grant No T 030844 and T 034872)

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ISSN 1406–0140