ISSN 0494-7304 1024-4441

ARTU ÜLIKOOLI
TOIMETISED
CTA ET COMMENTATIONES UNIVERSITATIS TARTUENSIS

976

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V

Töid kehakultuuri alalt

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Editor: T. Jürimäe

Tartu Ülikooli Kirjastuse trükikoda
Tiigi 78, EE2400 Tartu
Tellimus nr. 55.

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ESTIMATION OF PERCENTAGE BODY FAT BY THREE DIFFERENT METHODS

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Abstract

The purpose of this study was: (i) to assess body fat using three different body composition procedures — the Bodystat 500 analyser (BS) and estimates of body fat from the skinfold equations of Durnin and Womersley (DW) [5] and Jackson and Pollock (JP) [7]; (ii) to assess whether the resistance index (RI = height^2/resistance) was a significant predictor of fat free mass (FFM). The subjects were 10 young males, mean age 23.4 (2.01) years, mean height 182.9 (1.9) cm and mean mass 87.4 (5.6) kg.

Percentage body fat and FFM predicted from the Bodystat analyser were compared with predicted values from the two skinfold equations. The correlations obtained were: BS % fat: DW % fat, r = 0.99, BS % fat: JP % fat, r = 0.98; DW % fat: JP % fat, r = 0.98; BSFFM: DWFFM, r = 0.97; BSFFM: JPFFM, r = 0.99; DWFFM: JPFFM, r = 0.96. Analysis of variance showed there to be no statistical differences ($p < 0.01$) between any of the % fat content values. The correlation co-efficients between RI and % fat and FFM were RI: BS % fat, r = 0.63; RI: DW % fat, r = 0.57; RI: JP % fat, r = 0.56; RI: BSFFM, r = 0.57; RI: DWFFM, r = 0.26; RI JPFFM, r = 0.28. None of these correlations were significant at $p < 0.01$ level.

It was concluded that estimates of body fat and FFM obtained from the Bodystat analyser were as accurate as estimates from the skinfold equations of Durnin and Womersley [5] and Jackson and Pollock [7] but that RI was not a suitable predictor of FFM in young athletic men.

Introduction

Methods of assessing body composition are generally divided into two categories, direct and indirect. The former category is achieved by the dissection of human cadavers and animals. Only a limited number of such measurements have been made [2, 12]. Indirect methods are non-invasive techniques used to provide suitably accurate estimates of body composition. The main established methods of assessing body composition include the technique of hydrostatic weighing which was first used by Behnke [1] in 1942. It is regarded as one of the more accurate and reliable methods of body fat content assessment, even though it is inconvenient to perform for those who lack water confidence. Other methods include gamma ray spectrometry, total body water by isotope or solute dilution and whole body potassium measured from potassium 40. The main disadvantage of these techniques is that they need to be performed in the laboratory situation. Anthropometric methods using weight and height ratios or various combinations of skinfolds, circumferences and diameter measurements are the methods that are more typically used in the field situation to assess body composition. A relatively new body composition assessment technique that may also be used in the field situation is that of bioelectrical impedance analysis (BIA). BIA was first reported in 1909 by Cremer [19] who measured impedance in biological specimens. Mann [11] in 1937 reported non-invasive measurements in humans with the work of Thomassett [18] in the 1960s establishing the basic principles of BIA. The clinical support to substantiate these principles was provided by Nyboer [13, 14] in 1970 and 1972. The BIA method simply requires the placement of four electrodes on the subject at specified locations and is therefore simple and quick to use compared to some of the other established methods. BIA is based on the bioelectrical properties of the human body with impedance measures used to detect changes in various physiological functions. The basic principle of body impedance is based on the concept that electrical flow is conducted better through hydrated fat free tissue and extracellular water compared with fat tissue due to the greater electrolyte content and thus lower electrical resistance. As a result of this impedance is directly related to levels of body fat. The greater the fat content the greater the resistance.

There have been many studies that have investigated bioelectrical impedance analysis as a useful method of estimating body composition in adults, [4, 10, 15, 16, 19]. The first commercially available instrument (the RJL system) was used to assess fat free mass (FFM) by densitometry and whole body resistance procedures by Lukaski et al [10] in 1986 and Segal et al [16] in 1985. Both studies showed highly significant relationships between FFM and whole body resistive index (RI). RI is height^2 divided by resistance with correlation coefficients of $r = 0.98$ by Lukaski [10] and $r = 0.94$ by Segal [17] having been produced with FFM.

It has been shown that resistance and height^2 used separately [17, 20] or expressed as RI [6, 10, 17] have higher correlation coefficients than impedance, reactance, age, sex, body mass and body mass index. Lukaski et al [10] validated the relationship between RI and densitometrically determined FFM. They showed RI to be a valid and reliable predictor of FFM in both men (r = 0.97) and women (r = 0.95). Van Loan et al [20] also showed RI to be strongly correlated with FFM (r = 0.97).

The purpose of this study was to: (i) to investigate BIA in the estimation of percent fat, and FFM compared with estimates from the equations of Durnin and Wormersley [5] and Jackson and Pollock [7] which use skinfold measurements to estimate body density and (ii) to assess whether the RI would be a significant predictor of FFM in a male athletic population.

Method

The subjects in the study were 10 healthy males from various tennis clubs in the North West of England. The mean subject characteristics are presented in Table 1.

Total body resistance and reactance were measured with a four terminal portable RJL impedance analyser (BIA 103, RJL Systems, Detroit, Michigan), which transmitted a current of 50khz at 800mA from the surface electrode.

A Bodystat 500 analyser (Bodystat, Douglas, Isle of Man) and software was also used to estimate percentage fat and FFM on each subject.

The above two techniques were performed with the subjects in the supine position with their limbs abducted from the body ensuring that the limbs were not in contact with the trunk. The current electrodes were places on the ventral surface of the right hand and foot just above the knuckles and below the toes. The detector electrodes were placed midway between the radial and ulna styloid processes of the right hand and the medial and lateral malleoli of the right ankle. Five resistance and reactance measurements were taken for each subject and the mean of the five measurements used as the representative value.

Skinfold measurements were taken using Holtain skinfold cahpers. The sites were the triceps, biceps, subscapular, suprailiac, abdomen, chest and anterior thigh as described by Lohman et al [9]. Two measurements were taken at each site and the mean of the two used as the representative value. All measurements were taken on the right side of the body. The skinfold measurements were used to predict body density using the equations of Durnin and Womersley [5] and Jackson and Pollock [7]. Using these body density values percentage body fat,

fat free mass and fat mass were then calculated. Percentage body fat was calculated as a percentage of body mass using the formula of Brozek et al [3].

The data were analysed using the Superstats statistical package involving descriptive statistics, Pearson product moment correlations, analysis of variance, and Student's T tests. Percentage body fat and FFM estimated by BIA were compared with the values estimated by the equations of Durnin and Womersley [5] and Jackson and Pollock [7].

Results

The means and standard deviations for age, mass, height, electrical impedance and estimated percentage fat, FFM and FM values are given in Table 1.

Table 1

Means and standard deviations for anthropometric measurements

	Mean	SD
Age (years)	23.4	2.0
Mass (kg)	87.4	5.6
Height (cm)	182.9	1.9
RJL resistance value	456.6	23.6
RJL reactance value	62.1	4.7
Resistance index	68.8	6.5
Bodystat % fat	16.1	1.5
Bodystat fat mass	14.2	2.2
Bodystat fat free mass	72.2	3.7
Durnin & Womersley % fat	16.5	1.6
Durnin & Womersley FM	14.4	4.9
Durnin & Womersley FFM	72.7	3.5
Jackson & Pollock % fat	16.9	1.6
Jackson & Pollock FM	14.8	2.3
Jackson & Pollock FFM	72.6	3.7
RJL impedance	460.0	23.2

The correlation between the three different methods of calculating percentage body fat and fat free mass are shown in Table 2.

Analysis of variance showed there to be a non significant different ($F = 0.71$) between the three methods as would be expected from the mean values in Table 1.

Table 2.

Correlation between methods of measuring body fat

Method	r	p<
Bodystat % fat: Durnin & Womersley % fat	0.99	0.001
Bodystat % fat: Jackson & Pollock % fat	0.98	0.001
Durnin & Womersley % fat: Jackson & Pollock % fat	0.98	0.001
Bodystat FFM: Durnin & Womersley FFM	0.97	0.001
Bodystat FFM: Jackson & Pollock FFM	0.99	0.001
Durnin & Womersley FFM: Jackson & Pollock FFM	0.96	0.001

Table 3

Correlations between RI, % body fat and FFM

Methods	r
RI: Bodystat % fat	0.63
RI: Durnin and Womersley % fat	0.57
RI: Jackson and Pollock % fat	0.56
RI: Bodystat FFM	0.57
RI: Durnin and Womersley FFM	0.26
RI: Jackson and Pollock FFM	0.28

The correlations between the resistance index and percentage body fat and FFM are shown in Table 3.
At $p < 0.01$ (critical value 0.66) there were no significant correlations between the RI and % fat or FFM by any of the methods.

Discussion

The lack of statistically significant differences between the three methods of estimating percentage body fat showed that the Bodystat 500 analyser is as valid as the skinfold measurement of Durnin and Womersley [5] and Jackson and Pollock [7]. It is accepted that this study is based on a small sample size, but their homogeneity gives more credibility to the statistics. The advantage of the Bodystat 500 analyser could be for more heterogeneous samples, especially those containing individuals whose skinfold measures are difficult to measure. This applies to the Durnin and Womersley [5] equation when obese individuals are difficult to measure because of caliper slippage and to the Jackson and Pollock [7] equation when the thigh reading of muscular individuals is also difficult to establish with accuracy. The reliability of the Bodystat 500 has been established as satisfactory by Jurimae and Juriso [8]. The Bodystat 500 analyser can therefore be used as an alternative, reliable method for the prediction of percentage fat and FFM in healthy people of mid range BMI (21–26).

The RI in this study was not a good predictor of either percentage body fat or FFM, yielding non significant correlations. As RI is based on resistance and height squared, it emphasizes the importance of the conductor length in the estimation of body fat or FFM from electrical methods. It is hardly surprising that RI: Bodystat % fat almost reached the critical level for significance (r = 0.63 as opposed to the critical level of 0.66 at $p < 0.01$) as the formula used to calculate % fat would include resistance and height. Reactance is commonly measured in addition to resistance and impedance is then calculated from the formula: impedance = the square root of [resistance squared + reactance squared]. It was an interesting observation that the impedance values for the Bodystat averaged at 426 ohms, whereas for the RJL the average was 460 ohms. A T-test on these values indicated a significant difference between the impedance values yet when converted to percentage body fat or FFM values, the differences were non-significant. Having confirmed with the manufacturer that the Bodystat values are impedance and not resistance, (and stated in print by Maughan, [12]), we conclude that the formulae to predict the body fat and FFM values are different between manufacturers. Although RI as a simple index to estimate body fat or FFM has not in this study supported the work of Lukaski et al [10], it is recognized that the small sample size may be a contributing factor. Critics of electrical impedance methodology tend to have available alternative and expensive options such as neutron activation or bone densitometers. In the quest for a low cost, non-invasive, transportable, ethical, field method for epidemiological use, this study gives further support to bioelectrical impedance as a viable option.

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THE PREDICTION OF RESIDUAL VOLUME FROM LUNG FUNCTION AND ANTHROPOMETRY

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Abstract

The purpose of this study was to examine whether lung function and anthropometric measures will predict residual volume by the criterion method of gas dilution.

A Pearson product moment correlation coefficient was undertaken using three lung function indices and three anthropometric measurements as the predictor variables. A strong positive correlation was revealed for two indices of lung function, FEV_1 and TLC ($r = 0.74$, $p < 0.01$ for both). A positive correlation was also obtained for vital capacity ($r = 0.58$, $p < 0.05$).

Examination of the anthropometric methods showed non significant correlations with the criterion measurement of residual volume.

The result obtained from this study would suggest that anthropometric measurement will not suffice in the prediction of residual volume but that lung function indices are a valid and useful method of prediction, particularly FEV_1 which can be measured by use of a simple spirometer.

Introduction

Accurate determination of the changes in the static lung volumes can be obtained by the use of an air displacement spirometer. However some gas remains in the lung after a maximal expiration, this is the residual volume (RV). The volume of gas in the lungs after a normal expiration is the functional residual capacity (FRC). Neither FRC or RV can be measured with a simple spirometer. However, various gas dilution techniques can be used, the helium dilution technique being the most widely used in clinical situations.

The measurement of the total lung capacity and its subdivisions, including the FRC and the RV by the closed circuit helium dilution method requires 20 minutes of the subject's time yielding values which are reproducible to within ± 200 ml [1].

Other less time consuming methods are available as a method of predicting the residual volume. A nomogram which relates indices of lung function to stature and age for both male and female subjects is available [1]. This method is believed to be acceptable as both the FRC and RV show relatively little variation between individuals of the same sex and stature in young healthy subjects [4]. However, this method is unsuitable in subjects with lung disease due to abnormal residual volume as a result of gas being trapped within obstructed airways.

Methods to assess changes of the lungs with breathing can be undertaken with various anthropometric methods: height, weight, age and change in circumference of the chest wall during breathing. Although the increases in circumference observed by this method do tend to be small and hence its accuracy questionable, it is however a very simple method and requires little time.

The purpose of this study was to examine the methods available for prediction of residual volume from lung function indices and anthropometric measurements and to evaluate whether these predictions will predict residual volume using the criterion method of helium dilution.

Method

Twelve physically active women (35 ± 15 years, mass 58 ± 15 kg and height 167 ± 11 cm) volunteered to take part in this study.

Chest circumference measurements were recorded by taking the mean of three readings for full inspiration and maximal expiration in three areas; the level of the axillary fold and the level of the 8th and the 11th rib respectively. The difference between inspiration and expiration was calculated and the sum of the means of the three measurements was recorded. Lung function measurements of peak expiratory flow rate (PEFR) and forced expiratory volume in one second (FEV_1) were obtained using a single-breath dry spirometer (Vitalograph Limited) and a Wright peak flow meter. Subjects were instructed to inhale maximally and follow this with a maximal expiration. For these recordings of ventilatory performance, the subject was instructed to attempt three tests; the mean of the three determinations was used to provide a stable index.

Other indices of lung function (vital capacity, functional residual capacity, total lung capacity and residual volume) were obtained by use of a gas dilution spirometer (PK Morgan Ltd). The subject is connected to a spirometer containing a known concentration of helium which is virtually insoluble in blood. After some breaths, the helium concentration in the spirometer and the lung become the same. Since no helium has been lost the amount of helium present before equilibration (concentration x volume) is $C_1 \times V_1$ and equals the amount after equilibration $C_2 \times (V_1 + V_2)$. From this $V_2 = V_1 (C_1 - C_2)/C_2$. In practice oxygen is added to the spirometer during equilibration to make up for that consumed by the subject and also carbon dioxide is absorbed [3]. After equilibration of the gas transfer the spirometer, subjects were connected to the machine by securing their mouth around a mouthpiece and applying a nose-clip. After a period of normal breathing (tidal volume, TV) the subject was asked to breath out maximally (to residual volume, RV). The subject was then asked to breath in maximally (their vital capacity, VC). RV is calculated as functional residual capacity (FRC) — expiratory reserve (ER). Total lung capacity (TLC) is equal to RV + VC.

In order to correct for internal inconsistencies in the results, firm instructions were given by the same operator. To avoid the possibility of ventilatory capacity alterations all measurements were taken under the same conditions (i.e. in terms of time of day and avoiding heavy meals beforehand) and a correction factor was employed to allow for alterations in ventilatory capacities due to change in temperature.

Using a prediction nomogram [2] relating indices of lung function, residual volume was predicted from the three indices of lung function obtained: FEV_1, VC and TLC. The peak expiratory flow rate, although measured was not used as an index of ventilatory ability in this study. This was because it was demonstrated that trials were dependent on the degree of expiratory effort and it was not as reproducible as the FEV_1.

A Pearson-product-moment correlation was performed on these three parameters against the criteria measurement of residual volume by helium dilution.

Results

Table 1 gives the correlation coefficients, means and standard deviations for the residual volumes predicted from the nomogram from the variables of FEV_1, vital capacity and total lung capacity.

Table 2 gives the correlation coefficients, mean and standard deviations for the residual volumes predicted from height, mass and mean chest expansion.

All the correlations in Table 2 are non-significant, having failed to reach the critical value for $p < 0.05$.

Table 1

Correlations and means (standard deviations) for residual volume

Nomogram Predictor	Residual Volume Mean (SD)	Correlation Coefficients	p <
FEV	1.15 (0.43)	0.75	0.01
VC	1.21 (0.60)	0.58	0.05
TLC	1.27 (0.41)	0.74	0.01

Table 2

Correlations, means (standard deviations) for height, mass and mean chest expansion

Predictor	Mean (SD)	Correlation Coefficient
Height	1.61 (0.12) m	0.45
Mass	61.0 (7.6) kg	-0.44
Chest Expansion	8.5 (1.9) cm	0.31

Discussion

The high correlations obtained between the predictions of residual capacity from nomograms and the actual measurement support the opinion of Cotes et al. [1] that lung function measures can be used appropriately to predict residual volume. The merit of this is that the direct measurement of residual capacity is costly both in terms of time and operator expense. Helium dilution techniques are often only to be found in hospitals, whereas the need for residual volume may be elsewhere. This would especially apply in human performance laboratories where hydrostatic weighing is used to estimate body fat. The error produced by using residual capacity predicted from a nomogram based on FEV_1 for estimating body fat is likely to be less than per cent. For epidemiological research this is probably acceptable. Changes to body fat caused by specific treatments may require a direct measure of residual volume to reduce errors further. It was interesting to note in Table 1 that vital capacity only predicted residual volume at $p < 0.05$ with a correlation ($r = 0.58$) which accounted for only 34 per cent of the variance. Vital capacity has been demonstrated to show larger variations with treatment and operator conditions than FEV_1. This may have contributed to the poorer correlation, although on a theoretical basis it would be expected that a measure of lung volume would be more closely related to residual volume than a measure of lung power. The anthropometric measures were non-significantly correlated but as they are a further step removed from the use of lung function measures to predict residual volumes this is not surprising. In most laboratories needing to estimate residual volume the equipment to measure lung volumes is likely to be available. Prediction from simple anthropometric variables is valuable in field conditions when more complex equipment is unavailable. In this situation the need to estimate residual volume is less likely to be necessary and if it is required then the use of a simple flow meter such as the Wright peak flow meter would be the method of choice.

It is recognized that this study is based on a relatively small sample size and of a single sex. However it does provide a basis for a more extensive study of men and women and gives further support to those experimenters who are concerned that using the prediction of residual volume is limiting their experimental validity. Those researchers who are in the fortunate position of having direct access to helium dilution or other direct methods of measuring residual volume should continue to do so. For those unable to obtain such access a predictive nomogram, with the limitations described here, will continue to be an acceptable alternative.

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THE ROLE OF STRENGTH TRAINING IN ENHANCING THE PERFORMANCE CAPACITY OF SPRINTERS (SWIMMERS)

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Introduction

In cyclic athletic disciplines, the athletes' results, to a large extent, depend on their performance capacity, that is, on their ability to develop high power and to maintain it for a certain period of time. To enhance the performance capacity, various methods are employed, including strength training in different ways. It is known that performance capacity and the athletes' results in many sports closely correlate with the development of maximal strength and muscle circumference. Not always, however, does strength training increase performance capacity. Quite often, performance capacity and athletes' results decrease in the result of intensive strength training [10, 11, 13, 16].

The aim of our research was to establish the effect of different strength training methods on various physiological, morphological and biomechanical characteristics and performance capacity of low-trained students and qualified athletes — swimmers.

Methods

In the experiment with low-trained students (31 persons aged 18–24 years) we used four methods of strength training (see Table 1). These methods were selected for specific aims of physiological effect. The method for the 1st group consisted of training with submaximal weights until exhaustion. Such training facilitates the increase of maximal strength and myofibrillic hypertrophy in all muscle fibers, and it enhances the energy potential — the glycogen contant and the activity of corresponding ferments mainly in the fast muscle fibers [7, 15].

Table 1

Methods of strength training

	Experimental groups			
	I (n = 8)	II (n = 7)	III (n = 7)	IV (n = 9)
Weight (% of max.)	70–90	60–70	40–50	40–50
Repetitions	3–12	8–12	15–25	15–25
Tempo:				
a) maximal				x
b) medium	x			
c) slow		x	x	

Series 4–10
Rest 3–5 min (between series)

The method for the 2nd group employed slow, smooth movements without relaxation of the muscles. Exercises were performed with 60–70% of maximal weights and were stopped before reaching exhaustion. In such exercises, mainly the slow muscle fibers are involved. The muscle tension stops the blood supply of muscles [17], the result being a higher concentration of free creatine and lactate. Such conditions facilitate the hypertrophy of myofibrils mainly in the slow and the fast oxidative muscle fibers [14, 18].

The 3rd group performed their strength training with 40–50% of the maximal weight, doing movements with maximal power but in a slow frequency — one movement per every 3–4 seconds. Several physiological investigations show that when very fast movements are performed with great power, mainly the fast twitch units and muscle fibers are selectively activated [11].

The 4th group performed strength training with 40–50% of the maximal weight in maximal frequency until exhaustion. This method is similar to that of the 3rd group, while the high tempo facilitates fast concentration of lactate and rapid development of fatique. Such a pattern of muscle work is characteristic for competition exercises performed with maximal power.

All four groups performed two exercises: 1) bench press, and 2) imitation of swimming motion in a special devise [19] while lying on a swimming ergometer. Exercises by these methods were performed in two sessions a week for six consecutive weeks. In the following second period (three weeks) the groups' training methods were interchanged: the 1st and 2nd groups took up training by the initial method of the 3rd group, while the 3rd and 4th groups used now the initial method of the Ist group.

The experiment with swimmers was carried out after completion of the experiment with low-trained students. In the athletes' strength training, the methods of the 1st and 3rd groups were utilized which caused the gratest enhancement of performance capacity for low-trained students. Swimmers performed strength training thrice a week: two sessions by the method of the 1st group, and one session by the 3rd group's method. The swimmers' group included two Masters of Sports, two 1st-class athletes and three 2nd-class athletes (7 persons altogether, aged 18–24 years). The athletes' group differed from the low-trained students by a slightly lower mean body weight (see Table 2), greater mean chest circumference, and considerably higher maximal strength when performing the swimmer's motion imitation (for 26%) and performance capacity during the 45 s test on the swimming ergometer (for 17.5%).

Before the experiment and after each stage of it, the following measurements were done: body weight, circumference of the upper arm and chest, maximal strength, maximal power of one movement, performance capacity during the 30 s bench press test, performance capacity during the 45 s test on the swimming ergometer. Swimmers were additionally tested for their stroke force in water and swimming speed in 50 meter distance.

The upper arm circumference measurements were taken before warm-up on a strained muscle with a tape measure, while the chest circumference measurements were taken in a relaxed state at the nipple level. On the basis of these measurements, the relative muscular hypertrophy resulting from strength training was estimated. The maximal strength was measured by the maximal lifted weight in both exercises, and the isometric strength was measured during the swimming motion imitation, lying on the swimming ergometer, with the strength dynamometer, by generally accepted methods [19]. The maximal power of one movement was measured by the method of cyclography, after M. Shakirzyanov [20], during the bench press with 50% of the maximal weight. Performance capacity during the 30 seconds test was measured with the same weight, performing the exercise in maximal tempo. For the purpose of calculating the work, only the overcoming motion was taken into account. Performance capacity during the 45 s test was measured on the swimming ergometer with the constant resistance of 3 kgP, which roughly corresponds to water resistance while swimming at competition speed.

Results and discussion

A close positive correlation was established between:
- maximal power and maximal strength, $r = 0.88$;
- 30 s performance capacity and maximal strength, $r = 0.94$;

Table 2

Changes in morphological indices, maximal strength, power and performance capacity on consecutive training stages

Experimental groups	Body weight kg	Chest circumference cm	Upper arm circumference cm	Max. strength on bench press kg	Max. strength on swimming motion imitation kg	Max. power with 50% weight W	Work in 30 sec. test on bench press kg/m	Work in 45 sec. test on swimming ergometer kg/m
I								
Before experiment	77.7±1.9	99.6±1.5	34.3±1.0	71.1±6.6	36.5±3.2	507±43	524±50	647±51
After 1st stage	77.9±1.8	103.7±1.8*	35.8±0.9*	87.1±6.8*	45.1±3.5*	551±35**	662±49*	773±54*
After 2nd stage	–	–	–	86.2±6.4	44.3±3.4	574±40**	649±52	763±53
II								
Before experiment	75.1±5.1	99.2±3.2	35.4±1.3	71.8±6.9	32.7±3.1	532±56	523±59	557±52
After 1st stage	75.5±5.2	101.5±3.1*	36.1±1.3*	82.9±7.1*	40.2±3.3*	530±51	610±57*	647±56*
After 2nd stage	–	–	–	82.9±6.7	40.4±3.0	572±57*	642±60**	673±57**
III								
Before experiment	74.1±5.8	96.7±1.4	33.7±1.4	69.3±5.5	32.4±2.9	504±44	490±56	599±58
After 1st stage	74.3±5.6	98.5±3.2	34.5±1.3*	78.0±5.7*	38.1±2.8*	560±43*	623±60*	698±62*
After 2nd stage	–	–	–	81.4±5.8*	40.0±3.1**	541±42**	625±69	741±64*
IV								
Before experiment	75.5±3.8	98.7±1.8	33.8±1.1	70.0±3.4	34.4±2.6	449±28	528±36	664±48
After 1st stage	75.1±3.5	99.2±1.5	34.0±1.1	72.8±3.8	38.7±2.7*	487±32*	632±49*	696±49*
After 2nd stage	–	–	–	82.1±3.9*	43.3±2.4*	548±32*	657±47*	748±51*
Swimmers								
Before experiment	73.2±2.9	101.3±2.6	33.6±1.2	71.9±4.7	42.8±2.6	–	–	726±54
After 6 weeks	73.8±3.1	103.4±2.8*	34.6±1.3*	82.5±4.8*	52.5±2.8*	–	–	839±57*

* $p < 0.05$
** $p < 0.01$

– maximal power and chest circumference, r = 0.75;
– maximal power and upper arm circumference, r = 0.75;
– 30 s performance capacity and chest circumference, r = 0.82;
– 30 s performance capacity and upper arm circumference, r = 0.80;
– 30 s performance capacity and maximal power, r = 0.79.

Maximal power and performance capacity (with 50% of maximal weight) correlate weakly with the maximal speed of an unresisted movement, r = 0.40 and r = 0.19 respectively.

Changes in morphological indicators, maximal strength, power and performance capacity on consecutive stages of training are shown in Table 2.

In the result of six weeks of strength training, the circumference of upper arm and chest increased significantly for individuals in the 1st, 2nd and 3rd low-trained student groups (Fig. 1). In the 4th group, changes in muscle circumference were small, for some individuals measures even decreased. Changes in body weight were small in all groups, significant changes did not occur.

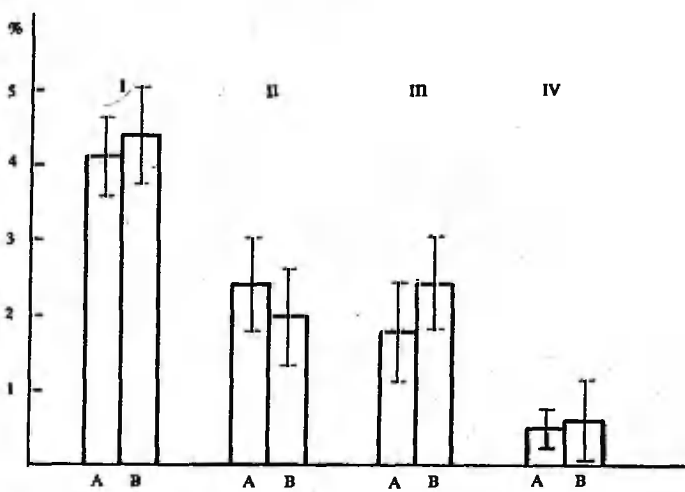

Fig. 1. Enhancement of chest and upper arm circumference after 6 weeks of training.
I–IV — experimental groups
A — chest circumference
B — upper arm circumference

The maximal strength on the bench increased significantly for individuals in the 1st, 2nd and 3rd groups, while they increased in all groups on the swimming motion imitation exercise (Fig. 2). Characteristically, strength on the swimming motion imitation exercise increased in all four groups, even for individuals whose muscle circumference did not increase. The maximal strength in this exercise was determined by the maximal weight, allowing the subject to fully complete the swimming movement while staying on the swimming ergometer. Strength on this exercise increased rapidly during the first two weeks, while further enhancement was lower. This may be explained as a result of developing specific inter-muscular coordination, since before the experiment students had not performed such an exercise. In the case of the bench press exercise, however, which had been used before in the students' physical education lessons, the muscle strength started to grow only in the third ... fourth week when 6–7 sets of each exercise were done. Such load was usually not utilized during the physical education lessons. Isometric strength measurements proved to be not sufficiently objective, since the strength varied considerably on one and the same day. On the contrary, differences in dynamic strength during repeated measurements usually did not exceed 1 kg.

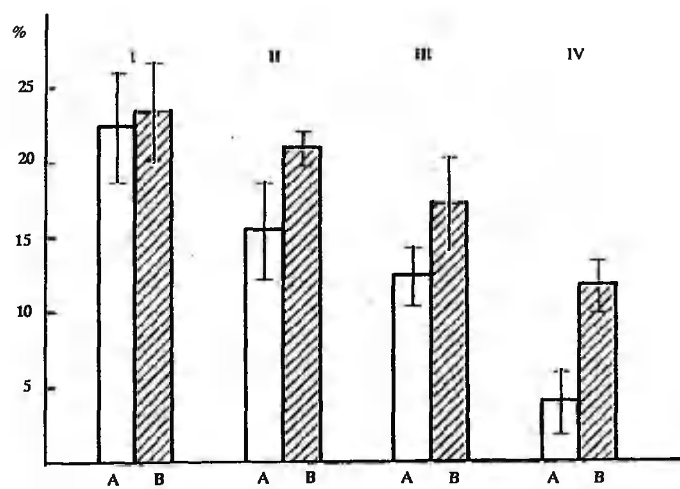

Fig. 2. Enhancement of maximal strength after 6 weeks of training.
I–IV — experimental groups
A — maximal strength on the bench press
B — maximal strength on the swimming motion imitation

The one-movement maximal power on the bench press, with 50% of the maximal weigth, increased in the 1st, 3rd and 4th groups (Fig. 3). The greatest power increase was established in the 3rd group (11.1%)

performing explosive movements alternated by 3–4 s rest intervals. For most individuals in the 2nd group, however, who did slow movements without relaxing their muscles, the maximal power decreased. It might have been caused by muscles-antagonists being involved which is usual when performing slow movements under great tension.

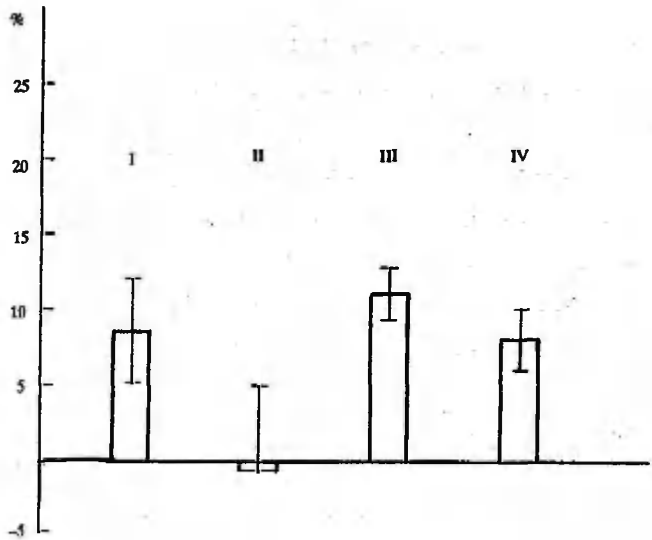

Fig. 3. Changes in maximal power of one movement on the bench press with 50% of the maximal weight after six weeks of training.
I–IV — experimental groups

The increase of maximal power is caused by other physiological processes. For the 1st group, the power enhancement is mainly related to muscular hypertrophy — the increased amount of myofibrils and enlargement of energy sources. In this group, the maximal power of one movement increased both with large (80%) and small (20%) weights. On the contrary, in the 4th group where muscular hypertrophy was small, power increased within a narrow resistance range — with 40–60% of the maximal weights — whereas with 20% and 80% power enhancement was small: in some cases the power even diminished. Consequently, power enhancement in this group is related to a special coordination between muscles which typically develops as a result of overcoming a cetrain resistance with maximal speed. Such changes have also been fixed by other researchers [10, 15]. In the 3rd group, the power enhancement was facilitated both by the muscular hypertrophy and by that special inter-muscular coordination: consequently, the enhancement of maximal one-movement power was the greatest in this group.

Performance capacity during the 30 s test on the bench press and during the 45 s test on the swimming ergometer increased considerably in all groups (Fig. 4). It has been observed by other researchers too that training muscles with different resistance, the enhancement of performance capacity (strength endurance) in tests with average external resistance is substantial and fairly similar [1, 2]. For example, nine weeks of muscle training with high weights and low maximal repetition rate (6–8 repetitions), and with low weights and high repetition rate (15–20 repetitions), led to an increase of performance capacity, testing athletes with 60% resistance, for 25% and 28% correspondingly [2]. The greatest enhancement of performance capacity was observed when a combined training program of both these methods was used [2].

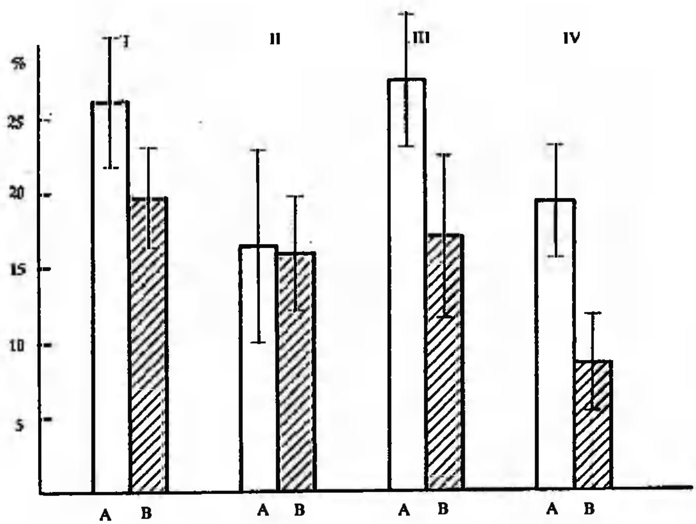

Fig. 4. Enhancement of performance capacity.
I–IV — experimental groups
A — in the 30 seconds test on the bench press
B — in the 45 seconds test on ergometer

Another research established that as a result of training with small weights (30–40 and 100–150 repetitions), the relative muscular endurance substantially increased — for 22% and 28% correspondingly, while the maximal strength failed to enlarge. Training with high weights and low repetition rates, however, enhanced the maximal strength and also the absolute muscular endurance, while the relative muscular endurance (in a test with resistance determined in per cents of the maximal strength) did not increase [1]. In our research, the greatest enhancement of performance capacity (absolute muscular endurance) resulted in the 1st and 3rd groups. Methods used by the 2nd and 4th group were less effective. This was confirmed by the experiment's second stage when the strength training methods were inter-exchanged between the groups. On this second stage, the performance capacity in both tests significantly increased in the 2nd and 4th groups who were now taking up the methods of the 3rd and 1st group correspondingly. On the contrary, in the 1st and 3rd groups (who also changed their methods of training) increases in performance capacity were small (Table 2). Besides, a disadvantageous summation of differing training effects was observed: in the first group, maximal power increased but performance capacity decreased, while in the 3rd group the maximal power decreased but performance capacity enhanced (see Table 2). Therefore the athlets' group was treated with these methods simultaneously (two trainings with the 1st group's method and one session with the 3rd group's method a week). The swimmers' group continued their swimming sessions during the strength training stage in various regimes with approximately the same amount of load, with the exception of aerobic load which was reduced by about 50%. The swimmers' group's sessions were arranged in such a manner that after the strength training (for at least 24 hours) no high aerobic exercise followed, while after an endurance training no strength training followed within the next 24 hours. Such a session plan was based on researches having established that the effects of strength training and endurance training on the formation of new muscle tissues differ and are mutually competitive [3, 6, 12, 21, 22]. As a result of endurance training the number and size of mitochondria enlarges, the activity of mitochondria and some cytoplasmic enzymes increases, and the diameter of slow and oxydative-expands-glycolytic muscle fibers expands [3, 6]. It is established that the adaptation of mitochondria progresses due to the specific synthesis of mitochondric proteins which is facilitated by metabolic and hormonal changes that develop as a result of endurance training [12, 22]. These changes sharply reduce the synthesis of myofibrillic and sarcoplasmic proteins [12, 21]. In their turn, metabolic and hormonal changes produced by strength training, facilitate the synthesis of myofibrillar proteins in glycolytic and oxidative-glycolytic muscle fibers while impeding the synthesis of mitochondral proteins. As a result, the quantity of contractive proteins increases without an adequate growth of mitochondria. In addition, the relative density of mitochondria and capillaries decreases and the production of lactate increases, which facilitates a more rapid development of fatigue [8, 9]. For these conditions, simultaneous training of muscle strength and muscular endurance does not usually produce a growth of muscle circumference and increase of performance capacity even in low-trained individuals [4, 23]. Strength in this case may enhance due to the development of nervous coordination mechanisms, which does not produce increased power in fast movements.

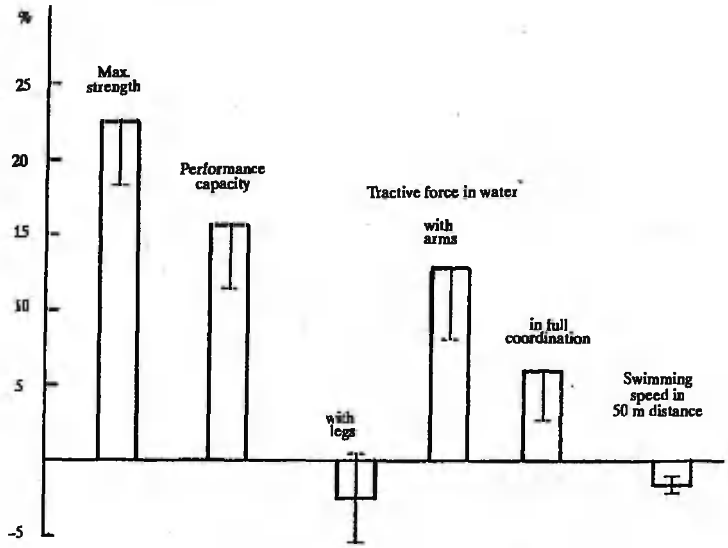

Fig. 5. Changes in swimmers strength, performance capacity and swimming speed after 6 weeks of training.

In our experiment with swimmer-sprinters the main purpose was to establish the effect of sustained strength training on the athletes' special performance capacity. However, it would be inappropriate to exclude aerobic load altogether, since even in the shortest swimming distance (50 m) which can be made in no less than 20 seconds, aerobic energetics and aerobic performance capacity play a significant role [5, 11, 15]. The training program used in our experiment was intended to significantly enhance muscle circumference, strength and maximal power, while maintaining aerobic capacity on the level attained before. By using this combined method in the course of six weeks, the muscle circumference significantly increased (Table 2), as well as the maximal strength, performance capacity and the stroke force in water when swimming only with the help of arms (Fig. 5). The tractive force of legs slightly decreased, but it increased for 5.8% when swimming in full coordination. Nevertheless, swimming speed in the 50 m distance was lower than before the strength training. This can be explained by a weakening of coordination. swimming technique and the feeling of water. Swimming speed rapidly increased again, however, after suspending strength training, when most athletes surpassed their personal records. These athletes whose muscle circumference, maximal strength and performance capacity had enhanced comparatively, showed smaller increase of speed, and they did not surpass their personal records. Masters of Sports had their strength training suspended 17 days before competition while their performance capacity on the ergometer was tested on the next day after competition. Fig. 6 shows the dynamics of maximal strength, performance capacity (on ergometer) and swimming speed (in 50 m distance) for two Masters of Sports after six weeks of strength training and three weeks after suspending strength training. The athlete A's muscle circumference, maximal speed and performance capacity significantly enhanced. After he suspended strength training, his swimming speed rapidly increased, and he surpassed his personal records in the distances of 50, 100 and 200 m. The athlete B, however, fell ill at the beginning of the strength training stage, and consequently his maximal strength and performance capacity enhanced less and three weeks after suspending strength training decreased to the former level. The athlete B's results in competition were below his personal record.

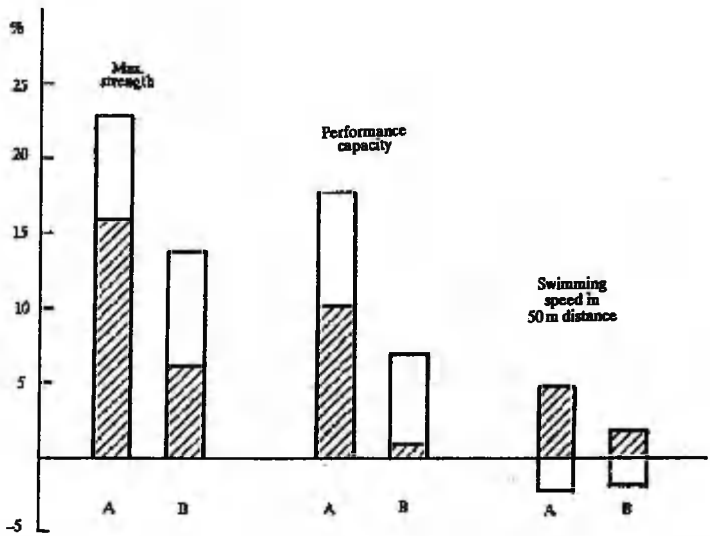

Fig. 6. Changes in maximal strength, performance capacity and swimming speed for the Masters of Sports A and B.
Open bars — changes after six weeks of strength training
Striped bars — changes in 3 weeks after suspending strength training

Three weeks after suspending strength training and notwithstanding very high swimming load (II sessions per week), the muscle circumference, maximal strength and performance capacity fell significantly while swimming speed enhanced (Fig. 6).

Athletes of lower qualifications did not take part in competition. After six weeks of sustained strength training, the athletes continued strength training once a week and had swimming training three times a week. In the first week after warm-up, the athletes used mainly anaerobic lactate loads: 3 x (4 x 50 m) in maximal speed, where the interval between sets was 3, 2, 1 min long, and the interval between series was 10 min long. In the second week they used mainly aerobic load: 3 x 800 m, with a pause of 3–5 minutes. In the third week mainly anaerobic non-lactate load was used: 3 x (4 x 15 m) in maximal speed, with the interval between sets of 2–3 min, and 10 min between series.

At the beginning of each consecutive week, the athletes' performance capacity during the 45 s test on ergometer and the swimming speed in the 50 m distance were tested. After the anaerobic lactate training on all occasions both the performance capacity and the swimming speed enhanced and surpassed the initial (before the strength training period) level. After a week of aerobic training, the results in both tests did not change significantly, while in the third week, after sessions in a highly intensive anaerobic non-lactate regime both test results rapidly increased and in most cases reached the personal record level. Muscle circumference and strength did not change significantly in the course of three weeks.

Conclusions

1. The highest increase in power and performance capacity is achieved through a combined strength training method using submaximal weights which facilitate muscular hypertrophy, and using medium weights and performing exercises with maximal power which increases performance capacity through mechanisms of nervous coordination.

2. Strength training may have positive as well as negative effect on swimmers. The positive effect in the enhancement of muscle circumference, power and performance capacity, while the negative effect is a weakening of coordination, technique and the feeling of water.

3. Strength training must be sufficiently long and a effective in order that the muscle circumference, power and performance capacity could increase significantly. Otherwise the negative effect of strength training on swimming speed can be more expressed than the positive one.

4. Strength training must be suspended not earlier than 5–8 days before competition. If suspended earlier, the muscle circumference and performance capacity would decrease significantly.

5. After suspending strength training, swimming loads must be increased in an anaerobic, non-lactate regime which, in comparison with other training regimes, produces the greatest increase in performance capacity and swimming speed.

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ANTHROPOMETRIC DETERMINATION OF NUTRITIONAL STATUS OF PRIMARY SCHOOL CHILDREN IN NIGERIA

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Abstract

This study was designed to evaluate the nutritional status of primary school children on class and sex basis. One hundred and twenty-six (126) children attending different primary schools in Ojo Local Government area of Lagos State were randomly selected for this study.

The following anthropometric variables were quantified: height in cm; weight in kg; chest and head circumferences in cm.

Expected weight for height was computed for all the subjects. The degree of wasting was determined as the actual weight of the children expressed as a percentage of the expected weight for height. The nutritional status of the children was determined according to McLaren and Read's standard. Chest-head ratio and Ehrenberg's formular were also applied in the determination of nutritional status. Descriptive statistics were employed in the treatment of data.

The study revealed that moderate and severe protein-energy malnutrition (PEM) were most prevalent in the junior primary classes and marasmus is most common among female children. Obesity was most prevalent in the upper primary classes, especially in male children. It was concluded that Nigerian children were not adequately fed.

Anthropometric indices of weight, height, body circumference, body girth and skinfold are accepted signposts of nutritional status of children [3, 4, 6, 9, 10, 11, 13]. Dugdale and Lovell [2] used anthropometric indices of height and weight for quantifying children's obesity and proposed body mass index as a useful tool in the assessment of nutritional status of children; the index is independent of age and sex. Expected weight for age has been frequently used in the assessment of nutritional status of children [3, 4]. The use of weight for age in evaluation of nutritional status was reported as concealing two different nutritional conditions: stunting and wasting [13]. The use of weight for age in nutritional surveys is also limited in the third world countries where records of age are hardly or inadequately kept. The expected weight for height which is independent of age, sex and race [3, 7] has been suggested for community nutritional surveys. Ehrenberg's lawlike relationship [5, 6, 13] between weight and height which is also independent of age, sex and race, has also been suggested as a measure of nutritional status in children.

The primary objective of this study was to evaluate the nutritional status of primary school children on class and sex basis.

Methods and Procedure

Subjects: One hundred and twenty six (65 females and 61 males) public primary school children in Ojo town, Ojo Local Government area, Lagos, were randomly sampled for this study. These children were regarded as urban non-privilege because they were drawn from free public primary schools.

Anthropometric measures: The following anthropometric variables were quantified: height in cm; weight in kg; chest and head circumferences in cm.

Standing height was quantified in cm as described and recommended by Nelson [8] on a stadiometer. The subject stood erect, heels, buttocks, upper part of the back and occiput against the vertical upright of the stadiometer. Arms were freely by the sides. The external auditory meatus and the lower border of the orbit were in a plane parallel to the floor.

Nude weight was quantified in kg on a Soehnle spring scale with provision for recalibration. Subjects were asked to stand erect properly on the scale with body weight evenly distributed between the two heels.

Chest circumference was measured in cm in mid-respiration using a new cloth tape. The site of measurement was at the substernal notch in a plane at right angle to the vertebral column. Chest measurement was taken thrice and the mean computed.

Computation and Classification

Expected weight for height was computed from Weech's [15] equation using the actual height of individual subjects. The degree of wasting was determined as the actual weight of the child expressed as a percentage of the expected weight for height. McLaren and Read's

[7] standard was used in classifying subjects into one of the following classes:

(i)	Above 110%	:	Obesity
(ii)	90–110%	:	Normal
(iii)	85–90%	:	Underweight or mild protein energy malnutrition (PEM)
(iv)	75–85%	:	Moderate PEM
(v)	Below 75%	:	Severe PEM

Clinical observations were also carried out. Subjects with actual body weight below 75% of the expected weight for height and without oedema were classified as marasmus while those with oedema were classified as kwashiorkor.

Chest-head ratio was also computed for the subjects. A chest-head ratio of less than 1 has been suggested as a positive anthropometric sign of malnutrition in children [10].

Using Ehrenberg's lawlike relationship between height and weight, Kpedekpo [5] and Lovell [6] observed that the degree of deviation of a constant, C, from 0.4 was possibly related to nutritional status. Ehrenberg's lawlike relationship [6] states that:

C = $\sum$ (log $\bar{w}$ – 0.8$\bar{h}$/n where;
$\bar{w}$ is the mean weight in kg;
$\bar{h}$ is the mean height in m.

Analysis – Descriptive statistics and percentages were employed in the treatment of data.

Results and Discussions

Table 1 shows the means for height, weight, chest and head circumferences of the subjects on sex and class bases. The female samples had a mean height of 131.7cm ±12; mean weight of 25.21kg ±7.57, mean chest circumference of 60.85 ±6.02; and a mean head circumference of 52.48cm ±1.96. The male samples had means of 130.64cm ±12.39; 25.25kg ±7.14; 62.33cm ±5.65 and 53.03cm ±1.82 for height, weight, chest circumference and head circumference respectively.

Table 2 shows the means for expected weight for height, percent expected weight, chest-head ratio and Ehrenberg's constant, C, on class and sex bases. The female samples had means of 29.3kg ±5.78; 85.45 ±3.9; 1.16 ±0.07 and 0.33 ±0.02 for expected weight for height, percent expected weight, chest-head ratio and C respectively. The male samples had a mean of 28.8kg ±5.71 for expected weight for height and means of 87.42 ± 4.69; 1.18 ±0.07 and 0.34 ±0.02 for percent expected weight, chest-head ratio and C respectively.

Table 1

Means of actual Height, Weight, Chest and Head Circumferences

	FEMALE					MALE				
Class	n	Ht., cm	Wt., kg	Chest C, cm	Head C, cm	n	Ht., cm	Wt., kg	Chest C, cm	Head C, cm
Pry. 1	10	118.47± 5.07	18.75±2.77	56.35±2.0	51.18±1.57	11	113.87± 4.26	16.75±2.55	55.53±3.1	51.35±1.24
Pry. 2	10	121.16± 6.47	19.05±2.67	57.17±2.07	51.34±1.09	10	124.34± 5.14	21.35±2.24	59.63±2.3	52.76±1.73
Pry. 3	14	127.8 ± 7.12	23.4 ±3.77	59.88±3.82	52.76±1.96	10	127.58± 7.44	23.0 ±5.07	60.88±4.83	51.94±1.77
Pry. 4	10	137.65±11.04	28.05±7.83	58.36±6.05	52.96±1.44	10	136.05± 7.3	27.5 ±4.64	64.69±2.9	54.24±1.23
Pry. 5	11	139.65± 9.58	28.41±5.5	64.0 ±4.36	52.45±2.26	10	138.26± 7.84	29.25±3.87	64.79±3.89	53.43±1.02
Pry. 6	10	146.26± 6.4	34.35±8.24	69.4 ±5.61	54.08±1.96	10	145.39± 8.36	34.5 ±6.04	69.14±4.38	54.61±1.53
Sum	65	131.7 ±12.43	25.21±7.57	60.85±6.02	52.48±1.96	61	130.64±12.39	25.25±7.14	62.33±5.65	53.03±1.82

Table 2

Means of Expected Weight for Height, % Expected Weight, Chest; Head Ratio and Ehrenbergs's C

Class	FEMALE					MALE				
	n	Expect. Wt. for Ht., Kg	% Expect. Wt.	Chest-Head ratio	c	n	Expect. Wt. for Ht., Kg	% Expect. Wt.	Chest-Head ratio	c
Pry 1	10	22.55±2.18	82.95± 7.38	1.1 ±0.04	0.32±0.04	11	20.66±1.69	81.04± 9.94	1.08±0.06	0.31±0.05
Pry 2	10	22.77±2.96	80.14± 4.14	1.11±0.04	0.31±0.02	10	25.16±2.39	85.08± 6.99	1.13±0.03	0.33±0.04
Pry 3	14	26.89±3.4	86.04± 9.09	1.14±0.07	0.34±0.04	10	26.79±3.66	85.3 ± 9.4	1.17±0.09	0.33±0.04
Pry 4	10	32.26±6.5	86.02± 7.89	1.1 ±0.09	0.33±0.04	10	31.16±3.98	87.95± 6.01	1.19±0.05	0.35±0.03
Pry 5	11	33.29±5.44	85.7 ±13.76	1.22±0.05	0.33±0.07	10	32.41±4.33	90.9 ±11.13	1.21±0.07	0.36±0.05
Pry 6	10	37.06±3.9	91.84±14.67	1.28±0.07	0.36±0.07	10	36.62±5.1	94.26±11.77	1.27±0.08	0.37±0.05
Sum	65	29.3 ±5.78	85.45± 3.9	1.16±0.07	0.33±0.02	61	28.8 ±5.71	87.42± 4.69	1.18±0.07	0.34±0.02

Presented in Table 3 is the nutritional status of subjects, in percentages, based on McLaren and Read's [7] standard. 3.08% of the female samples were obesed while 4.92% of male samples were obesed. 23.07% of the female samples and 24.5% of the same samples were within the range for well-fed children. 16.92% of the female samples and 22.95% of the male samples suffer from mild PEM (underweight). 44.26% of the male samples and 44.62% of the female samples suffer from moderate PEM. Oedema was not present in any of the subjects. Therefore, none of the subjects suffer from kwashiorkor. However, 12.31% of the female samples and 3.28% of the male samples suffer from marasmus – severe PEM.

Of the total sample, only 3 female subjects (4.62%) and 2 male subjects (3.28%) had a chest-head ratio of less than 1. Of the total subjects, only 6 females and 7 males (10.32%) had C value of 0.4 and above.

The result of this study revealed that moderate and severe PEM were most prevalent in the junior primary classes (primaries 1–4) and marasmus is more common among female than male children (Tables 2 and 3). This result is supported by the previous findings of Gomez [3], Waterlow [13], Lovell [6], Shakir [10] and Kpedekpo [5]. Obesity was most prevalent in the upper primary classes (primaries 5 and 6) and most common among male children (Table 3). These findings can be attributed to nutritional and weaning practices common in most Nigerian communities. It is the erroneous belief of most Nigerian illiterate adults that food items such as meat, eggs and milk are required only by the adults. The consumption of meat and meat products by children, the adults belief, could inadvertently result in extravagance and stealing. The prevalence of marasmus among females could be due to the preference shown for male children by Nigerian parents. This could probably result in more food attention, especially protein food items, for the male child. The food attention factor could also account for the high incidence of obesity in male children in upper primary classes. Also, the practice of weaning children on carbohydrate diets may have contributed to the findings of this study.

The improvement in the protein energy status of upper primary school children could be attributed to the provision of mid-day meals in schools. This could also be due to the fact that upper primary school children could, to some extent, be responsible for what they eat outside their family homes. The result of this study further revealed that inadequate food intake, especially protein energy intake, may be the most limiting growth factor in these age groups.

Shakir *et al.* [10] observed that a chest-head ratio of less than 1 was a reliable test for malnutrition in infants. In this study, the mean chest-head ratios of 1.16 ±0.07 and 1.18 ±0.07 were obtained for female and male subjects respectively. These findings contradict the

Table 3

Nutritional Status of Subjects in Percentages based on McLaren and Read Standard (1972)

Class	Sex	n	Above 110%	90–110%	85–90%	75–85%	Below 75%
Pry 1	F	10	–	20%	20%	40%	20%
	M	11	–	9.09%	–	81.82%	9.09%
Pry 2	F	10	–	–	28%	70%	10%
	M	10	–	30%	20%	50%	–
Pry 3	F	14	–	35.71%	21.43%	35.71%	7.14%
	M	10	–	20%	20%	50%	10%
Pry 4	F	10	–	30%	–	70%	–
	M	10	–	30%	30%	40%	–
Pry 5	F	11	9.09%	–	27.27%	45.45%	18.18%
	M	10	10%	40%	20%	30%	–
Pry 6	F	10	10%	50%	10%	10%	–
	M	10	20%	20%	50%	10%	–
Sum	F	65	3.08%	23.07%	16.92%	44.62%	12.31%
	M	61	4.92%	24.59%	22.95%	44.26%	3.28%

report of Shakir et. al. [10]. This contradiction could be attributed to differences in population. While the chest-head ratio may be a reliable test of infantile malnutrition, the use of this ratio in the assessment of nutritional status of primary school children is not supported by this study. The use of Ehrenberg's lawlike relationship between weight and height as an index of nutritional status is justified by this study. From the result of this study, when the value of Ehrenberg's constant, C, is below 0.35 malnutrition is suggested while a C value of above 0.44 suggests obesity.

From the findings of this study, it can be reasonably concluded that urban non-privilege primary school children in Nigeria are not adequately fed. The incidence of malnutrition is greater in female than male children probably because of preferential treatment of the male child by the parents, especially in polygamous homes.

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THE RELATIONSHIP BETWEEN CALF AND THIGH GIRTHS AND LEG MECHANICAL POWER IN PRIMARY SCHOOL CHILDREN

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Abstract

The study was primarily designed to examine the relationship between calf and thigh girths and leg mechanical power in children.

Twenty-seven boys and twenty girls from the population of primary fourth grade pupils in two of the public primary schools in the Military Cantorment, Ojo, were randomly selected and studied.

Age was recorded to the nearest birthday. A spring scale was used in measuring nude body weight which was evenly distributed to both legs as in normal standing. The Behnke and Wilmore [3] and Wilmore and Behnke [10] procedures were employed in the quantification of stature, calf and thigh girths. Vertical jump performance was measured using the Mathews [9] procedure. Leg mechanical power was computed from body weight and vertical jump performance using the Baumgartner and Jackson [2] equation.

Descriptive statistics, t-test of significance and the Pearson product-moment correlation were employed in data analysis. The level of significance was 0.05.

The study revealed that the girls were significantly taller and heavier than the boys. This finding was attributed to the early adolescent growth spurt in girls. Nude body weight, sum of calf and thigh girths and stature correlate significantly with leg mechanical power in both sexes. Calf girth only correlates significantly with leg mechanical power in girls. This finding is attributed to differential growth rates in calf muscle among the two sexes.

Introduction

Muscular strength is one of the several performance factors of physical fitness (PF). Strength also contributes to power, another performance factor of PF. Power is the product of force and velocity while strength is the amount of force/tension that a muscle group can exert against a resistance in a maximal effort. This is in contradistinction to muscular endurance.

Strength (dynamic and isometric) is fundamental to all athletic events and is the primary contributor in power events such as the jumps, the throws and the sprints. Isometric strength is sin qua non in posture stabilization, initiating and recovery movements, as well as in ballistic movements and change of directions; and all these skills are evident in athletic performance.

Several factors, physiological and psychological, are known to modify the expression of strength [7]. The length and the cross-sectional area (hyperthrophy) of muscle, together with other bio-mechanical factors, influence the physiological manifestation of strength. Increased muscle hypertrophy has long been associated with increases in muscular strength and power. It is reasonable to expect a positive relationship between muscle size and muscular power. This study was, therefore, designed to study the relationship between thigh and calf girths and leg mechanical power in children.

Method and Procedure

Subject

Twenty-seven boys and twenty girls were randomly selected from the population of Primary fourth grade pupils from two of the Public Primary Schools in the Military Cantonment, Badagry Expressway, Ojo and studied. Random sampling of subjects was decidedly delimited to Primary fourth grade pupils because it was assumed that pupils in this grade would comprehend instructions better than pupils in lower primary grades while pupils in the upper primary grades (5 and 6) were intensively preparing for the promotion and end-of-course examinations.

Age was recorded to the nearest birthday as provided by the subject. This was later cross-checked with the age recorded in the class register. Where there was any discrepancy, the age recorded in the register was accepted as correct.

Nude body weight (NBW) was measured in kg on a portable Soehnle spring scale; body weight was evenly distributed on both legs as in 'normal' standing. This was later converted to pounds.

Stature was measured in inches on a portable stadiometer as described by Wilmore and Behnke [3]; subject stood flat footed with eyes looking straight ahead and with back in touch with the measuring bar.

Calf and thigh girths (circumference, c) were measured in cm.

using a new cloth tape with the subject in the orthograde position. The tape was manipulated to maintain close contact with the skin without compressing underlying soft tissues. Thigh girth (c) measurement was taken just below the gluteal fold while calf girth was taken at the maximal point [3]. Thigh and calf girths were measured with the subject in normal standing position with body weight evenly distributed on both legs without any tension. The mean of bilateral measures was taken as representative.

All anthropometric variables were quantified thrice and the mean computed as the representative value. All measurements were carried out by the author alone.

Performance measure

Vertical jump (VJ) was evaluated in inches using the procedure of Mathews [9]. Two practice sessions of four VJs per session with two minutes rest between the sessions were allowed. Two minutes after the second trial session, VJ was evaluated. Three test jumps were allowed and the mean computed as the value for VJ performance.

Leg mechanical power (LMP) in ft-ibs was computed from the measures of NBW and VJ performance [2]:

$$\text{LMP (ft-ibs)} = \text{VJ (ins)} \times \text{NBW}/12.$$

Analysis

Descriptive statistics, the student's t-test of significance and the Pearson product-moment correlation (r) were employed in the treatment of data. The alpha level was set at 0.05 ($p < 0.05$).

Results

The mean ± SD and the range for the measured and computed variables are shown in Table 1 on sex basis. The correlation coefficients (r) between LMP and measures of body weight, height, calf and thigh girths are shown in Table 2 for male and female subjects.

The study did not reveal any significant differences in age, calf girth, vertical jump performance and LMP among the two sexes. Significant differences in favour of the female were revealed in weight, height and thigh girth.

The two sexes did not vary much in age, calf girth and VJ performance. The mean age for the boys was 10.89 ± 1.34 years while the average age for the girls was 10.9 ± 1.17. However, the female subjects revealed much variation in nude body weight, height, thigh, girth and LMP compared with the males (Table 1).

Table 1

Means, standard deviations and range of anthropometric variables, vertical jump and leg mechanical power on sex basis

	Male (n = 27)		Female (n = 20)	
Variable	x̄	Range	x̄	Range
Age, years	10.89± 1.34	8.0 –14.0	10.9 ± 1.17	9.0 –14.0
Wt., Lbs	55.77± 5.4	46.2 –64.9	62.51±12.06	44.66–99.0
Ht., ins	52.7 ± 1.84	49.0 –58.0	54.65± 3.2	51.0 –63.0
Calf c, cm	25.25± 2.6	21.5 –36.5	26.55± 2.76	22.0 –24.3
Thigh c, cm	36.01± 2.25	32.0 –39.0	39.6 ± 3.16	34.0 –49.0
VJ, ins	11.09± 2.16	6.3 –14.96	11.02± 2.23	6.3 –13.78
LMP, ft-ibs	51.99±12.99	25.99–76.76	57.74±16.25	23.45–95.87

Except for calf girth, other anthropometric variates correlate significantly with leg mechanical power in male subjects. Nude body weight revealed the highest correlation (.7408) while calf girth correlated poorly (.3308) with leg mechanical power.

Table 2

Co-efficients of correlation between leg mechanical power, body weight, calf and thigh girths in primary school children on sex basis

	r	
Leg Mechanical Power vs:	Male	Female
Nude body weight	.7408*	.7121*
Thigh girth	.6569*	.7268*
Height	.5971*	.5081*
Sum of Calf and Thigh girths	.551*	.7635*
Calf girth	.3308	.5935*

* Significant at 0.05

Leg mechanical power in females significantly correlates with all the anthropometric variates that were examined in this study. The highest correlation co-efficient was shown by the sum of calf and thigh girths (.7635), followed by the thigh girth (.7268). Leg mechanical power and height revealed a *r* of .5081 in females.

It is pertinent to emphasize the increase in *r* when leg mechanical power was correlated to the sum of the calf and thigh girths in female subjects. This, however, was not the case with the males.

Discussion

The mean height of 52.7ins ± 1.84 for male subjects is similar to that reported by Johnson [8] for Lagos urban adolescent males of comparable age; however, the male subjects of this study were 7.33lbs lighter than Johnson's [8] male subjects. The female subjects of this study were also of similar height with Johnson's [8] female subjects of comparable age but were 8.99lbs lighter than Johnson's [8] female subjects. The subjects of this study (females and males) were also of comparable heights but lighter than 1964 West Indies primary school children of comparable age [1]. The probable nutritional implication of this finding is that Lagos urban children were better fed in the 1970s than now; and that under-nutrition grossly affects soft muscle and fat tissues rather than skeletal tissue. It can be concluded that the subjects of this study suffered from acute malnutrition.

The result of this study in respect of the significantly higher values for height, weight and thigh girth in the females is in conformity with the data of Johnson [8]. The female subjects also revealed a higher but non-significant value for calf girth. Johnson [8] reported that up to the age of 14 years, girls were on the average taller than boys, while girls aged 10–15 years were on the average heavier than boys. However, these trends are reversed at puberty. Harris [6] observed that bone ossification, dental maturity, as well as physiological and neurological maturity are reached sooner in the female.

VJ performance was similar in both sexes. The mean values for VJ performance were 11.09ins ± 2.16 and 11.02ins ± 2.23 for male and female subjects respectively; however, the females revealed a higher but non-significant LMP than the males. The pertinent reason for this observation is that body weight was used in the computation of LMP. Although the females were significantly heavier than the males, the similarity in VJ performance among the two sexes accounted for the non-significant difference in LMP. The height gain in VJ is due to the strength of leg extensor muscles [4, 5]. The similarity in VJ performance between the two sexes suggests comparable strength of leg extensor muscles. Harris [6] reported differential quantities in muscle distribution in the upper body and the trunk among the sexes while muscle quantity in the leg is similar before puberty. Jenson and Fisher (1972) also reported the same rate of strength increases in boys and girls to about the age of 10. Although not examined in this study, the significantly higher value of thigh girth in the females may be accounted for by subcutaneous fat.

Nude body weight showed the highest significant correlation (.7408) with LMP while the sum of calf and thigh girths revealed the least significant correlation (.551) in the boys.

The relationship between calf girth and LMP in males was not significant. The sum of calf and thigh girths revealed the highest significant correlation (.7635) with LMP in the females while stature showed the least but significant correlation (.5081). Baumgartner and Jackson [2] reported a correlation range of .70 to .90 between body weight and leg power. This is supported by the result of this study.

Granted that other biomechanical and psychological factors that affect the expression of muscle strength are constant for the two sexes, the study revealed that the thigh muscles contribute more to LMP than the calf muscles in both sexes.

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ON THE THRESHOLD VALUE OF THE PHYSIOLOGICAL LOAD OF PHYSICAL EDUCATION COURSES IN COLLEGES AND UNIVERSITIES

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Major achievements have been made in the study of the physiological load in sports by the medical circle all over the world, however the studies on the physiological load in the physical Education Courses in schools are still in their preliminary stage. The theories of values of physiological load have equipped us with methods and theoretical foundations to further carry out the study on Physical Education in schools. In order to improve the scientization of our physical education in schools, esp. colleges and univerisities, further practical studies and discussions about the standard and methods of the threshold values of the physiological load in college physical education are needed.

Object and Metod of Study

Object of Study

In reference to the Provincial Authority's evaluation towards the physical education in colleges and universities, a total number of over 300 colleges and universities and more than 600 students were tested regarding the physiological load of physical education classes.

Method of Study

a) Chinese made Remote Heart Rhythm Sensors Were adopted to record pulse data, the physical load index in the physical education classes.

b) Data were recorded when the testees' pulse was at 120–140/min, over 140/min and below 120/min, (named respectively X, S and SX).

c) The mathematical model of the physiological load was built up

$Dv = TV \cdot k^m$ $D_R = T_R \cdot K^m$

Dv: the increasing speed of Heart Rhythm

Tv: exercising time

D_R: recovering speed of the Heart Rhythm

T_R: time of recovery of Heart Rhythm

K^m: intensity of exercise

m: coefficient of intensity

II. Analysis of the Results

1. Standard judging of the threshold value of the physiological load in the physical education classes

a) According to the statistics of the surveys, the changes of the physiological load of the tested students are in direct proportion to the exercising time and the coefficient of exercising intensity. Meanwhile, the volume of the physiological load is connected to the levels of the specific content of the education. This proves that in the same repeated physical exercise, there are the differences in the exercising volume, length of the breaks, speed and intensity of every exercise. Therefore, the volume of the physiological load is not merely the kind of relation between the volume and intensity; we should also consider some other elements such as the contents of education and exercises.

b) In reality, we found that in 87% of students the physiological load volumes are within the valid range, i.e. pulse volume ranging from 120 to 140 beats per minute. 88% of them were able to keep this state for 2/3 of the whole class periods, and only 8.19% of the tested students went above the valid threshold value, however the differences have no statistical significance.

c) During the survey, all of the tested students felt that the intensity of the P. E. classes is physiologically acceptable. But those boy students who were tested in 1000 metre running and girl students who where tested in 800 metre running, all exceeded the physiological load volume standard, and among students who attended the practising basketball and soccer matches, 63.5% were able to exceed the physiological load of 150/BPM pulse rate, and held on to that state for 1/3 of the whole class time. These figures show that introducing high intensity sporting events to colleges and universities has its special meaning in enhancing the physical condition of the students.

d) The statistics proved: the pulse rate between 125 to 156 BPM, which indicates the physiological load of the college students, is a valid threshold value of their physiological load. And the above mentioned rate must be kept for 2/3 of the whole class time. This volume fits the reality of the physical education in our colleges and universities.

The measurement of the physiological load volume and the choosing of the evaluation method

In the practice of physical education, we need to have a fast as well as an exact method to measure the physiological load volume of the students. Therefore, this thesis also focuses upon the question of choosing the right way of measurement in order to promote the level of scientization of physical education by applying the threshold value of physiological load.

a) Reverse computation of the Pulse Rate Recovery after Classes

We can calculate the pulse rate of the students during and after classes respectively by applying traditional methods of measuring and processing the pulse rate datas. Therefore, using arithmetical knowledge, we will be able to build up the following formula indicating the relations between average pulse rate during the classes and the recovering pulse rate within 3 to 5 minutes after classes:

$y = a + bx$ (y = calculated average pulse rate, "a" and "b" are coefficients, x = recovering pulse rate volume)

b) **Applying the "Vector Model" testing and data processing method**

Design a "Vector Model" by using mathematical theories, using the pulse rate datas taken during and after one class, we can obtain the physiological load volume of the class.

c) Applying Step Regression and Charts

We can build up the following regression model using the average pulse rate volume and the recovering pulse rate volume:

$y = b_o + B_1^1 + B_2^2$

(y = calculated average pulse rate, b = coefficient, x = recovering pulse rate volume)

III. Conclusion

1. According to this Threshold Value theory, also with the reference of the survey results of a certain number of colleges and universities within Liaoning Province, we recommend that the standard volume of the threshold value of the physiological load for our colleges ranges from 125 to 156 BPM, which is also supposed to be kept for 2/3 of the whole class time. Only in this way can we reach the goal of promoting the physical conditions with our physical education method.

2. AS to the theory of threshold value of physiological load, when used in practice, we should always pay attention to all the elements and factors, and also the specific content of our teaching as well as the intensity of the repeated exercises of the same content. In this way, we can correctly apply the theory, which will certainly be a very stable foundation for our sports education practice.

3. The teachers in colleges and universities are strongly recommended to master this theory, esp. the correct method of measurement and evaluation and also all kinds of data processing techniques. This will surely enhance the scientization of our physical education.

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STUDY AND ANALYSIS OF ELECTROENCEPHALOGRAMS OF COLLEGE STUDENTS WHO ARE ON DIFFERENT SPORTS TRAINING LEVELS

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The functional state of the Central Nervous System (CNS) is the essential element which affects the forming and developing of human exhaustion. The function of the nervous system decreases when a human being is physically fatigued. We can clearly see from the researches conducted by numerous medical researchers that it is a rather common method to perform studies and observations from the angle of medical nursing and bedside practice, and on the other hand, to study the electrical waves produced by the cerebral cortex during the process of cerebral exhaustion and the relationship between sports training and the relavant characteristics of the Electroencephalogram (EEG) are seldom applied. We are going to discuss how the sports training level can influence the EEGs of college students on the basis of comparative analysis of their EEG charts.

I. Samples and Methods of the Study

1. Samples

50 college students who previously had a minimum sports training experience of 3 years, among whom 24 are boys and 26 girls; another 30 ordinary college students who had no sports training experience before, among whom 20 are boys and 10 girls, for comparative study.

2. Methods

a) Instrument applied is the Chinese made MD–82B EEG machine;

b) Procedures: sample figures were displayed on the machine before testing, single record was applied, 10/20 System was adopted in the placement of the sensors. Sample students were in a close space, in the sitting position, and the following datas were recorded:

1) EEG datas when testees are quiet;

2) EEG datas when testees are under pressure (with 30" preliminary testing figure), and EEG datas when testees are physically tired; (the first one after);

3) EEG datas when testees are recovering from the state of exhaustion (the third one after).

Under pressure means that the testees' arms were to be burdened with heavy objects (10 kilograms for boys and 5 for girls), with an 85°-angle between the fore-arms and upper-arms (elbows be kept away from all body parts), for 3 minutes each time, until testees can not hold the position any longer.

3. Data Processing.

II. Analysis of the Test Results

1. Comparison when all the testees are quiet

There is no significant differences between the Index a, the amplitudes of the "a" waves of each group of students tested ($T < 1$, $P > 0.05$). Among the indexes and datas of each testing group, 16% of all the testees had shown slight abnormality.

2. Comparisons when all the testees are burdened

The changes in the "δ" waves and "ø" waves are not statistically significant enough to be recorded. The β indexes of both test groups increased, there were no big changes in the index and amplitudes of the δ wave.

3. Comparisons when all the testees are fatigued

Through comparative analysis on the EEG charts of all tested groups, only the increase of ø wave is worth recording.

4. Comparisons when recovering from exhaustion

The groups that had sports training experiences before recovered faster than other groups.

III. Conclusions

1. Through the EEG charts, we can see that 16% of all the testees had shown slight abnormalities which indicated that they are on their edges, and the percentage of the group with previous sports training is higher than that of the group with no sports training history. I think that some students who had sports training experience have shown the early symptoms of over-training, but these features did not gain proper attention.

2. The EEG feature of a human being when he is quiet and calm, has nothing to do with his sports training level, since no significant differences in the indexes and amplitudes of the "δ" waves occured

MODELING AND MOTOR LEARNING
A Mini Review

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Introduction

Modeling is a general process in which observers attempt to reproduce the action demonstrated by another person. Within the realm of sport and physical education, the process of modeling serves its most important function in the demonstration and acquisition of motor skills. However, this critical teaching technique is not well understood owing to the paucity of literature examining the process and product of skill modeling. Perhaps this lack of empirical attention has been due to the complexity of the modeling process. Because motor skill modeling involves both physical and psychological processes, one must integrate information from the literature on motor behavior, social psychology, and biomechanics to understand its effects on skill learning.

1. The functions of modeling

Modeling can be defined as the cognitive, affective, and behavioral changes that result from observing others, while models are individuals whose behaviors, verbalization, and nonverbal expressions are attended to by observers [18]. Traditionally, modeling has served three functions in affecting the behaviors of observers [1, 2, 17]. First, observational learning effects represent the acquisition of new skills and behaviors by the observer. When subjects see repeated demonstrations that draw attention on the salient aspects of a skill, in combination with appropriate and contingent feedback, this leads to positive changes in learning and performing skills [25, 27]. A second function of modeling concerns the response facilitation. An observed model is used to encourage a behavior that may not otherwise have been emitted [14, 27]. The third function of modeling is described as its inhibition/disinhibition effects on behavior. This function focuses on reducing avoidance behaviors through effects of observer's psychological response such as self-confidence, motivation, and anxiety. These psychological effects of modeling have been studied extensively and reported in the clinical, health, and educational psychology literatures [14, 18]. The three functions of modeling account for developmental, learning, and social psychological changes in observers, and thus the topic of modeling extends knowledge from the areas of motor learning and control, motor development, and sport psychology.

2. Theoretical perspectives

Modeling theories provide a valuable resource because they help to explain how individuals perceive visual demonstration as well as which aspects of a demonstration learners focus on and retain. Knowing the how and what of visual perception enables one to develop practice that promotes optimal demonstrations [4, 13].

To date, the majority of investigations exploring modeling have been based on Bandura's [1] social learning theory, which suggests that modeling influences operate primarily through an informative function, whereby observers symbolically code modeled behavior. According to Bandura, people must learn new motor skills either by direct experience or observation. Most human motor behavior falls into the latter category and is learned observationally through modeling. With respect to modeling and motor performance, variables that have been examined testing Bandura's theory included temporal placement of the model [11], optimal number of demonstrations [4], specific model characteristics [9], and informational and motivational elements of the modeling process [9, 14, 15]. Results from these investigations have shown that models can convey pertinent information to the observer that will enhance motor performance.

Observational learning, or modeling, is governed by four component subprocesses: attention, retention, motor reproduction, and motivation. The first two subcomponents comprise the response acquisition phase. This phase involves both the process by which individuals discern the important cues from modeled acts and the manner in which the modeled responses are covertly coded and rehearsed. The motor reproduction and motivation are incorporated into the performance reproduction phase, during which learners use these covertly coded responses to guide overt behavior. The most desirable outcome of these processes would be attending to task relevant cues that are retained in long-term memory and used to guide responses whereby the individual is both physically capable and motivated [3, 13]. These four processes have been corporated in the two-factor theory of imitation developed by Yando et. al. [29]. He emphasized that the emitted response to modeled events will be determined by two factors: the observer's cognitive development level and his or her motivational system.

In 1986, Bandura [2] expanded his understanding of the performance reproduction phase whithin his newly titled social-cognitive theory. He suggested that the behavioral reproduction of the individual involves a comparison of incoming sensory feedback from the overt enactment to the cognitive conception acquired via the model.

Many authors have attempted to provide empirical support for various aspects of Bandura's theoretical approach to modeling [5, 9, 13, 14, 15].

Scully and Newell [19] proposed an interesting alternative to Bandura's social-cognitive oriented theory of modeling. The salient information picked up from modeling, according to these authors, is the observation of the relative kinematic pattern over time. It is thought that if learners can approximate the relative kinematic patterns observed in the demonstration within certain ranges of performance, it might be considered that the skill has been modeled. To examine these relative kinematic patterns it is essential to employ biomechanical techniques that allow for quantitative evaluation of kinematic parameters. Southard and Higgins [20] conducted one of the few studies involving a kinematic analysis of the movement sequence during observational learning. It was found that a demonstration group was no better than a control group at succesfully changing limb configuration or segments velocities. Cristina [3] strongly advocated an interdisciplinary strategy incorporating both ideas and methods from biomechanics and other fields related to cognitive science in studying issues in motor learning, and in observational learning in particular.

3. Developmental aspects of modeling

Observational learning or modeling is a powerful and sometimes unintentional tool for children's motor skill and social psychological development [27, 28]. The power of modeling can be seen in children's exposure to new motor skills, attempts at improving previously learned skills.

Perceiving a visual demonstration will be a different process at each stage of development, and therefore the developmental idiosyncrasies of children need to be considered [21, 23]. Both attention and retention capabilities are significantly different between children and adults. Age related differences in information processing have been supported by empirical studies [8, 22]. In an extensive review of information processing differences between children and adults, Thomas [22] emphasized the need for the use of prompted rehearsal for facilitating children's skill learning. Modeling techniques can be especially facilitative because of the difficulty children have in formulating a visual image based upon verbal description only. Observation of a model allows the child to visually associate the verbal description of a motor task and gain information regarding task relevant cues for successful skill execution [12, 28].

Children are slower at processing information and thus require more time to comprehend visual stimuli. In addition, they are unable to selectively attend to movement characteristics until about 12 years of age [8]. Furthermore, younger children have a limited memory capacity and less sophysticated retention strategies [8, 22]. While older children and adults spontaneously invoke strategies such as verbal rehearsal and labeling to help remember, younger children will only adopt such strategies when promted [27].

Several recent developmental studies have examined the role of verbal rehearsal strategies, particulary as an aid to the retention of important modeled information by children. Weiss [24] examined the effects of age, modeling, and verbal self-instruction on the performance of children. An observed age by model type interaction indicated that older children performed equally well with either a silent or verbal model, whereas younger children performed best with a verbal model. After extending this investigation, Weiss and Klint [26] concluded that verbal rehearsal strategies aid children's ability to attend selectively to relevant task component and to remember a specific execution order of skills. Similar findings were reported in a study by McCullagh, Stiehl and Weiss [16], which addressed the role of visual and verbal models as well as verbal rehearsal in the skill acquisition process of children.

Summary

In summary, contemporary modeling theories emphasized the critical role of cognitive-developmental and perceptual capabilities in the effective reproduction of modeled skills. Attentional capabilities, memory capability, and use of rehearsed strategies must be accounted for in demonstration. Because motor skill modeling involves both physical and psychological processes, one must integrate information from the motor behaviour, social psychology, and biomechanics to understand its effects on motor skill learning.

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EFFECT OF AEROBIC EXERCISES ON BODY COMPOSITION, BLOOD LIPOPROTEINS AND WORKING CAPACITY IN RELATION TO THE INSULIN LEVEL IN BLOOD

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Abstract

The purpose of this experiment was to study the effect of systematic exercise training on physical working capacity, body weight and composition and blood lipoprotein content depending on different initial levels of insulin.

During 8 weeks 121 female university students, aged 18–27, practiced aerobic exercises (aerobic dance or jogging) for three times a week, one session lasting for 50 minutes (HR 140–150 beats/min^{-1}. "Joggers" (n = 46) and "dancers" (n = 75) were divided into groups according to the initial level of insulin: < 10.0 μU/ml; 10.0–20.0 μU/ml; > 20.0 μU/ml. Higher level of insulin was in accordance with bigger body weight. Significant correlations were found between insulin levels before and after training, on the one hand, and body weight, fat % and body fat mass, on the other hand. The reduction of body weight as a result of the training was not found in the subgroup of "joggers" with the initial insulin over 10 μU/ml^{-1} and in the subgroup of "dancers" with insulin over 20 μU/ml^{-1}.

The training-induced reduction in blood insulin level was most pronounced in persons with higher initial insulin levels. Thus exercise training normalizes the level of insulin. High level of insulin (> 20 μU/ml^{-1}) abolished the effect of aerobic dance on the improvement of PWC_{170} and on the levels of lipoproteins. Both in "joggers" and "dancers" it was found that the higher the initial insulin concentration, the lower was the PWC_{170} per kg of body weight before and after training.

Key words: exercise training, body weight, body fat, plasma insulin, blood lipoprotein, working capacity.

Introduction

The increase in energy expenditure associated with aerobic exercise training can produce the mobilization of the energy stored in the adipose tissue, if such an increase is not compensated by enhanced energy intake or by decrease in other components of energy expenditure. Accordingly, when the energy intake of the subjects was not controlled, aerobic exercise training did not give unanimous results in regard to reducing the body fat [1–4]. However, even in cases of controlled diet the training efficiency is variable. Probably there exist a number of conditions modulating the training effect on body mass and the amount of fat tissue. From these conditions attention must be paid to the individual differences in hormone levels. Many studies have demonstrated that obesity as well as the regional distribution of adipose tissue are related to insulin secretion [5–9]. Obesity is associated with insulin hypersecretion, whereas upper body fat accumulation is related to reduced hepatic insulin extraction and diminished insulin clearance [10, 11].

The given experiment was conducted in order to study the effect of systematic exercise training on body weight, working capacity and blood lipoprotein in dependence on different initial levels of insulin.

Material and methods

Subjects. 136 female university students were subjected to full medical examination by a physician. The students with cardiovascular disease, diabetes or other endocrine disorders were excluded. The students did not have plasma glucose values $> 140\ \mathrm{mg} \cdot 100\ \mathrm{ml}^{-1}$. The oral glucose tolerance test indicated normal glucose tolerance according to the classification of the National Diabetes Data Group [12]. The subjects were divided into the control group (15 students) and two training groups. Exercise training consisted in one group in jogging (n = 46) and in the other group in aerobic dancing (n = 75). The body mass and composition of the subjects are presented in Table 1. The age of the subjects varied between 18–27 years. The mean age in the control group was 20.7 ± 0.5 (mean ± S.D.), in the joggers' group 18.6 ± 0.1 and in the dancers' group 20.3 ± 0.2 years. The height of the subjects was 165 ± 2, 167 ± 1 and 165 ± 1 cm respectively. For the analysis of training effects both training groups were further divided by the initial insulin level into subgroups: blood insulin $< 10\ \mu\mathrm{U/ml}^{-1}$; 10–20 $\mu\mathrm{U/ml}^{-1}$; $> 20\ \mu\mathrm{U/ml}^{-1}$.

Training. Training sessions consisted of aerobic exercises (aerobic dancing or jogging) for 50 minutes at the heart rate of 140–

Table 1

Effects of an 8-week exercise training program on body mass and body composition

		"Dancers" n = 75	"Joggers" n = 46	Control group n = 15
Body weight (kg)	before	73.90 ± 1.21	68.50 ± 1.04	74.00 ± 2.29
	after	72.40 ± 1.19	66.90 ± 1.08	72.50 ± 2.20
	change	–1.50 ± 1.70	–1.59 ± 1.50	–1.57 ± 3.17
Body fat (%)	before	31.62 ± 0.51	29.77 ± 0.54	32.59 ± 0.97
	after	29.04 ± 0.47	27.14 ± 0.58	30.60 ± 1.09
	change	–2.58 ± 0.69*	–2.64 ± 0.79*	–1.99 ± 1.46
Body fat (kg)	before	23.77 ± 0.75	20.55 ± 0.62	24.42 ± 1.53
	after	21.40 ± 0.69	18.25 ± 0.64	22.46 ± 1.51
	change	–2.37 ± 0.99*	–2.20 ± 0.89*	–1.96 ± 2.15
Lean body mass (kg)	before	50.15 ± 0.55	47.93 ± 0.58	49.61 ± 0.85
	after	51.01 ± 0.56	48.54 ± 0.59	50.00 ± 0.89
	change	0.86 ± 0.78	0.61 ± 0.83	0.39 ± 1.22

Values are means ± S.E.M.
Asterisks denote statistically significant change ($p < 0.05$).

150 beats/min^{-1}. Exercises were performed three times a week for 8 weeks. During the jogging session the total distance covered was 6.5 to 7.5 km. The sessions of aerobic dancing were organized by the program proposed by Matov et al. [13]. The energy expenditure during both sessions was computed by tables [14] and was approximately 400 kcal. The subjects kept a diary where they recorded the consumed food for the calculation of energy intake. The subjects also recorded other muscular activities in addition to the training sessions. The ratio between the total energy expenditure and energy intake was close to 1.0 in the control group (1.02 ± 0.03) and in the dancers' group (0.98 ± 0.01). In the joggers' group the ratio was a little bit lower (0.94 ± 0.01). In dancers who were divided by the insulin level into three groups, the ratio remained the same (0.97 ± 0.02; 0.98 ± 0.01 and 0.98 ± 0.01 to the respective insulin levels of < 10.0 μU/ml^{-1}, 10–20 μU/ml^{-1} and > 20.0 μU/ml^{-1}). In the "joggers" with the insulin level < 10.0 μU/ml^{-1} the ratio was 0.92 ± 0.01, while in the "joggers" with the insulin level of 10–20 μU/ml^{-1} the ratio was 0.98 ± 0.01.

Measurement of total body fat and physical working capacity. Body fat percent was computed by Pařizkova [15]. Physical working capacity was assessed by the test PWC_{170}. The test was performed on a bicycle ergometer according to Karpman [16].

Blood analysis. Venous blood samples were taken before and after the training period (8 weeks) in the morning between 8 and

9 a.m. following 12 hours of fasting. The blood sampling was adjusted to days 8–14 of the ovarial-menstrual cycle. Insulin levels were determined radioimmunologically [17]. The total cholesterol concentration was determined by the Lieberman-Burchard reaction, high density lipoprotein-cholesterol (HDL–C) by heparin-$MnCl_2$ precipitation procedure [18]. Low density lipoprotein-cholesterol (LDL–C) was calculated by the Friedewald equation [19]. Triglycerides (TG) were measured using Lachema kits (ČSFR).

Statistical analyses. Pre-exercise and post-exercise values were compared using the t-test for paired observations. Correlation analyses were performed using the Pearson interclass coefficient [20].

Results

Effect of training on the body mass and composition. The studied 8 weeks period resulted in a reduction of body weight in 90% of "joggers", 77.5% of "dancers" and 73% of control persons (Fig. 1). The correlation analysis showed before the training period that the body weight, fat % and body fat mass were significantly related to the initial level of insulin in blood (Table 2). After the training period, the body weight, fat % and body fat mass correlated significantly to insulin levels both before and after the training period. Changes in fat % and body fat mass were in negative correlation with the changes in insulin concentration. Under the influence of training the body fat mass and fat % were reduced significantly only in the subgroups of initial insulin level $< 10\ \mu U/ml^{-1}$. In addition to this, the fat % decreased in "dancers" subgroup of initial insulin level 10–20 $\mu U/ml^{-1}$ (Fig. 2).

Effect of training on the insulin level in the blood. There were significant correlations between insulin levels before and after the training period in both groups. Thus, the training did not change the interindividual relations in insulin levels. The change in insulin level was more pronounced in persons with higher initial levels (Table 2). Accordingly, training did not cause a significant decrease in the blood insulin level if the initial values were $< 10\ \mu U/ml^{-1}$. If the initial level of insulin was higher, a significant decrease was found both in "joggers" and "dancers" (Fig. 3).

Effect of training on the working capacity. Training induced significant increases in PWC_{170} values in all subgroups except the "dancers" with the initial level of insulin $> 20\ \mu U/ml^{-1}$ (Fig. 4). The same result was obtained in PWC_{170} values per 1 kg of body weight. The lack of improvement in physical working capacity in "dancers" with a high initial insulin level was due to the existence of a person who responded to the training by an increase in insulin concentration and by a decrease in physical working capacity.

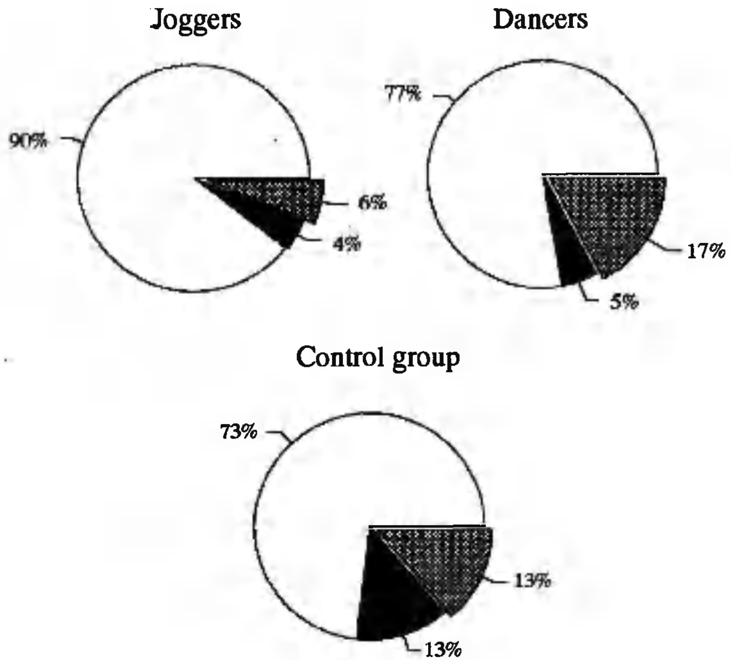

Fig. 1. Frequency of various changes of body weight in various groups. White sector — % of persons exhibiting a decrease of body weight, striated sector — % of persons exhibiting an increase of body weight, black sector — % of persons with stable body weight.

By the results of the correlation analysis, mutual relations between insulin levels and working capacity were established when insulin levels were plotted against PWC_{170} per kg of body weight. The higher the blood insulin concentration before training, the lower was the PWC_{170} per kg of body weight both before and after training. A negative correlation was found between changes in insulin and physical working capacity in "dancers". In "joggers" the change in insulin concentration correlated significantly with the change in PWC_{170} per kg of body weight (Table 2).

Effect of training on the lipoprotein content in the blood. A general result of training was the reduction in the total cholesterol and LDL-cholesterol concentrations. The exception was the subgroup of "dancers" with the initial insulin level $> 20\ \mu U/ml^{-1}$. In this subgroup no change in the blood lipoprotein content was found (Fig. 5). HDL-cholesterol level rose significantly only in "dancers" with the initial level of insulin $< 10\ \mu U/ml^{-1}$. HDL/total cholesterol increased

Table 2

Statistically significant correlations of insulin levels with recorded indices of body composition and physical working capacity

		"Joggers" (n = 46)			"Dancers" (n = 75)		
		Insulin before	Insulin after	Insulin change	Insulin before	Insulin after	Insulin change
Body weight	before	0.63	0.39	0.33	0.39	0.51	N.S.
	after	0.61	0.36	0.34	0.41	0.52	N.S.
	change	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Body fat %	before	0.52	0.49	N.S.	0.33	0.52	–0.26
	after	0.60	0.31	0.37	0.47	0.53	N.S.
	change	N.S.	0.32	–0.46	N.S.	N.S.	–0.23
Mass of body fat	before	0.65	0.49	0.28	0.36	0.53	N.S.
	after	0.67	0.36	0.40	0.45	0.54	N.S.
	change	N.S.	0.36	–0.40	N.S.	N.S.	–0.25
PWC_{170}	before	–0.39	N.S.	–0.51	N.S.	0.30	–0.27
	after	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
	change	–0.31	N.S.	–0.39	N.S.	0.35	–0.35
PWC_{170} per kg b.w.	before	–0.36	–0.49	–0.33	–0.23	N.S.	N.S.
	after	–0.30	N.S.	N.S.	–0.24	–0.27	N.S.
	change	–0.41	–0.30	N.S.	N.S.	0.38	–0.31
Insulin	before	–	0.45	0.07	–	0.31	0.48
	after	0.45	–	–0.36	0.31	–	–0.68
	change	0.67	–0.36	–	0.48	–0.08	–

only in "dancers" if the initial level of insulin was > 20 $\mu U/ml^{-1}$. The blood triglyceride content declined significantly in "joggers" with the initial insulin level 10–20 $\mu U/ml^{-1}$ and in dancers with insulin level < 10 $\mu U/ml^{-1}$. No significant correlation was found between insulin and lipoprotein levels.

Control group. During the studied 8-week period no significant changes were recorded in body fat %, blood insulin level, or the blood lipoprotein content (levels of total cholesterol, HDL-cholesterol, LDL-cholesterol, HDL/total cholesterol). A significant decrease was found in the blood triglyceride content (–0.27 ± 0.10 $mmol/L^{-1}$).

Discussion

In agreement with the significance in insulin hyperproduction in obesity development [10, 11, 21] the obtained results indicated at an overall correlation between body weight and basal insulin level in the blood. Before the training period the insulin concentration in the

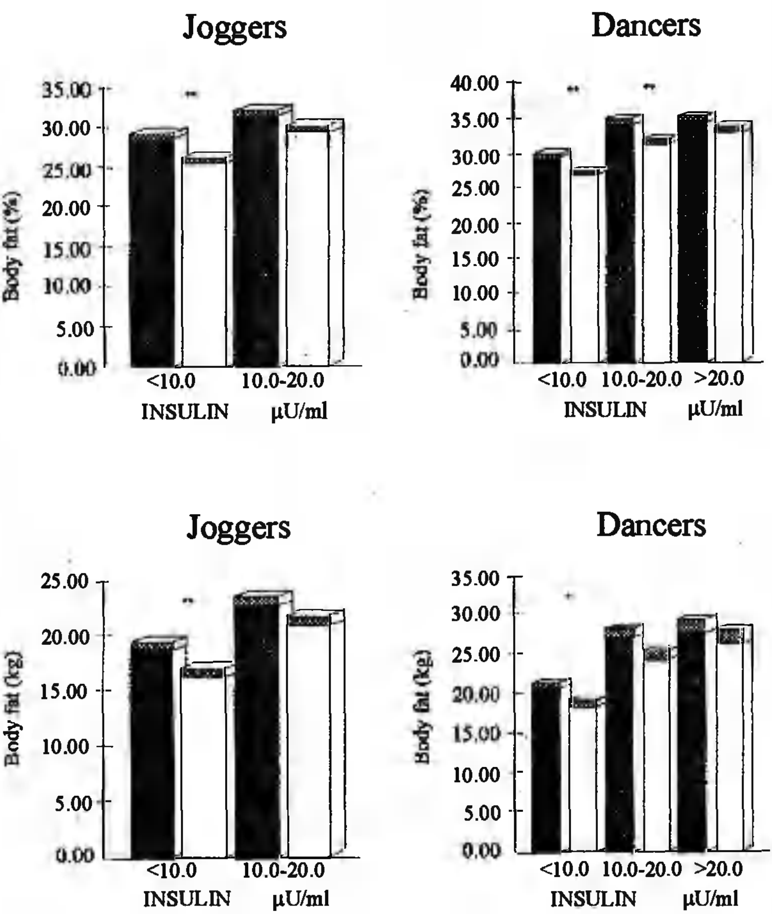

Fig. 2. Alterations of body fat % (upper part) and body fat mass (lower part) in two experimental groups in dependence of the initial insulin level in blood. Striated columns indicate mean values before and white columns after the experimental period. The dotted part of columns represents SEM. The asterisks indicate the statistically significant differences between values before and after the experimental period: * $p < 0.05$, ** $p < 0.01$.

blood correlated also with the physical working capacity of persons, estimated by PWC_{170}. Previously the blood insulin level was found to be in correlation with maximal oxygen uptake as well as with body weight [22]. The obtained results confirmed the aerobic training effect on the basal insulin level [23–26]. This training effect was found in result of endurance running as well as of aerobic dancing. However,

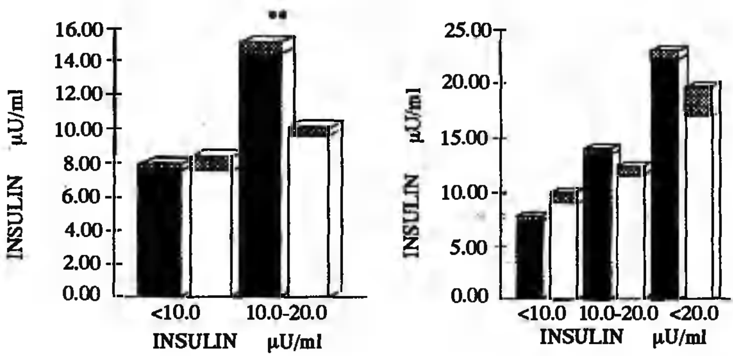

Fig. 3. Alterations in blood insulin concentration in two experimental groups in dependence of the initial insulin level in the blood. For further explanation see Fig. 2. SEM is indicated by cross-striated part of column.

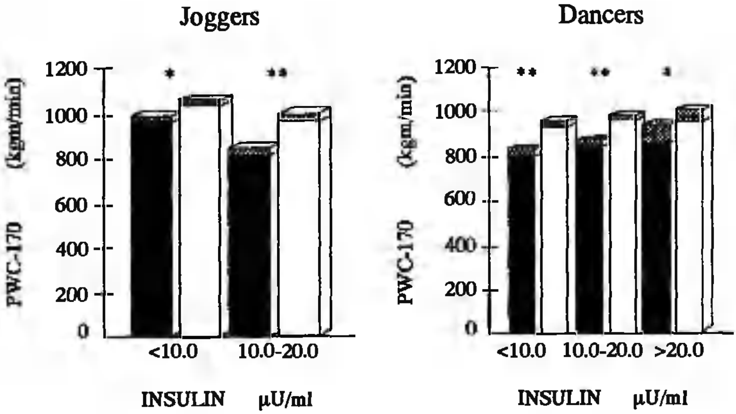

Fig. 4. Alterations in PWC_{170} in two experimental groups in dependence of the initial insulin level in the blood. For further explanation see Fig. 2. SEM is indicated by cross-striated part of columns.

the training effect was more pronounced in persons with higher initial level. The change was not common in persons with the initial level $< 10\ \mu U/ml^{-1}$. Therefore the results suggest that the endurance training effect on the blood insulin level is, first of all, a normalizing one.

The aerobic training effect on physical working capacity occurred to be in relation with the initial insulin concentration in the blood. This

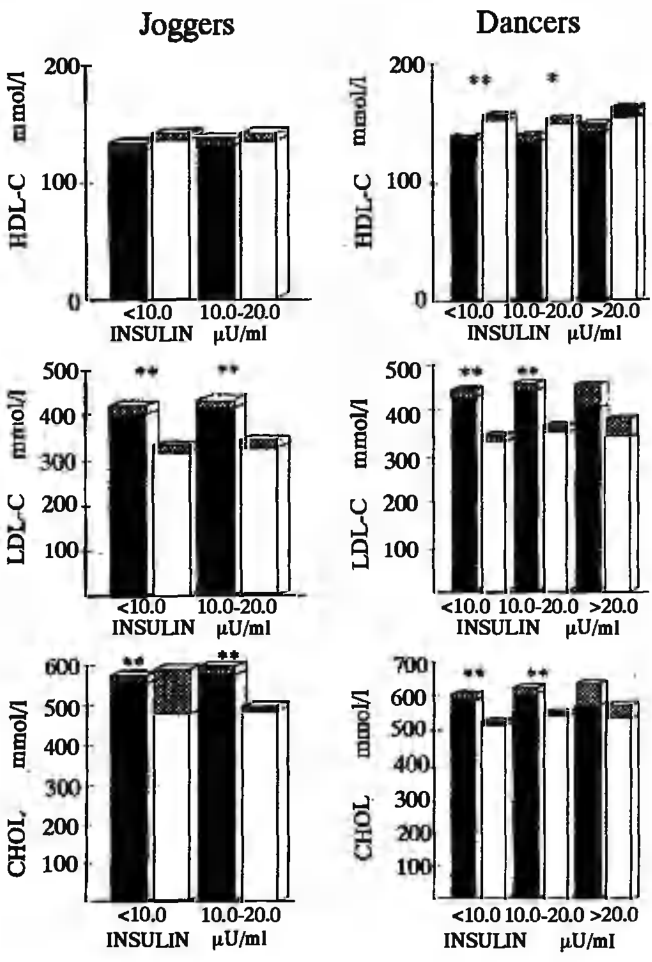

Fig. 5. Alterations in blood lipoprotein contents in two experimental groups in dependence on the initial insulin level in the blood. For further explanation see Fig. 2. SEM is indicated by cross-striated part of columns.

was indicated by two results. (1) In a subgroup of persons possessing an initial insulin level over 20 μU/ml^{-1}, the training effect was not found. (2) The higher the blood insulin concentration in blood before the training, the lower was the PWC_{170} per kg b.w. not only before but also after training. These results suggest that in persons with elevated insulin level training has to reduce the insulin concentration in the blood to obtain training effect on the physical training capacity. Negative correlations were found between changes in insulin concentration and PWC_{170}. Concequently less pronounced decrease in insulin concentration associated with smaller improvements in physical working capacity.

Less striking were the relations between insulin levels and training effect on body weight and fat mass. Nevertheless, significant correlations were found between insulin levels before and after training, on the one hand, and body weight, fat per cent, and body fat mass after training, on the other hand. A distribution of persons to subgroups by the initial insulin level indicated that training did not induce reductions in fat mass and fat percentage in "joggers" with the initial insulin concentration over 10 $\mu U/ml^{-1}$ and in "dancers" with the initial concentration over 20 $\mu U/ml^{-1}$.

A common effect of aerobic training is the so called antisclerotic change in the blood lipoprotein content [27–30]. The obtained results confirm the earlier data [31] that both forms of aerobic training — running and aerobic dancing — induce corresponding changes. However no significant changes in blood lipoprotein contents were found in "dancers" with the initial level over 20 $\mu U/ml^{-1}$. Thus the high insulin level may aggravate also the training effect on lipoprotein contents.

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THE KINEMATICS OF RUNNING AND OVERHAND THROWING IN 8-YEAR-OLD CHILDREN

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Introduction

In studying the movement of a human, it is appropriate to observe and analyze the changing shape of the body and the force used to propel the body. In kinematics, the concentration is on the geometry of motion through distance and time measures of the changing shape of the body, without reference to the forces producing it. Kinematic studies have produced information about displacement and velocity of the body during movement [2, 5].

Developmental aspects and gender differences of fundamental movement patterns are usually examined on the basis of movement kinematics [1, 2, 6, 8, 11, 12]. The developmental patterns of running and overhand throwing have certain differences. The kinematics of running resembles the adult running pattern already by the age of 5...6 years [3, 4]. Results have revealed that gender differences in running kinematics were associated with the movement of the swing leg [5]. Only few studies [2, 5, 8] have reported developmental aspects of the running pattern in young children.

Gender differences in the kinematics of overhand throwing appeared already in early preschool years and these differences increased with the age [6, 9, 11]. These differences have been reported to be both qualitative and quantitative in nature. Halverson et al. [6] reported that boys not only participated in more organized throwing activities than girls, but they also remebered practicing overarm throwing more frequently than girls. However, the differences in throwing performance appear to be too great and seem to occur at too early an age to be completely attributable to the environmental variables [13]. The performance of throwing tasks tended to be stable across the longitudinal perspective. This stability reflects a greater genetic influence on performance [1].

The purpose of the present study was to investigate selected kinematic variables in running at maximal speed and overhand throwing of 8-year-old children.

Methods

The subjects were 60 healthy local elementary-school children, of which 33 were boys and 27 girls. All children were 8-year-old at the time of measurement. Both the children and their parents were informed about the nature of this study, and parental written consent was obtained.

Testing procedures. The local school stadium was used for recording the kinematic characteristics of running and overhand throwing. Two testing sessions were required to complete testing of the given subjects in running and overhand throwing. In the first session the kinematics of running at maximal speed was recorded. During data recording each child was first videotaped while standing on the running course holding a meter stick which served as a linear scale. In order to help to locate joint centers in later analysis, joint markings were placed on the joint centers of the limbs. Three trials of each child were recorded with the help of a "Panasonic" videocamera which was placed during the taping to the left of the child. The camera objective was placed perpendicular with the running course. The distance between the camera and the child was 20 meters. In the second session the kinematics of overhand throwing was recorded. The videotaping conditions were the same as in the first session. Each child performed 3 trials with a tennis ball (weight 150 g). The task of the child was to throw as far as possible. Data analysis was carried out with the help of Human Movement Kinematic Analysis computer programme "KINEX". Two-dimensional videotape analysis was employed to obtain the kinematic characteristics. The videotape data were processed by computer programme which provided frame-by-frame stick figure computer graphics. The 40 msec frame-by-frame interval was used in data analysis. The videotape data were analyzed using the equipment located in the Kinesiology Laboratory, Tallinn Pedagogical University.

All the recorded characteristics were expressed as means and standard deviations. T-test was used for establishment of gender differences.

Results

The mean height and weight of boys and girls are presented in Table 1. There were significant differences between boys and girls in respect to body weight. Table 2 outlines the kinematic parameters of running. There were no significant differences regarding the step length, duration of support and flight phases and loss of horizontal velocity during support phase. However, boys surpass girls significantly in running speed. The kinematic parameters of overarm throwing are presented in Table 3. There were significant differences in favour of boys in all recorded parameters.

Table 1

Anthropometric parameters

Parameter	Boys		Girls	
	M	SD	M	SD
Height (cm)	135.1	6.2	134.1.	7.3
Weight (kg)	31.5	4.3	28.7	3.4*

* p < 0.05

Table 2

Kinematic parameters of running

Parameter	Boys		Girls	
	M	SD	M	SD
Running speed (m/s)	5.3	0.5	5.0	0.8*
Step length (cm)	138.9	14.4	134.9	12.5
Support phase time (s)	0.154	0.2	0.148	0.5
Flight phase time (s)	0.120	1.4	0.116	2.2
Loss of horizontal speed (m/s)	-0.63	0.1	-0.63	0.08

* p < 0.05

Table 3

Kinematic parameters of overhand throwing

Parameter	Boys		Girls	
	M	SD	M	SD
Throwing result (m)	23.3	6.2	17.5	4.4*
Horizontal ball velocity (m/s)	16.3	2.4	13.3	2.6*
Angle of ball release (degrees)	28.2	3.7	24.9	5.2*
Throwing time (s)	1.32	0.1	1.21	0.4*
Swing phase time (s)	0.92	0.8	0.73	0.3*
Throwing phase time (s)	0.38	0.2	0.48	0.1*

* p < 0.05

Discussion

The results of this study provide evidence for gender differences in the overhand throwing kinematics in prepubertal children. Regarding the running kinematic pattern, no gender differences were found. As in many previous studies, the significant advantage of boys in overhand throwing kinematics [6, 7, 9, 10] was confirmed.

The literature on motor development implies that children have mastered the fundamental movement pattern by the age of five or six years [3, 4]. When examining the maximal speed running kinematic parameters both in 8-year-old boys and girls, it become evident that the general characteristics of running do not differ. No support to this finding has been found in previous studies [2, 8] because boys and girls have been studied separately. Only Fortney [5] has examined the gender differences in maximal speed running kinematics in 2 to 6-year-old children and the results have revealed that there were gender differences in parameters associated with the movement of the swing leg. The results of the given study do not support these findings because the movement of different body segments was not studied. The greater running speed of boys in the present study is in agreement with earlier researchers, who suggest that boys tend to run about one-third foot per second to one foot per second [15] faster than do same-age girls. Regarding the kinematics of overhand throwing, it become evident that clear gender differences appeared between 8-year-old boys and girls. These results support the findings of earlier studies [6, 10, 14] where the gender differences in overhand throwing were found. The throwing distance and horizontal ball velocity are two more frequently studied kinematic parameters of overhand throwing. The present investigation revealed that boys surpass girls in horizontal ball velocity by 3 m/s. These data supported other studies [6, 12] in which sex differences in ball velocities were examined. The throwing distance differences found in the present study are closely related with the horizontal ball velocity differences and with other kinematic parameters. One common explanation for developmental differences between sexes is that girls do not have the same amount of experience in overarm throwing as boys [12]. However, Nelson et al. [9] reported that although the biological factors are not the major contributors of gender differences in throwing, these factors have a certain influence to the throwing performance.

In summary, our results indicate gender differences in kinematic characteristics of overhand throwing. In these characteristics 8-year-old boys surpass significantly the same-aged girls. In running kinematics gender differences were not found. Future research is needed to examine which factors contribute to sex differences in fundamental movement kinematics of elementary school children.

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RESTORATION OF NORMAL FUNCTIONAL ACTIVITIES AFTER EXERCISE

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The aim of the brief review is to indicate the factors influencing or controlling the transition from the exercise level of functional activities to the resting level. Various phenomena of the postexercise recovery are discussed and plotted against the activities of the regulatory mechanism and intrinsic pecularities within the system.

Introduction

Exercise performance is followed by a recovery period. This is the time when the following tasks have to be accomplished: (1) transition from the exercise level of functional activities to the resting level, (2) normalization of homeostatic equilibriums, (3) replenishment of energy resources together with a temporary supercompensation for them, (4) reconstructive alterations, particularly in regard to cellular structures and enzyme systems. An integral of all recovery processes is the restoration of the initial level of working capacity of the organism.

The first two tasks are actualized within minutes or in particular cases, within hours. The corresponding processes constitute the stage of rapid recovery. The actualization of other tasks consumes more time and thereby the stage of delayed recovery follows. However, the term "delayed" does not mean that the onset of replenishment of energy stores or of the reconstructive alterations is necessarily delayed. The realization of these tasks is delayed.

This review has been composed in order to discuss the phenomenology of the postexercise restoration of functional activities. In part the abolishment of oxygen debt was considered the main reason for maintaining functional activities over the resting level during a certain time after exercise [54]. However, the recovery phenomena cannot be completely explained solely by the "postexercise consumption of extra oxygen". Therefore various influences and control mechanisms have to contribute to the functional changes in the stage of rapid recovery.

Cessation of muscular contractions at the end of exercise or various kinds of physical work cause a change in regulatory influences: the regulatory actions of central command and proprioceptive impulses drop out. As a result, rapid changes occur in the functions of organs responsible for oxygen transport, despite the persisting high demand for oxygen supply of skeletal muscles only just having acted. These transitory changes are opposite to the initial adjustments at the beginning of exercise in the direction of change, but similar to the general pattern: first there is a rapid and then a gradual decrement of functional activity. While the rapid changes within the first 1–2 minutes express the cessation of the actions of central command and proprioceptive influences, the second gradual and often undulated decrease may be explained by the reduction of influences from metaboreceptors and of hormonal influences. Differently from the initial adjustments, exercise intensity is a factor that retards the rate of postexercise changes. After highly intensive exercise during the first 5–10 s the heart rate may not change and then the following decrease is not characterized by so steep a slope as after less intensive exercise [45, 90, 112]. A possibility of a regulatory inertia seems to exist as well: the duration of exercise may be overriden by the persisting excitement of the cardiac center, stimulating the sino-atrial node through sympathetic discharge. A further increase in the heart rate was noticed during the first 5–8 s in 65% of persons after 15-s cycling at maximal possible rates [45].

After weight-lifting exercise the duration of cardiac cycle further diminished within 3–7 s. The obtained levels were after clean and jerk 145 ± 3 and after two-hand snatch 134 ± 2 beats per min. A pronounced increase in the duration of the cardiac cycle, a respective decrease of the heart rate, began in the second half of the first min after putting the bar on the floor [99]. The duration of the weight-lifting exercise (4–7 s) was too short for pronounced hormonal changes. Only to a modest extent the muscle metaboreceptors might influence the heart rate just after the end of exercise. It is more likely that there exists a prevalent influence from respiration during weight-lifting and after putting the bar on the floor as well as from changes in venous return, related to corresponding pecularities in respiratory movements. A possibility of a regulatory inertia seems to exist as well: the duration of exercise may be overriden by the persisting excitement of the cardiac center, stimulating the sino-atrial node through sympathetic discharge.

The postexercise dynamics of heart activity are characterized by enhanced respiratory arrhythmia as well as by pronounced waves in the duration of the cardiac cycle corresponding to the third waves in blood pressure (Fig. 1). This picture is revealed in association with a steep slope of the heart rate decrement and mainly in well-trained persons [45]. An increased rate of recovery of heart frequency was found in trained persons also after exercise with increasing intensity up to the individual maximum [27]. It is likely that the steep slope of the heart rate expresses not only the decrement of metabolic influence but also a strong parasympathetic influence. Mostly in well-trained persons after the exercise the heart rate decreases from 20–40 s to values below the initial [45, 64, 94]. This can be considered an expression of "hypothalamic tuning" of automatic nervous influences. By Gellhorn [41], autonomic imbalance due to the prevalence of sympathetic or parasympathetic actions causes increased sensitivity to change in the opposite direction. The previous prevalence of sympathetic influence during exercise sensitizes the parasympathetic effects. As a result the heart rate decreases below the initial values. However, this change does not appear after very strenuous exercise. Instead of that after strenuous exercises and in most cases in untrained persons the heart rate may stabilize to a level of 5–20 beats per min higher than the initial [45, 64, 94].

After a 5-min exercise the heart rate decreased exponentially to the initial level during the first postexercise minute despite the maximal noradrenaline level in the blood at the same time. Therefore it was suggested that the rapid heart rate recovery after exercises is related to the increased vagal tone rather than to the decrease in the activity of the sympatho-adrenal system [82].

Summing up, the following variants of heart rate postexercise dynamics were found (Fig. 2): (1) undulated process — a rapid decrease to values below the initial followed by normalization to the initial level, (2) aperiodic process with restitution of the normal heart rate within 1–2 min, (3) aperiodic process with stabilization of the heart rate on a level above the initial, (4) torpid process without any stabilization during the first 5 min (heart rate remains elevated for 20–30 min) [94].

By using various methods it was found that a rapid decrease of cardiac output and stroke volume occurs within the first 1–2 postexercise minutes. Then a less abrupt decrease follows [23, 24, 29, 74].

The transition from exercise to rest is connected with a short-term drop in the intra-arterial pressure, often to values below the initial [32, 38, 55]. Already after 5–10 s a new increase in blood pressure takes place. The latter lasts approximately 20–40 s [55]. After that a gradual decrease in arterial pressure follows. The same dynamics were established in the mean arterial pressure using a non-invasive method for its continuous recording [31]. A secondary increase in stroke volume was found during 1–2 min after exercise. During this time period the peripheral resistance remained low and only later it increased gradually [29].

By using special equipment, the ausculatory recordings of blood

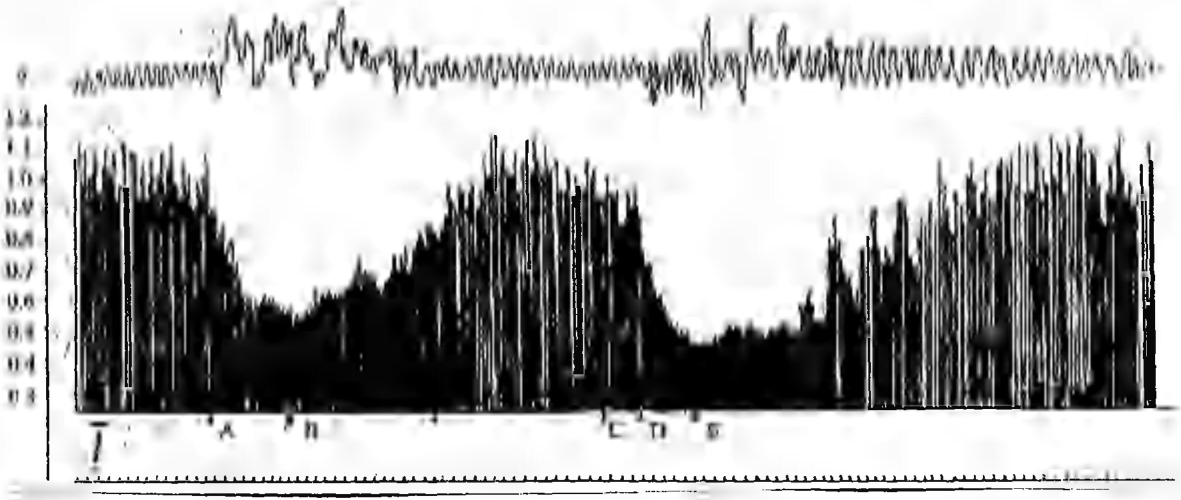

Fig. 1. Dynamics of duration of cardiac cycle during and after exercises. From the top: pneumogram, height of each vertical line corresponds to the duration of cardiac cycle (the data is indicated on the ordinate in seconds), time of experiments by 5 s; A — the onset of cycling on ergometer at the rate of 90 rpm, B — the end of exercise, C — pre-cycling command, D — the onset of cycling on ergometer at the highest possible rate, E — the end of exercise. The figure was obtained from the author's archive.

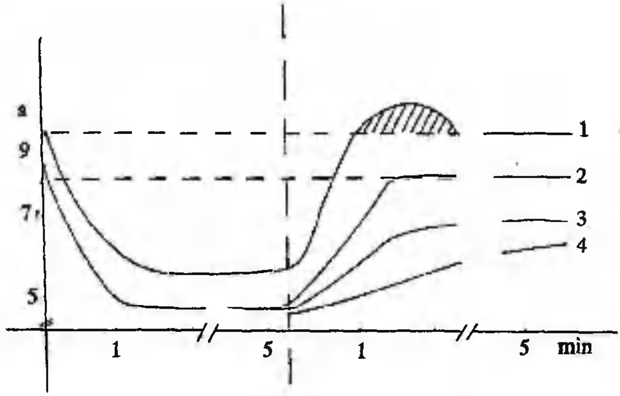

Fig. 2. Four variants of heart rate postexercise dynamics [94]: 1 — undulated process, 2 — aperiodic process with restitution of the normal heart rate within 1–2 min, 3 — aperiodic process with stabilization of the heart rate on a level above the initial, 4 — torpid process without any stabilization during the first 5 min.

pressure were obtained over every 8–12 s. A comparison of the pattern of ausculatory blood pressure during and after various exercises showed that after exercise maximal arterial pressure rises to levels higher than those recorded during exercise when the exercise duration was 30–60 s and therefore insufficient for blood pressure to increase to the adequate level (Fig. 3). After cessation of exercises lasting for 3–5 min, maximal arterial pressure decreases without any secondary rise [103]. When the person was in a standing position, the blood pressure drop was common immediately after the end of 1-min cyclic exercise. The following rise in maximal pressure as well as the decrease in the heart rate were less pronounced than in the sitting position (Fig. 4). When the blood flow to legs was prevented by a bandage on the thighs, there was no immediate decrease in blood pressure and the postexercise increase was the same as in the sitting position [104]. Thus the immediate postexercise drop in arterial pressure is related to the aggravated venous return due to the cessation of the muscle pump function. Already in the 1930s it was demonstrated that a circulatory collapse called "gravity shock" revealed during prolonged standing after intensive exercises. The phenomenon can be avoided by a pressure bandage on the thighs [79].

Differently from this mechanism a late mild hypotension may follow within a period from 0.5 to 3 hrs after the end of exercise. It seems not to be due to an acute impairment of baroreflex function [14, 26, 91]. Prostaglandins produced by skeletal muscles and kidney as a result of exercise may contribute to prolonged postexercise vasodilation [77].

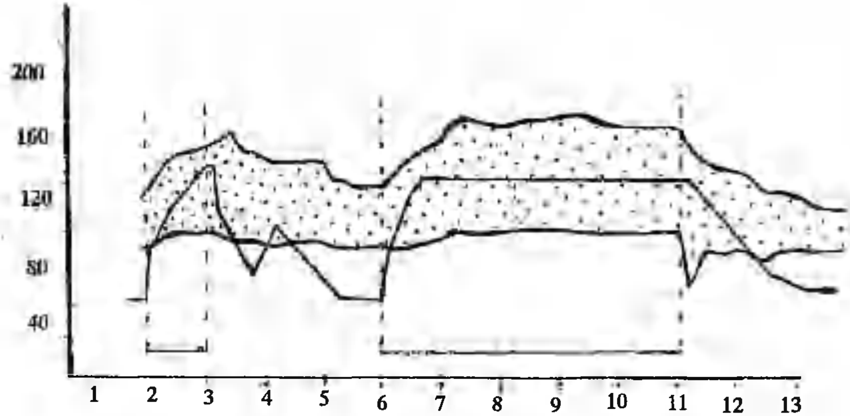

Fig. 3. Dynamics of heart rate (solid line) and arterial ausculatory pressure (maximal pressure — the upper broadline of the dotted area, minimal pressure — the lower broadline of the area). The onset and end of exercise are indicated by interrupted vertical lines. On the ordinate heart rate (beats per min) and arterial pressure (mm Hg). The time is indicated by min. On the left 1-min and right 5-min exercises performed at the same intensity [103].

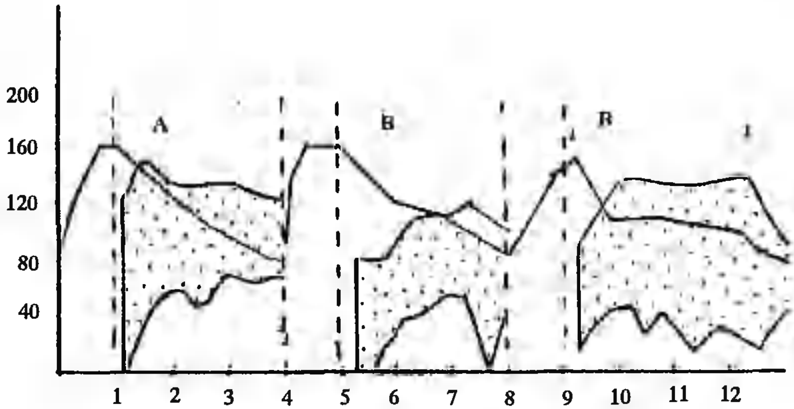

Fig. 4. Dynamics of heart rate and arterial auscultatory pressure during and after three 1-min cycling exercises performed at the same intensity [104]. On the left — person in sitting position after exercise, in the middle — person in standing position after exercise, on the right — person in standing position but immediately after the exercise a pressure bandage on the thighs. The rise of pressure in the bandage up to 200 mmHg is indicated by the first arrow and the release of thighs from bandage by the second arrow. Other explanations see on Fig. 3.

The transition of lung ventilation and oxygen uptake from exercise level to resting level is usually described by a simple exponent: during the first 1–2 min the changes are faster than later on [48]. Immediately after the end of a 5-min cycling at moderate intensity the respiratory frequency and depth decreased in association with a reduced electrical activity of intercostal muscles [57].

The exponential curve may not be revealed after short-term highly intensive exercise or after static efforts. After cycling exercises performed at the highest possible oxygen demand, the amount of oxygen corresponding to the lactate component constituted 37%, 49% and 44%, the oxygen consumed during exercise 3%, 11% and 26% of the total oxygen demand respective to exercise duration of 10 s, 15–20 s, and 30–45 s [58].

The alactatic component of oxygen debt is considered to correspond to the amount of O_2 necessary for refilling the body's oxygen stores and for restoration of normal levels of ATP and phosphocreatine. Resaturation of blood hemoglobin amounts to about 0.2 l O_2 after submaximal and 0.3 l O_2 after supramaximal exercises [5]. For resaturation of muscle myoglobin additional 0.1 and 0.2 l O_2 are necessary after submaximal and supramaximal exercises respectively. Thus the total contribution from O_2 store replenishment is 0.3 l after submaximal and 0.5 l after supramaximal exercises [10]. Data were presented indicating that phosphocreatine and ATP concentration decreases by 1.0 and 12.0 $\text{mmol} \cdot \text{ng}^{-1}$ in both the submaximal and supramaximal exercise [68]. The latter corresponds to an O_2 cost of 0.6 l. Consequently, the alactic O_2 debt has to be approximately 0.9–1.1 l O_2. A three times higher value of alactatic O_2 debt was calculated for highly qualified sportsmen by a steeper slope of V_{O_2} after a supramaximal exercise [105].

There is no exact evidence that the replenishment of phosphocreatine store occurs during the time of repayment of the fast component of oxygen debt. A study of the rat leg muscle by phosphorus nuclear magnetic resonance demonstrated that phosphocreatine concentration rises to the initial level at the end of the recovery period in accordance with the normalization of V_{O_2} by muscle tissue [73].

Evidence was also provided demonstrating a dissociation between the kinetics of lactate removal and the slow component of the postexercise oxygen uptake [21].

Neither the total oxygen debt nor the 'lactic debt' give exact measures of the amount of energy released in anaerobic processes [12, 46, 109]. The main arguments are: (1) increased body temperature alters the intensity of metabolism, (2) intensive function of myocardium and respiratory muscles continuing after exercise, need additional energy, (3) altered muscle tone may cause changes in oxygen uptake, (4) changes in blood level of adrenaline, thyroxine and some other hormones may alter the intensity of oxygen uptake and the ratio between oxidative phosphorylation and free oxidation, including free radical oxidation.

Elevated temperature has been suggested to decrease phosphorylative coupling efficiency in mitochondria [16]. As a consequence, more O_2 would be required for a given amount of ATP to be synthesized. The temperature effect is calculated to amount to 1.2 l of oxygen during the first hour of recovery after submaximal and 0.6 l supramaximal exercises when the exercise was performed in comfortable temperature [5, 6, 53].

Intensive function of the myocardium and respiratory muscles continuing after exercise need additional energy. It was calculated that the O_2 cost of moving an additional blood volume through the circulation is about 1.3 l after submaximal and 0.7 l for the first hour after supramaximal exercise. The ventilatory cost constitutes 0.1 l O_2 [5, 6, 53].

Noradrenaline infusion induced small changes in $\dot{V}_{O_2}$ during electrically induced concentrations of the denervated canine gastrocnemius-plantaris muscle group *in situ*, but the arteriovenous O_2 content difference increased significantly. During post-contraction recovery, $\dot{V}_{O_2}$ was increased by 40% by noradrenaline infusion. The ratio of net recovery $\dot{V}_{O_2}$ to the $\dot{V}_{O_2}$ during contraction period was significantly elevated by noradrenaline [42]. Accordingly the blockade of adrenergic influences by administration of propranol reduces the rate of O_2 uptake during exercise and particularly during the post-exercise recovery period [12, 21, 22]. Catecholamines, thyroxine and glucocorticoids can contribute to the increase in the Na^+–K^+ pump activity. These factors undoubtedly interact to affect the excess post-exercise oxygen consumption.

Lactate dynamics and pH values in postexercise recovery

Postexercise lactate values are widely used for evaluation of the participation of anaerobic glycolysis in the energy attaining of strenuous exercises. However, during exercise lactate accumulates because the increase in the lactate disappearance rate lags behind the increase in the lactate appearance rate [17]. Therefore the amount of resynthesis of ATP at the expense of anaerobic glycolysis will be underestimated if the calculations are based on the lactate accumulation in the blood or in the postexercise oxidation of lactate ("lactate debt"). One must take into consideration also the various pathways of the fate of pyruvate formed during exercise: besides the oxidation of pyruvate and the transformation to lactate, one part is used for alanine synthesis. Pyruvate determination does not help because the measured pyruvate gives only its residual amount in a moment of time. Nevertheless, these sources of errors will not make the use of lactate levels and lactate debt meaningless in evaluating the anaerobic energy production, because in supramaximal exercise the largest part of pyruvate is transferred to lactate and lactate production greatly exceeds its elimination. Only the quantitative estimation of the energy released in anaerobic glycolysis may be not exact.

After exercise a part of both the formed pyruvate and lactate is used for glycogen resynthesis in exercised muscles. After supramaximal exercises causing blood lactate levels of 10–16 mmol $\cdot$ l^{-1} and muscle lactate content of 25 mmol $\cdot$ kg^{-1} the proportion of lactate used for the resynthesis of glycogen has been estimated at 75% [52], 50% [4], and 13–27% [11].

The rate of lactate removal during recovery is directly related to the lactate concentration at the end of exercise [62]. Using a knee-extensor exercise model inducing exhaustion within 2–4 min, it was found that at the end of exercise, femoral vein plasma concentration of lactate is only half of that accumulated in the muscle (the muscle-blood gradient was 18 mmol $\cdot$ l^{-1}), but 3 min into recovery, the difference was reduced to 5 mmol $\cdot$ l^{-1}, and it was nil after 10 min of recovery. During 1 h of recovery as much as 82% of the lactate left the muscle as lactate via the blood stream [11].

After a 4-min exhaustive exercise the lactate release from working muscle gradually decreased. This process continued for at least 8–15 min [63]. After 3-min exhaustive cycling, blood lactate increased during the first 10 min while a pronounced drop occurred in the muscle lactate concentration. Thereafter lactate decreased also in the blood. In the period of 80 to 60 min after exercise the lactate concentrations in muscles will approximately equal [28].

In the blood the postexercise lactate curves could be fitted to a bi-exponential time function, consisting of a rapidly increasing and a slowly decreasing component [34, 40]. A comparison of lactate pattern after 3-min and 60-min exercises showed that with exercise duration the values of velocity constants of lactate increase and decrease were reduced [36]. In exercise intensities over the anaerobic threshold, the blood lactate concentration increased with the prolongation of exercise duration from 3 to 6 min, but the constants of kinetics for both postexercise increase and decrease of lactate concentration decreased [37]. The postexercise lactate kinetics is determined by the ability of tissues to utilize lactate as well as by factors limiting this process [35].

During the first 5 min of recovery after cycling with increasing intensity, the pyruvate concentration progressively increased in the blood. The lactate/pyruvate ratio decreased [107]. It has to be established if the decreased lactate/pyruvate ratio is a general phenomenon appearing immediately after the cessation of muscle contraction, and if it indicates a relative decrease in the pyruvate conversion by the corresponding metabolic pathways.

As a result of intensive anaerobic glycogenolysis an accumulation of hydrogen ions appears in the muscles [50, 87, 88] and in the blood [50, 67, 77]. The changes in pH values after exercise are parallel to the changes in lactate concentrations [67, 87, 88]. An intensive anaerobic exercise of 4 min duration resulted in a decrease of the thigh muscle pH from 7.15 ± 0.01 to 6.57 ± 0.04 and of the blood from 7.39 ± 0.04 to 7.04 ±0.03. During the first 5 min of recovery the decrease continued and then the pH values began to increase [3]. After another 4-min exhaustive exercise the low pH persisted for 4 min in arterial blood and then began to increase. In venous blood a graudal increase began from the first postexercise minute. Both values returned to a level close to the initial within 20 min [50]. Cycling at high intensity (mean heart rate 192) until exhaustion resulted in a pronounced drop of pH values in the *m. quadriceps* (total muscle pH from 7.08 ± 0.03 to 6.64 ± 0.12), intracellular pH (from 7.00 ± 0.06 to 6.45 ± 0.09), femoral venous blood (from 7.08 ± 0.06 to 6.93 ± 0.06) and arterial blood (from 7.27 to 7.14). Muscle lactate increased up to 22.0 ± 2.6 mmol/kg (intracellular lactate to 29.1 ± 3.4) and femoral venous blood lactate up to 17.5 ± 5 mmol/l. 20 min after exercise the muscle lactate remained elevated but both total muscle and intracellular pH were normal. The pH value of femoral venous blood normalized within 20 min. 30 min after exercise, significantly elevated pH values were found in comparison with the pre-exercise values. At the same time the blood lactate was insignificantly lower than the initial level [88].

In most cases lactate concentrations normalize within 30–60 min after intensive exercises [50, 67, 88].

Moderate exercise performed during recovery caused a faster elimination of lactate from the muscle [13, 15, 51]. First it was supposed to be related to enhanced perfusion [51]. However, the stimulation of the oxidation rate contra its decline may have significance as well. Anyway, mild exercise following a strenuous one enhanced lactate oxidation [47]. There is previous evidence that activity increases lactate removal also from the blood [60, 81]. Lactate disappearance after exercise at $\dot{V}_{O_2}$max level was intensified by exercise at 40% $\dot{V}_{O_2}$max but not by exercise at 65% $\dot{V}_{O_2}$max [110]. However, other studies indicated that recovery exercise at 65% $\dot{V}_{O_2}$max [51] or at 60% $\dot{V}_{O_2}$max [43] is optimal for speeding up lactate removal. After a 10-min exercise at 90% $\dot{V}_{O_2}$ max, active rest slightly below the anaerobic threshold improves the lactate removal rate compared to complete rest or active rest above the anaerobic threshold [80].

A number of studies on blood levels of hormone during the first 10–20 min of postexercise recovery revealed the continuation of exercise-induced change before the opposite change occurs. Thus the endocrine response to exercise may be more prolonged than the exercise itself (Fig. 5A). In other cases opposite changes were found to begin just after the end of exercise (Fig. 5B). These opposite changes do not mean a fast normalization of hormone levels in the blood. Quite often they reach concentrations significantly differing from the initial values. Thus the exercise-induced rise or drop may by changed by a decrease or an increase, respectively. The new hormone level may now persist for a long time. There are cases of a secondary rise in the hormonal level after a certain time of rest. Of course, there are also cases of gradual normalization of the hormone level to the normal concentration. The hormone changes in the recovery period express, obviously, not only the inertia of regulation in regard to exercise-induced changes, and the following normalization of the endocrine function. The regulation of metabolic processes during the recovery period may require specific changes in hormone levels.

During the first minute after the end of 5-min cycling exercises the noradrenaline concentration rose a little. During the following 10 min the hormone concentration decreased rapidly. Two months of training accelerated, but the following two months of detraining decelerated the restitution rate of the noradrenaline level. Increase in the power output during exercise from 1480 kpm $\cdot$ min^{-1} to 1920 kpm $\cdot$ min^{-1} slowed down the disappearance of noradrenaline from circulation [44]. A rapid decline in the adrenaline concentration after short-term exercises has been found by other investigators [61].

After prolonged exercise, high levels of catecholamines may persist for many hours or even for days. Both adrenaline and noradrenaline concentrations were increased for 2 hrs after 80-min exercise at 75% of V_{O_2} max [9]. After a marathon race the elevated level of adrenaline persisted for at least 24 hrs [78]. 24 hrs after the 24-h endurance run or triathlon competition the blood levels of free an sulpated catecholamines were elevated [86]. During a 6-day cross-country skiing as well as in the evening, the blood levels of catecholamines were elevated, but catecholamine response to the ergometer test, performed immediately after skiing, was normal. Eleven days after the hike the noradrenaline concentration was above the initial level by 25% [106].

After short-term exercises the increase in the blood cortisol concentration continues within the first 5–30 min [2, 3, 39]. This may be due to the inertia of the activation mechanism or of the secretory response of the adrenal cortex. The latter possibility was revealed

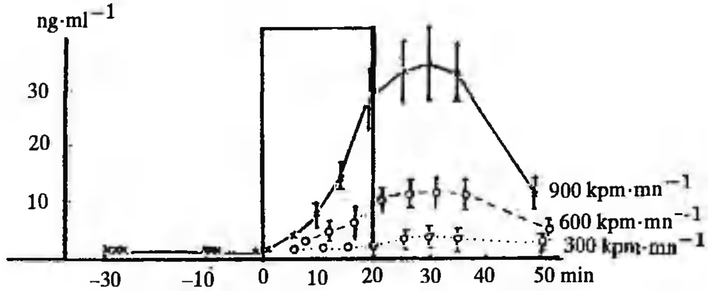

Fig. 5A Dynamics of somatotropin concentration in the blood after 20-min exercises of various intensities [93].

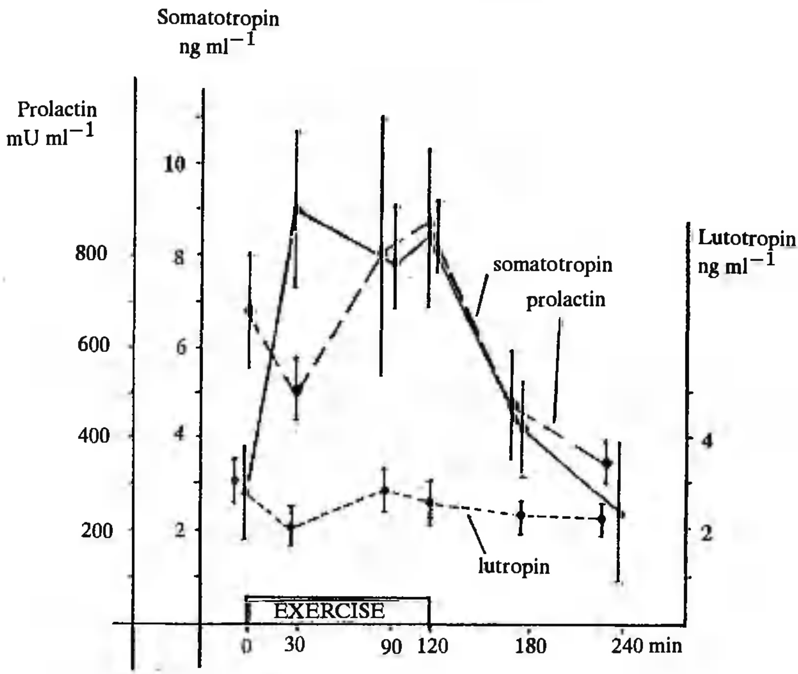

Fig. 5B Dynamics of somatotropin (solid line), prolactin (interrupted line), and lutropin (interrupted short lines) during and after 2-hour cycling exercise on ergometer [101].

in a study demonstrating the highest corticotropin level immediately after, but the highest cortisol level 15 min after 1-min cycling at 120% $\dot{V}_{O_2}$max [19]. The elevated blood cortisol after exercise has been shown to be related to the decreased rate of hormone elimination from blood plasma as well [33]. After a 30-min exhaustive exercise the blood cortisol level rose during the first 30 to 60 min, and then declined. The resting level was obtained within 90 to 120 min [92]. After 80-min exercise at 70% $\dot{V}_{O_2}$max a transient increase in the plasma cortisol concentration lasted for one hour after exercise [76]. A heavy anaerobic exercise (running 3 × 300 m) was followed by a high level of cortisol in the blood that persisted for 3 hrs. Then a drop in the cortisol concentration followed. 6 hrs after the end of exercise it was substantially below the initial level [72].

A decrease in the glucocorticoid level following the preceding postexercise increase was confirmed in a number of studies. For example 3–6 hrs after 13–14 km run a low cortisol level was observed [2]. After 2-h exercise at 60% $\dot{V}_{O_2}$max a decreased activity of the pituitary-adrenocortical system was established by levels of both corticotropin and cortisol below the initial within 6–24 postexercise hours. There were no systematical differences between data obtained from untrained persons and from well-trained sportsmen in endurance events [102]. Low levels of cortisol were found 24 hrs after marathon race [78], and running for 100 km [66]. 1, 2 and 4 days after running for 34 km, blood cortisol was insignificantly and, 8 days later, significantly below the initial values [30].

In rats the corticosterone content in the blood plasma and in the adrenals remained augmented during 5 days following the 30-min swimming (Fig. 6). The peak values were observed after 2 days in the adrenals and after 5 days in the plasma. One day later, repetition of the same exercise did not elicit any response. After 2 days the response was inversed. Following 3 to 5 days after the first exercise the response to the new exercise was exaggerated [100]. Is the latter a reflection of supercompensation for biosynthetic activity in the cells of the fascicular zone of the adrenal cortex? Anyway, an elevated content of ascorbic acid in the adrenal tissue was found several days after exercise [84].

Exercise is followed by a rapid increase in the blood level of insulin [20, 83, 85] (Fig. 7). This change is so rapid that any measurement of insulin concentration, not carried out while the subject is still exercising, may be misleading in regard to the detection of an insulin drop during exercise [83]. The concomitant increase in the C-peptide level in the blood indicates that insulin secretion increases just after the end of exercise [111].

After a 100 km run the insulin level in the blood was still increased

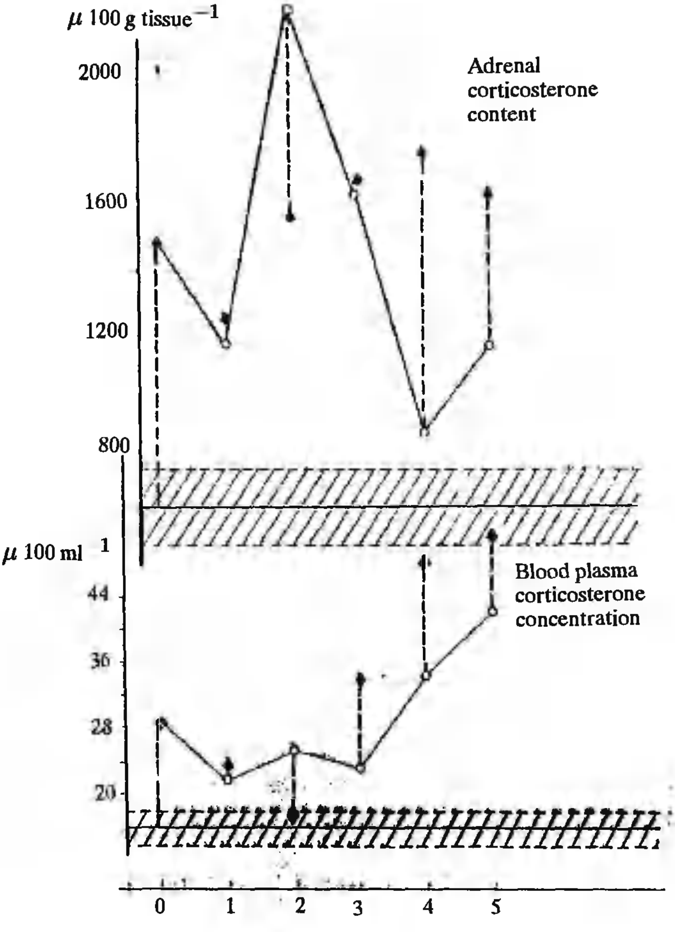

Fig. 6. Adrenal and blood plasma corticosterone concentration in rats after a 30-min swim [100]. Open circles — basal level; rhomboids — level after an additional 30-min swim; striated area — level of control group. Time is indicated in days.

24 hrs later [66]. Running of 34 km was followed by a decreased insulin level one day later [30].

The glucagon level decreases gradually from the highest concentration just after the end of exercise [25, 92]. Elevated glucagon values persisted for 90–120 min after 30-min cycling until exhaustion [20] (Fig. 7). 1, 2, 4 and 8 days after running of 34 km the glucagon concentration was close to the initial level [30].

In most cases the recovery period is characterized by a rather

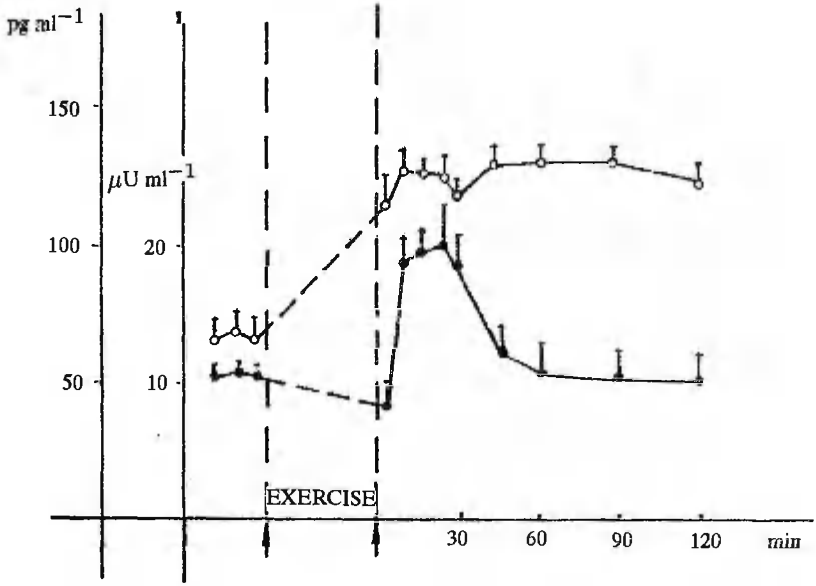

Fig. 7. Dynamics of insulin (closed circles) and glucagon (open circles) in blood plasma of men after an exhaustive exercise on the bicycle ergometer [20].

rapid decrease in the somatotropin concentration in the blood to normal values if the hormone level was augmented during the exercise [25, 92, 93]. The rebound time is dependent on the fitness level. After the cessation of a 30-min exhaustive exercise the somatotropin concentration returned to the resting level within 30 min in fit persons, but continued to increase for 60 min before declining in those who were unfit [92]. A postexercise increase in the blood somatotropin level was observed mostly after comparatively short-term exercises: after 20-min aerobic exercise or after 7 repetitions of 1-min anaerobic exercise [97, 98] or after intermittent weight-lifting exercises [96]. An anaerobic running exercise 3 × 300 m induced even in trained persons a persistently high somatotropin level during the first hour of restitution. Subnormal values were found 6, 24 and 72 hrs later [2]. In athletes the blood level of somatotropin was higher on the night after daytime training exercises than during the control night [1].

Usually the pituitary-testicular system does not respond until the recovery period. Within the first 6 hrs of restitution after various exercises for improved endurance, a gradual drop in the blood testosterone [2, 72, 102] (Fig. 8) and androstenedione [2, 72] occurs. The low levels of both compounds may persist for at least 3–4 days [2, 30, 66].

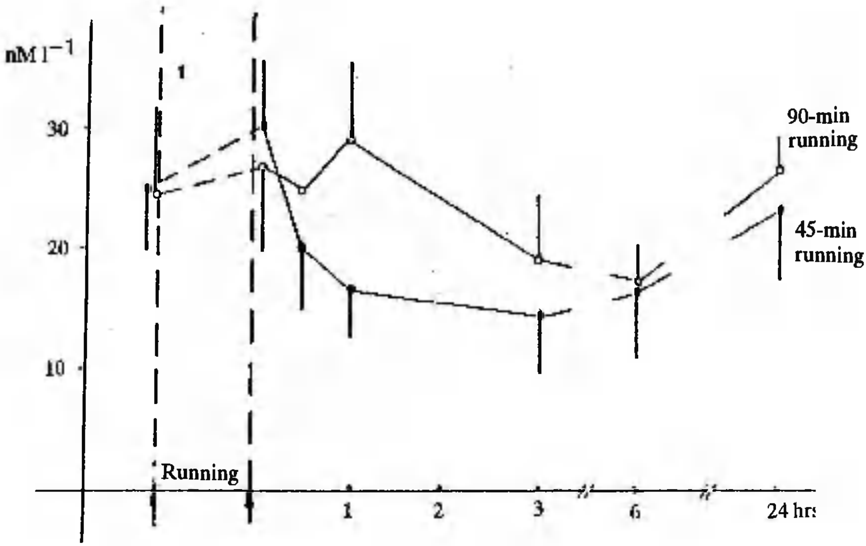

Fig. 8. Blood plasma testosterone levels after running for 45 and 60 min (13 to 14 km and 21 km respectively) [72].

Prolonged running (15 to 42 km) caused a decrease in the plasma testosterone concentration. The longer the run, the more time it took before the testosterone concentration returned to precontest levels [65].

In rats, short-term swimming with a high additional load (13% of body weight) caused a slight increase in the blood testosterone level that was followed during the first 2 hrs of restitution by a decrease in the hormone level. 4 hrs after the exercise a rise in the hormone concentration was detected, exceeding the resting level by 1.5 to 2.5 times [69]. This exercise bout caused postexercise rises in testosterone, androstenedione and estradiol content in the blood, skeletal muscles, and the myocardium. In skeletal muscles the hormone content was close to normal after 2 hrs, but increased after 48 hrs. 72 hrs after the exercise a decrease was observed in the androstenedione and estradiol content and a further increase in the testosterone content. The number of androgens-binding sites was increased by 20% 2 hrs and by 80% 72 hrs after exercise [95].

Immediately after the marathon run, increased thyroid activity was evidenced by elevated blood level of free thyroxine, free triiodothyronine and thyrotropin. Free thyroxine remained elevated 1 h later as well. 22 hrs after the race the thyrotropin concentration was decreased, thyroxine and triiodothyronine level were close to pre-race values. Comparison of the changes of free thyroxine or free triiodothyronine to free reverse triiodothyronine indicated that 22 hrs after the race still a favoured conversion of active hormones to inactive reverse triiodothyronine exists [89].

In rats 10-min swimming with additional load equal to 10% of body weight induced an increase in the thyroxine and triiodothyronine blood level for 48 hrs, with peak values for 1.5 hrs after the end of exercise. This response was observed even in rats made hypothyroid by repeated injections of mercasolil. The peak values were revealed 48 hrs after exercise [70].

Substantial changes in the endocrine system during the postexercise recovery period are evidenced by altered responses to repetition of the same exercise or to test exercise. In swimmers the noradrenaline, adrenaline, corticotropin, cortisol and somatotropin responses to a 100 m swim, repeated 1 h after the first swim, were suppressed in comparison with responses to the first exercise bout. When swimming for 1500 m was repeated, noradrenaline and adrenaline responses were exaggerated, cortisol and somatotropin responses decreased. In both exercises the insulin response did not change. Increases in lactate, glycerol and FFA level were more pronounced after the second repetition of these exercises [108].

When highly qualified weight-lifters performed two strength training session in one day, an increase in serum cortisol as well as in total and free testosterone concentrations was observed only after the second training session. One hour after the termination of the afternoon session a decrease followed in the levels of three hormones. Instead of an increase, the studied hormones decreased in response to the morning session. It was suggested that the diurnal variations might mask the exercise-induced changes during the morning session [56]. However, summation of the effect of the training session might also have an essential role. This possibility is indicated by a less pronounced increase in the lactate concentration and also by a more pronounced impairment of the maximal isometric force, the maximal rate of force development and relaxation-time after the second than the first training session [56].

Conclusion

Immediately after cessation of muscular concentrations a drop out of regulatory action of central command and proprioceptive influences cause rapid changes in the functions of organs responsible for oxygen transport. Rapid transitory changed occur despite the persisting of an increased level of various metabolites in muscles and blood. In heart activity the onset of the rapid change may be postponed for 5–15 s by a possible regulatory inertia after very intense exercises. Later the changes are influenced by hypothalamic tuning of sympathic and parasympathic influences. The cardiovascular changes are influenced also by a short-term fall in the intra-arterial pressure related, likely, to the drop out of the effect of "muscular pump" on the venous return of blood.

In the recovery period the hormone changes may depend on the inertia of regulation but also on the need for specific regulation of metabolic processes during the recovery period. The rapid increase of blood insulin level as well as the altered ratio between catabolic and anabolic hormones concern the latter.

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STUDIES ON INTERRELATION BETWEEN BLOOD LACTATE AND UREA RESPONSES

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Abstract

In order to test the relation between urea and lactate responses to exercise, the dynamics of these metabolites and glucose were studied in skiing on rollers for 40 km (11 adult biathlonists), biathlon on rollers for 21 km or in running for 26 km (10 junior biathlonists) and in ice-hockey training session (10 adult hockey players). 40 km skiing on rollers, biathlons for 21 km on rollers or for 26 km in running caused a gradual increase of urea level. Blood lactate levels elevated up to the level considered to indicate the anaerobic threshold (4 $mmol \cdot l^{-1}$). In ice-hockey players the main part of the exercise session increased urea concentration. The lactate level elevated up to 4.33 ± 0.27 $mmol \cdot l^{-1}$. When the test for anaerobic working capacity followed, the lactate concentration rose up to 14.1 ± 0.49 $mmol \cdot l^{-1}$, but urea dropped to initial values. No significant change was found in blood glucose level. The obtained results indicate that the reciprocal relation between lactate and urea responses to exercise appears when blood lactate concentration increases for above the level of anaerobic threshold.

Key words: exercise, glucose, lactate, urea.

Introduction

A great body of results evidence the exercise-induced increase in urea production, reflected in elevated urea levels in blood and tissues (for reviews see [5, 6, 8, 10, 11]). However, it has been reported that the optimal activity of several enzymes catalyzing biochemical reactions concerned in urea synthesis is at pH 7.7. At pH 7.1 urea synthesis was reduced by 40% in the liver [5, 9]. In order to test the contribution of lactate in control of urea synthesis, the urea and lactate dynamics were plotted in athletes during various prolonged exercises.

Methods

Subjects

An informed consent was obtained from highly qualified athletes. The persons constituted groups of 11 adult biathlonists (age 18–26 years), 10 junior biathlonists (age 16–18 years) and 10 ice-hockey players (age 18–27 years). All sportsmen were under systematical medical control. According to their health conditions they were allowed for training with high loads and for participation in competitions.

Protocol

(1) 40 km of skiing on rollers performed by 12 adult biathlonists in June: blood sampling in the morning and after 10, 20, 30 and 40 km was passed;

(2) The same exercise was repeated a month later on the same sportsmen;

(3) 26 km of biathlon in running performed by 12 junior biathlonists in July; blood sampling in the morning and after 12 and 26 km was passed;

(4) 21 km of biathlon on rollers performed by 12 junior biathlonists in July; blood sampling in the morning and after 10.5 and 21 km was passed;

(5) training session consisting of 20-min warm up, 45 min training game of ice-hockey and then a specific test of anaerobic working capacity (6×45 m dribbling at the highest rate); blood sampling in the morning, after training game, the test for anaerobic working capacity, and 30 min recovery after the end of session.

Blood samples were taken from the fingertip after a short-term heating. The first sampling was performed in the morning before breakfast. The next samples were obtained during exercise at various time points (see above). The exercise session began 2 h after the breakfast (10 a.m.). Before the studied exercises, usual warm-up was performed by the sportsmen.

Analyses

Urea, lactate and glucose were measured by standard procedures using commercial kits of lachema Bio-La-Test (Czech Republic). All analyses were made immediately after sampling in duplicate. The differences between duplicates did not exceed 8%.

Exercise-induced changes were statistically evaluated using paired t-test. Individual results obtained during exercises at various time points were compared to the initial level in the same person. Probability of 0.05 was designated as significant.

Results

The skiing on rollers for 40 km resulted in a gradual increase of urea concentration (Fig. 1). The lactate concentration rose during first 30 km and levelled off on average values (± SE) of 4.09 ± 0.48 mmol · l^{-1} (after 40 km). The blood glucose level remained constant throughout the exercise. The skiing velocity increased during the first 20 km and decreased during the last 10 km. Individual analysis revealed two extreme variants (Fig. 2). One of them was characterized by a moderate decrease of skiing velocity in association with further increase of blood lactate from the 30th to 40th km up to the value 6.3 mmol · l^{-1}. In this case urea concentration decreased during the last 10 km. In the other variant a pronounced drop in skiing velocity occurred during the last 10 km in association with reduction of lactate level (4.4 mmol · l^{-1} after the end of exercise) and further elevation of urea level.

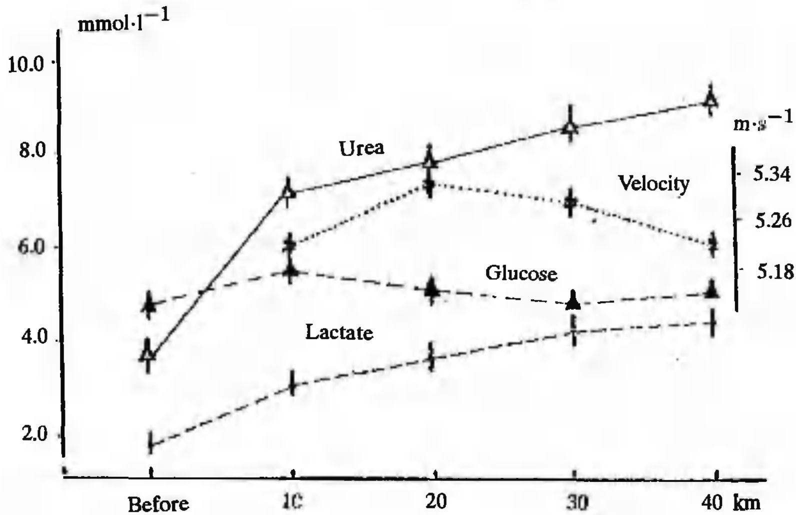

Fig. 1. Dynamics of blood metabolites during 40-min skiing on rollers. Open triangles — urea (mmol · l^{-1}), crosses – skiing velocity (m · s^{-1}), closed triangles — glucose (mmol · l^{-1}), closed small circles — lactate (mmol · l^{-1}).

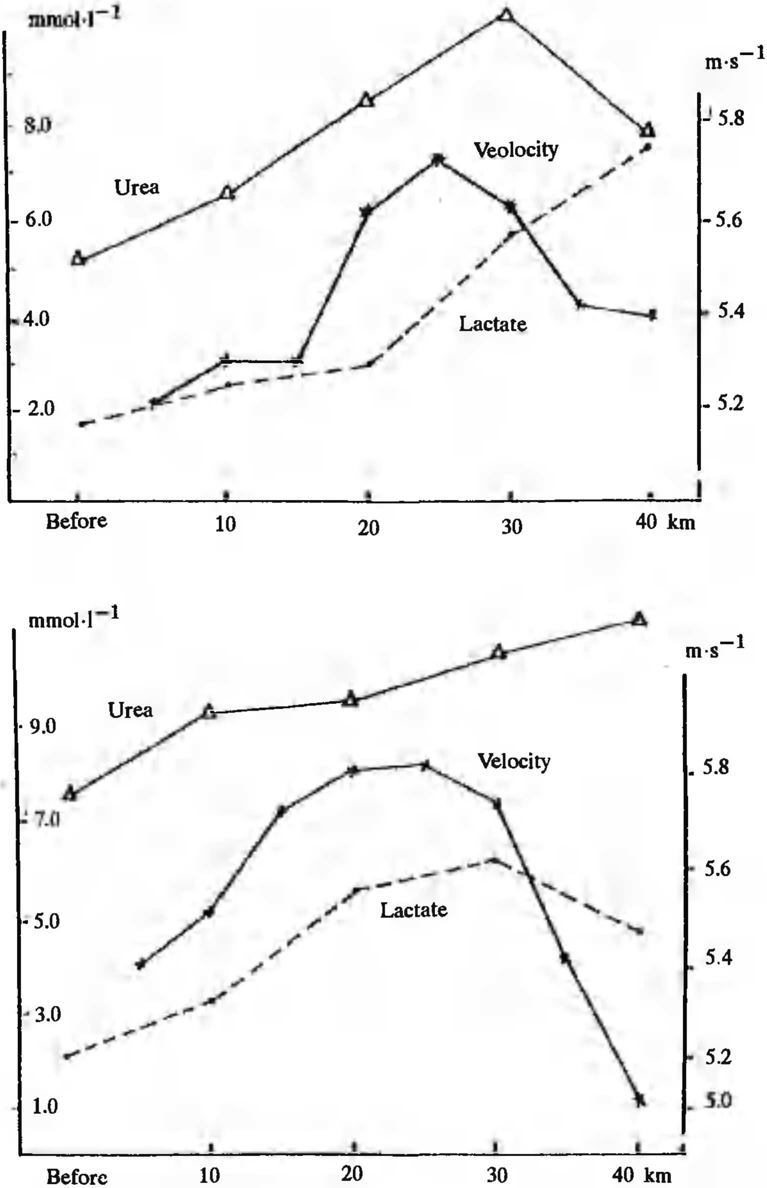

Fig. 2. Two individual cases of dynamics of blood metabolites during 40-min skiing on rollers. Open triangles — urea ($mmol \cdot l^{-1}$), crosses — skiing velocity ($m \cdot s^{-1}$), closed small circles — lactate ($mmol \cdot l^{-1}$).

In repetition of the same exercise a month later no principal differences in results were found except of a mild initial hyperglycemia (Table 1).

Table 1

Changes in urea, lactate and glucose levels (mmol · l^{-1}) in adult biathlonists during 40 km skiing or rollers in July (mean ± SE)

Time of sampling		n	Average velocity $m \cdot s^{-1}$	Urea	Lactate	Glucose
Before		11		6.58 ± 0.23	1.81 ± 0.12	5.11 ± 0.17
After	10 km	11	5.34 ± 0.09	7.11 ± 0.31	3.50 ± 0.15*	5.18 ± 0.21*
	20 km	11	5.34 ± 0.09	8.00 ± 0.34*	3.75 ± 0.15*	5.20 ± 0.16
	30 km	11	5.29 ± 0.10	8.50 ± 0.42*	3.93 ± 0.19*	4.93 ± 0.14
	40 km	11	5.53 ± 0.08	9.07 ± 0.30*	4.36 ± 0.24*	5.00 ± 0.25

Asterisk denotes significant difference ($P < 0.05$) from the initial values.

In junior biathlonists control training performed in summer on rollers or in running caused a gradual increase of both urea and lactate levels (Table 2). However, the lactate concentration increased only up to 4.54 ± 0.29 mmol · l^{-1} after the training session on rollers or up to 4.00 ± 0.29 mmol · l^{-1} after the running training session.

Table 2

Changes in urea and lactate levels (mmol · l^{-1}) in junior biathlonists during control training sessions in running or in skiing on rollers (mean ± SE)

Time of sampling	n	Average velocity $m \cdot s^{-1}$	Urea	Lactate
RUNNING				
Before	10		5.00 ± 0.26	1.37 ± 0.07
After 13 km	10	3.88 ± 0.06	7.75 ± 0.24*	3.00 ± 0.20*
After 26 km	10	3.34 ± 0.11	9.02 ± 0.38*	4.00 ± 0.29*
SKIING ON ROLLERS				
Before	10		5.58 ± 0.19	1.67 ± 0.09
After 10.5 km	10	4.11 ± 0.11	6.20 ± 0.15*	4.57 ± 0.22*
After 21 km	10	4.53 ± 0.06	6.94 ± 0.23*	4.54 ± 0.29*

Asterisk denotes significant difference ($P < 0.05$) from the initial values.

In ice-hockey players the main part of the training session increased significantly level of urea (Fig. 3). Lactate level elevated up to 4.33 ± 0.27 mmol · l^{-1}. When the test for anaerobic working capacity was performed, the lactate concentration rose up to 14.14 ± 0.49 mmol · l^{-1}, but urea dropped to initial values. 30 min after session both urea and lactate concentration were close to the initial level. No significant changes in blood glucose were found.

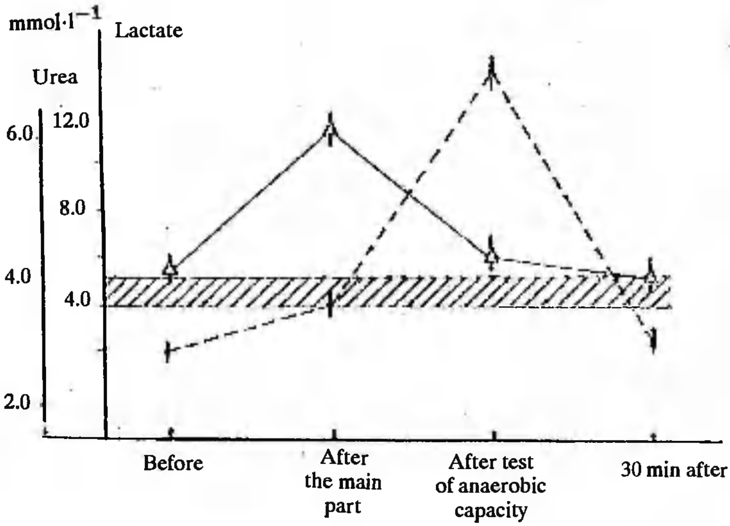

Fig. 3. Dynamics of blood metabolites during a training session in ice-hockey. Open triangles — urea (mmol · l^{-1}), closed small circles — lactate (mmol · l^{-1}).

Discussion

The obtained results indicate that the reciprocal relations between blood lactate and urea responses appear only when the lactate concentration rises far over the level of anaerobic threshold. This level is considered to be 4 mmol · l^{-1} [3]. Our results are in accordance with the following facts:

(1) the urea response appears mainly in aerobic exercise and depends on exercise duration [2, 7, 8];

(2) when short-term intense exercise is considered, blood urea remains relatively stable [1, 7, 8];

(3) in sportsmen the usual dependence of blood urea increase on the training load disappeared when highly intensive exercises were included into the sessions [11];

(4) at pH 7.1 urea synthesis was reduced by 40% in the liver [5, 9].

The first possibility to explain the inverse relationship between high lactate levels and urea concentrations is the inhibition of enzymes concerned in urea synthesis by pH decrease. However, in ice-hockey players the drop in urea concentration appeared to be rapid when an anaerobic exercise was performed. Obviously the inhibition of the urea synthesis had to be in combination with elevated urea elimination from the blood. A general effect is the increased renal clearance of urea, appearing after prolonged exercise [4]. By results of Gorski *et al.* [1] in response to vigorous anaerobic exercise (blood lactate rose up to 15 to 17 $mmol \cdot l^{-1}$) blood urea did not change and urea excretion by urine decreased. However, urea excretion by sweat increased. The latter is an opportunity to explain the rapid urea elimination from the blood during anaerobic exercises.

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FLEISCH PULSZEITSCHREIBER: AN EFFECTIVE METHODOLOGICAL PRINCIPLE. SIGNIFICANCE FOR EXERCISE PHYSIOLOGY

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Abstract

The "Pulszeitschreiber", constructed by A. Fleisch in 1930, was designed for recording of the time intervals between arterial pulses. The obtained recordings of the cardiac cycle provided good opportunities for analyses of the cardiac rhythm. The use of the recordings of R peak of ECG instead of arterial pulses as the impulse discriminating cardiac cycles, widened essentially the opportunities to use this method. An teleintervallograph was constructed for using the method in athletes in normal training conditions. Later on the basis or prolonged registration, methods were elaborated for computerized analysis of the cardiac rhythm. The diagnostic and prognostic values of this approach in operative control of the organism's state was confirmed in various physiological and clinical conditions, including studies on athletes. The Fleisch method supplied exercise physiology also with data on the transition process at the beginning and after the end of exercise, as well as cardiac rhythm in the anticipatory state, during exercise, and in postexercise recovery.

Introduction

Similarly to every man or woman, each apparatus has is own fate. There are apparatuses of short life-span. There are apparatuses possessing long-lasting life. There are also apparatuses which remain alive longer than their own life-span. Those are apparatuses which provide a new methodological approach or a new methodological principle. The Pulsezeitschreiber constructed by A. Fleisch belongs to the last group.

The Pulszeitschreiber was aimed for continuous recording of the heart rate. Before Fleisch there were some attempts to find possibilities for continuous recording of the heart rate. However, they were too complicated and did not provide a comprehensive picture. The complications were overcome by A. Fleisch, using a new and simple but fruitful idea: record the duration of each cardiac cycle — the 'Pulszeit'. It meant the continuous registration of time intervals between subsequent contractions of the myocardium.

The idea of A. Fleisch

A. Fleisch published the principle and description of the apparatus in 1930 [3] (Fig. 1). The new idea lay in recording of the time intervals between arterial pulses by drawing vertical lines, the height of which each corresponded to the time of a cardiac cycle (Fig. 2). This approach provided the visualization of subtle alterations in cardiac rhythm. Thus a principle of visualization of the studied process was used. It is not necessary to emphasise the essential role of the principle in the methodology of physiological studies.

In the Pulszeitschreiber, the principle was used in the following manner. The writing device of the apparatus draws vertical lines on the kymograph tape. An impulse from the device receiving the arterial pulsation, breaks off the upward movement of the writer and with the help of a spring, the writen quickly falls down to the basal line. Immediately after, a new upward movement of the writer begins (Fig. 3). In this way the height of each vertical line corresponds to the time of subsequent cycle.

The arterial pulses were transferred to electrical impulses with the aid a special pelot (Fig. 3). Each pulse caused an increase of the mercury in a capillar tube up to an electrode. Since the electrode and the mercury tank were connected with a source of electrical current, the electrical chain closed. In result an impulse was created breaking off the upwards movement of the writer.

Somewhat later the apparatus was adjusted for recording of time intervals in various physiological experiments. For example, M. Tiitso adjusted it for registration of cardiac rhythm in animal experiments [25]. The apparatus was adjusted for recording of time intervals between the formation of subsequent drops of fluid. It gave a possibility to use the apparatus in studies of the action of vasoactive substances on the blood flow rate in rabbit ear preparation. The recording of time intervals between drops was useful also in studies of the digestive process. The Pulszeitschreiber was used also for continuous registration of pedaling cycle time in exercising on bicycle ergometer [37].

A new variant of the apparatus was described by A. Fleisch in 1954

ZEITSCHRIFT FÜR DIE GESAMTE

EXPERIMENTELLE MEDIZIN

ZUGLEICH FORTSETZUNG DER

ZEITSCHRIFT FÜR EXPERIMENTELLE PATHOLOGIE UND THERAPIE

HERAUSGEGEBEN VON

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Sonderdruck aus Band 72, 3. u. 4. Heft

Alfred Fleisch:
Der Pulszeitschreiber; ein Apparat zur Aufzeichnung der zeitlichen Pulsintervalle als Ordinate.

BERLIN
VERLAG VON JULIUS SPRINGER
1930

Fig. 1. The title page of the Fleisch publication on the Pulszeitschreiber

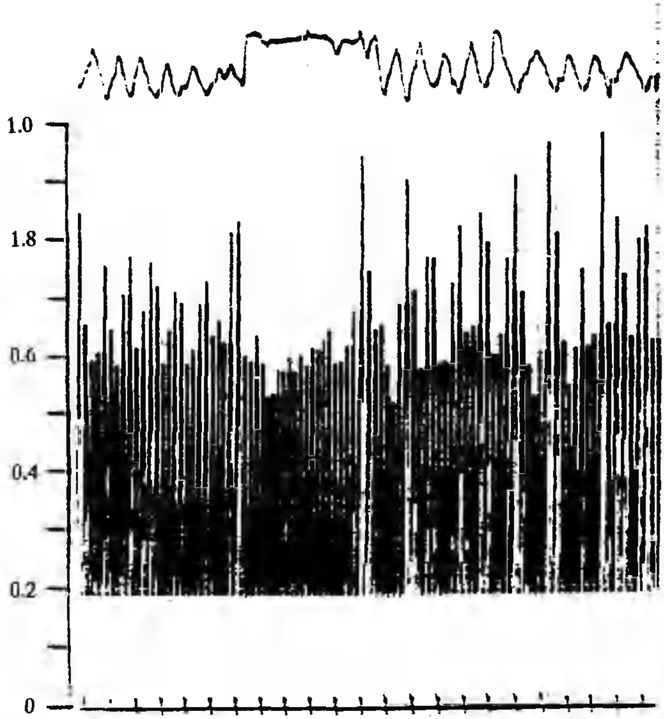

Fig. 2. Examples of recording the duration of cardiac cycles by the Fleisch principle. The dynamics of cardiac activity during a voluntary stop of breathing. From the top: (1) pneumogram, (2) duration of cardiac cycles, (3) time per 3 sec. The figure is obtained from the author's archives.

[6]. The principle of recording of cardiac cycle duration or other time intervals by means of vertical lines has been used by several researches [13].

Registration of the cardiac rhythm

Continuous recording or the cardiac cycle provided good opportunities for analysis of the cardiac rhythm [4, 25, 40]. In addition to the respiratory arhythmia, waves in the duration of cardiac cycle with periods from 8 to 16 s were described ("Langwellen"). Likely, these waves correspond to the tertial waves in arterial blood pressure. As early as 1932 it was suggested that pronounced respiratory arhyth-

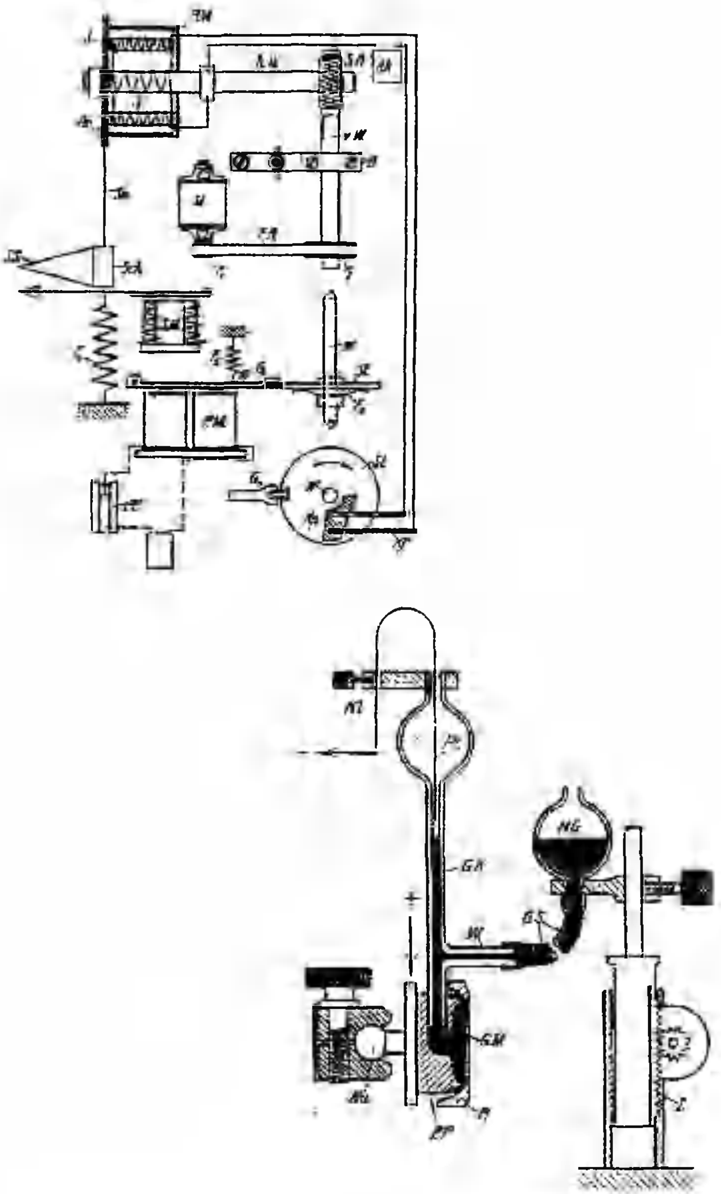

Fig. 3. The Fleisch Pulszeitschreiber. On the upper panel: the principal scheme. On the lower panel the pelot for receiving arterial pulses. All Figures are from the original publication of A. Fleisch.

mics is typical for the young heart possessing a good working capacity [40]. Later ontogenetic pecularities were discovered in the respiratory arhythmics: at the age of 10 to 15 years the respiratory arhythmics was characterized by a great diapasone between the shortest and longest cardiac cycles. In this age the so called "Vagus pulse" (Fig. 4) — single long cardiac cycles (up to twice longer as the mean level) — may appear on the second half of expiration [8]. These long cardiac cycles did not differ from others by the ECG; children who exhibited the vaguspulse had normal physical capacities [27].

The method has been used also for studying the dynamics of cardiac responses to various actions, including psychic strain [5], vagotomy, administration of atropine or adrenaline, Ashner reflex, and Valsalva maneuver [2, 4, 15–17, 21, 25, 40].

The further development of the method consisted in substitution of arterial pulses by R peak of ECG as the impulse discriminating cardiac cycles [20] (Fig. 5). A teleintervallograph was constructed for continuous recording of the action of exercises in athletes in normal conditions of sports activities [14]. The principle for time interval recording, including cardiac cycles, was used in various multichannel monitor-physiographs, constructed in the Laboratory of Biophysics of the University of Tartu and elsewhere.

Comparing the principle proposed by A. Fleisch for recording of cardiac cycle duration with the usual ECG studies, one must to point out not only the excellent visualization of the dynamics but also the good opportunities for prolonged registration. Later, on the basis of prolonged registration, methods were elaborated for computerized analysis of the cardiac rhythm. The diagnostic and prognostic value of this approach in operative control of the organism's state was confirmed in various physiological and clinical conditions, including space flights [1]. However, a great material collected by a Lithuanian group indicated that the value of such methodological approach essentially increases if the computerized analysis of the cardiac rhythm is performed together with analyses of the cardiac dynamics recorded by the Fleisch principle [41].

Significance for exercise physiology

The first attempt to use the Pulszeitschreiber in exercise studies was made by B. Wilhelmson [40]. She recorded cardiac activity during exercises of mild intensity. The main result was the decrease of the respiratory arhythmies with increased heart rate. However the "Langewellen" persisted. In the next study more intense exercises performed on a bicycle ergometer were used [24]. There were cases

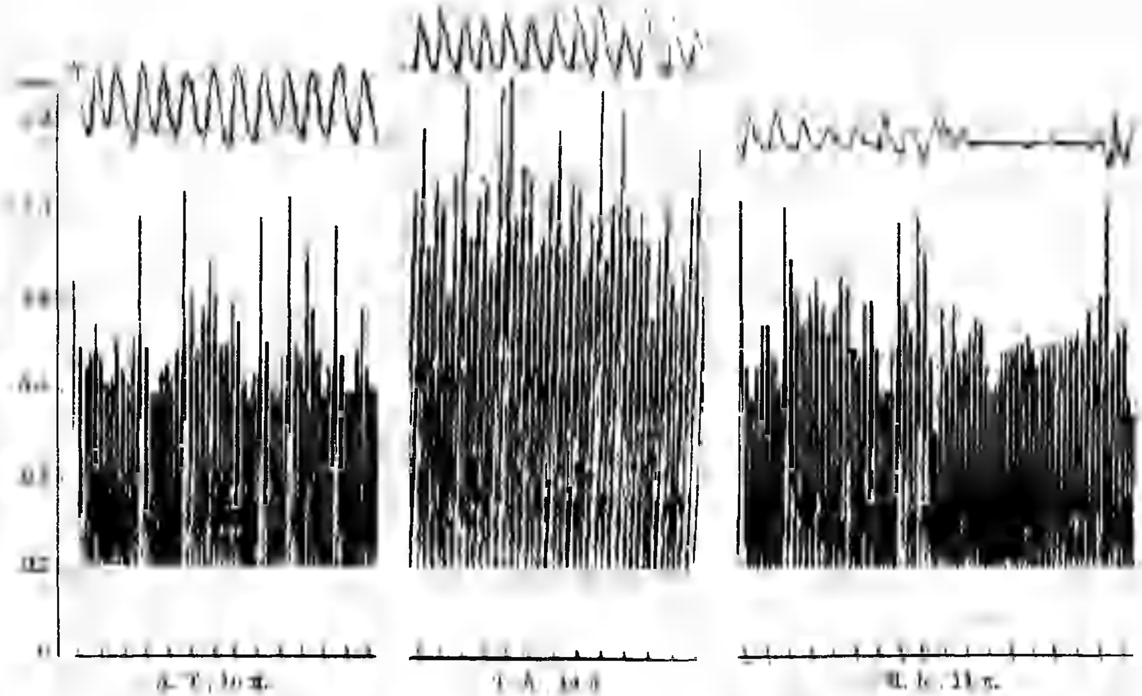

Fig. [illegible] Respiratory [illegible] in duration of [illegible] cycles in children. [illegible] the top (1) [illegible], (2) duration of subsequent cardiac cycles, (3) time [illegible]. On the left the "[illegible]" are shown in a 10-years old boy; in the middle — a [illegible] in a [illegible]-years old girl; on the right — [illegible] rhythmia during a voluntary [illegible] of breathing. The [illegible] were obtained [illegible] of the Institute of Physiology of University of [illegible]

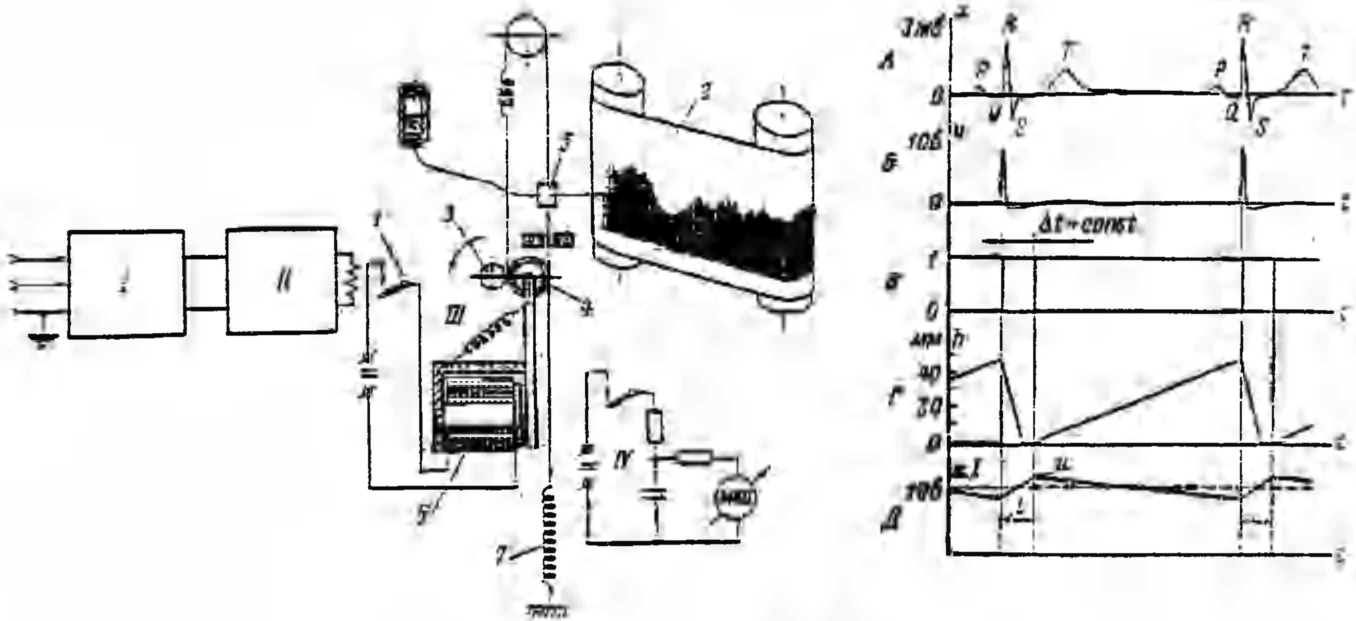

Fig. 5. A scheme of a cardiotachometer constructed by Raeban and Unger [20].

when heart rate increased up to 200–205 beats per min. The continuous registration of cardiac cycle duration enabled the authors an opportunity for exact description of the heart rate dynamic pattern during and after exercise. Also the heart rate increase was noticed after command preceding the exercise. During exercise the respiratory arhythmies decreased with increase in heart rate until the absence of arhythmies. After exercise the arhythmies as well as "Langwellen" became pronounced. However, in untrained persons after very intense exercise the heart rate recovery was slow. During the first two minutes or more the respiratory arhythmies was hardly visible.

In 1950s the Fleisch method was used to demonstrate the effect of forced expiration on the heart rate recovery [28]. A special analysis was made on the short-term heart rate response to commands preceding exercise [29]. In the anticipatory state before sports competitions two variants were found: (1) a pronounced increase in heart rate associated with reduced respiratory arhythmies, (2) a moderate increase in heart rate accompanied by a pronounced augmentation of respiratory arhythmies [30].

The exercise studied with the original method were complicated due to the fact that the arm fixed in the pelot for reception of arterial pulses had to be immovable. The complication was surpassed by substition of the arm pelot by ECG electrodes. In a great number of persons of both sexes and various fitness levels heart rate dynamics were recorded in very intense sprint of 15 s and in exercise lasting 3 min. The results of Tiitso and Pehap [24] were confirmed and extended [7]. A possibility of regulatory interia was shown that was reflected in further increase of heart rate during a few seconds after exercise, or the possibility that heart rate might persist for 5–10 s on the exercise level before its decrease. In trained persons the fast postexercise decrease in heart rate associated with the augmentation of respiratory arhythmia and "Langwellen".

Further, a long chain connecting the person and the apparatus was used. This allowed researchers to record the heart rate during and after various sports exercises: swimming for 25 and 100 m [18 35], gymnastic exercises on the beam, arm bending [31, 35] or weight lifting [36] (Fig. 6). Postexercise recordings were made also in runners after they finished runs for 100 or 400 m [32].

In order to use the obtained results for information on the functional capacity of persons, the total number of heart beats during the first three postexercises minutes (sum of recovery pulses) was accounted and used in relation to the actual intensity of the performed exercise [31, 32, 35]. This approach was used in control of training efficiency in Estonian top athletes [9, 18, 31]. The method of continuous registration of heart rate was used for analysis of fatigue development in repeated exercises or test exercises performed before and after train-

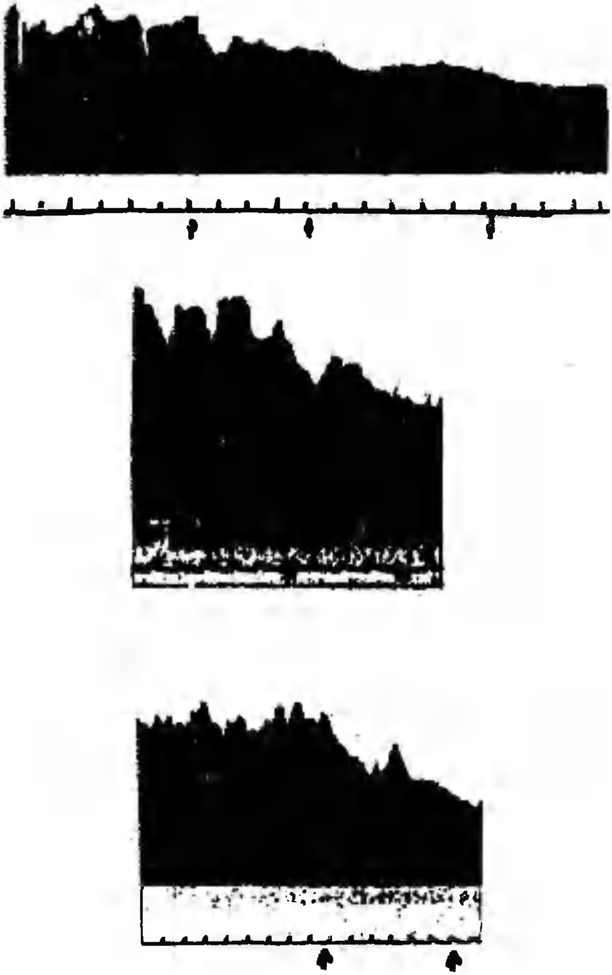

Fig. 6. Dynamics of duration of cardiac cycles in transition from rest to various exercises. From the top: (1) Transition to swimming for 100 m: first arrow indicates the command to take in the water the starting position, the second arrow — persons sunk into the water to take the starting position, the third arrow — the start. (2) Transition to weight lifting: the arrows indicate the command to go to the bar, and the onset of lifting. (3) Transition to and exercise on the gymnastic horse: the arrow indicates the command to go to horse, and the onset of exercise. Time is indicated per 5 sec. The figures were obtained from the author's academic dissertation for the degree of candidate of biological sciences.

ing sessions [19, 33, 34]. Experiments were performed also in order to compare the dynamics of heart rate and blood pressure during and after exercises of various duration and intensity [39] and to study the significance of body position for the recovery process [38].

Using the teleintervallograph in skiers, results were obtained demonstrating that in highly qualified skiers a good accordance exists between heart rate and the relief of the skiing track. In less qualified skiers the accordance was less pronounced. Skiers of low level failed to show the accordance. The results made possible also to evaluate the precondition for heart rate rise over 200 beats per min. This phenomenon was found in skiers of medium qualification. It was never found in skiers of either high or low qualification. It was suggested that heart rate rises over 200 beats per min in sportsmen having a certain level of fitness of the muscular system in association with a poor development of cardiovascular fitness [22].

In a study durations of both cardiac cycle and pedalling revolution were monitored during cycling exercises of various intensity. It was found that when heart rate increased over 160 beats per min, durations of the cardiac cycle remained constent despite variations in time of pedalling revolutions. Also the respiratory arhythmics disappeared [37].

More recently two extended studies were performed using the Fleisch principle for recording of the heart rate pattern in exercises. Results of A. Kepezhenas [11, 12] showed that in sportsmen the increase of aerobic working capacity associated with elevated respiratory arhythmies on the level of pronounced bradycardia. However, a further increase of aerobic working capacity might reduce the respiratory arhythmia. Temporary drops in performance capacity were reflected by increased heart rate in rest and during functional tests and reduced respiratory arhythmies.

Four variants of patterns of postexercise recovery of heart rate were described by N. Svoroskaya [23]. The appearance of these variants depended on the ratio between cardiovascular fitness and exercise intensity. In transition from rest to exercise an exponential increase or the phenomenon of search were found.

The changes in the amplitude of respiratory arhythmies have been used for differential evaluation the significance of increased parasympathetic tone or decreased sympathetic tone in origin of training bradycardia [10]. This study was also made by using the Fleisch principle. A close relationship between aerobic power and vagal tone was indicated in control of resting heart rate.

In conclusion, the Pulszeitschreiber was not only an apparatus for continuous registration of heart rate. By this apparatus a new principle was provided for continuous registration of physiological processes. In this way the method warranted an accumulation of valuable physiological information. The method promoted the development of exercise physiology.

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SENSITIVE PERIODS OF PHYSICAL DEVELOPMENT

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The coaches and teachers of physical education are well aware of the fact that the students cannot develop all the characteristics and abilities in the same way. The development of a person is determined by genetic and social programmes. The genetic factors determine the potential possibilities of the development. The process of passing on genetic information takes place at its best in certain external conditions. When the certain genetic information is missing, the quality does not develop even if the optimum external conditions are provided. The possibilities of developing sporting abilities are not endless and are limited by the genotype of an individual [6, 7, 9, 10, 14, 15].

It has been provided that the genetic information can be realised only if it is during every age period in optimum correlation with certain external environmental conditions and with the morphological and functional characteristics of certain age periods. The effectiveness of sport developments is noticeably higher when pedagogical influence coincides with the individual anatomical and physiological peculiarities of every age group [3, 4, 8].

The factors of pedagogical influence must correspond to the biological rhythm of motorics in different age groups. The influence of environmental factors (sport training) is not the same at different levels of the development of the organism. During every period of the individual development a certain complex of exercises and methods, based on the earlier changes in the organism and genetic information, gives the biggest effect. External factors that do not correspond to the abilities of the organism do not enable us to use the reserves that the organism has at different levels of its development. Only close connection with external environment makes it possible to develop heredity. The exercises and methods should favour the development of the hereditary abilities of young sportsmen. Inadequate influence can result in only partial revelation of these abilities, whereas in case of excessive loads the genetic possibilities can be exhausted.

It leads to the necessity for the choice of optimum training load [1, 6, 8, 10, 13, 15, 16].

Understanding the mutual influence of genetics and environmental factors arouses interest in establishing the "critical or sensitive" periods of development. During sensitive periods higher sensitivity towards external factors appears. At certain periods environmental factors have an optimum influence on the development. At other periods the influence can be neutral or even negative. Being aware of the critical periods and the amount of optimum training effect, we can regulate individual characteristics of the organism at different periods of ontogeny and guide the individual development [1, 5, 15].

Numerous researches have shown that several morphological characteristics are generally determined. In spite of the fact that morphological development undergoes important changes during different age periods, it is more or less stable and therefore it is possible to use morphological characteristics for prognosis at all ages. The role of the genotype increases constantly since birth and reaches its peaks during the period of sexual maturity [4, 6, 8, 9, 15].

There are also optimum periods of growth in the development of functions of movements and their fixation. During this period certain functions get fixed best. Missing this timing can result in slow or bad formulation of these functions. It takes more time and the results are instable. That is the reason for starting the mastering of one or another activity at the optimum age [3, 11, 15, 16].

The importance of sensitive periods in sports is essential in determining the specializing age, morphological readiness, optimum training load, formulating intellectual activities etc. Research has shown that when developing the abilities according to one's aim, the greatest effect is achieved in the period when their natural growth is highest. Using the same methods, the same load and intensity in the training gives different pedagogical effect in various periods. It is biggest during the period of the most intensive growth. Working upon physical abilities by training in the stage of faster development leads to a noticeable rise of these abilities.

The bigger the natural increases or physical preparation are, the greater is the effect provided by training the abilities in their critical stage.

As a result, the maximum growth of abilities is achieved. At the same time the basis for the future development dynamics of various physical abilities is established.

In case of early specialization and intensive training, without being aware of the anatomical and physiological characteristics of the organism and the duration and nature of sensitive periods, there is the danger that we do not fully realise the potential of the organism. Health problems and hindrance of the natural development cannot be excluded either [2, 3, 4, 6, 8, 12, 13, 15, 16].

Methodology

Proceeding from the above-mentioned considerations, the following aim was set to the research programme:

— to establish the sensitive periods of the physical development of Estonian schoolchildren of both sexes.

The research was carried out among Estonian adolescents. Boys within the age limit of 11–18 and girls of 10–17 were tested. According to their age, they fell into the following groups:

Age	10	11	12	13	14	15	16	17	18
Boys	–	317	344	365	350	341	286	230	197
Girls	144	198	170	142	122	123	99	83	–

The following tests were applied to grade the main abilities:

maximal strength — back muscle strength measured with dynamometre;

explosive strength or power — standing long jump, vertical jump, pushing a medicine ball (2 kg) from chest in the sitting position;

running — 30 m race.

Results and Discussion

The sensitive periods of physical development were established according to the annual growth rate. In Table 1 the annual growth increase or static strength (back dynamometria) is shown in percentage of the total growth in boys at the age of 11–18 and girls of 10–17 years.

Table 1

Annual growth increase in the back dynamometria (% of the total growth)

Age	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18
Boys	–	4.0	7.6	17.5	23.4	19.9	14.7	12.9
Girls	11.8	20.5	19.2	9.5	12.6	9.5	16.7	–

The research shows that the sensitive period of static strength development in boys was at the age of 13–16. The greatest increase occurs in the years 14–15 (23.4% of total growth). Among the girls the sensitive period of static strength development was at the age of 11–13 (39.7% of the total growth).

Table 2

Annual growth increases in the standing long jump (% of the total growth)

Age	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18
Boys	–	6.8	14.0	18.8	18.9	16.7	13.0	11.8
Girls	28.5	53.4	2.3	8.7	4.2	2.3	0.6	–

Table 3

Annual growth increases in the vertical jump (% of the total growth)

Age	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18
Boys	–	4.9	14.4	13.0	18.5	21.2	15.5	12.5
Girls	40.5	36.7	7.6	2.5	2.5	7.6	2.5	–

Table 4

Annual growth increase in pushing medicine ball (2 kg) from the chest in the sitting position (% of the total growth)

Age	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18
Boys	–	8.1	11.9	17.9	18.5	16.6	16.5	10.5
Girls	19.3	20.5	26.0	9.7	7.3	15.0	12.0	–

In Tables 2, 3 and 4 the annual growth increases of power (standing long jump, vertical jump and pushing the medicine ball from the chest in the sitting position) are shown for both sexes.

Tables 2 and 3 show that the sensitive periods of legs power development was at the age of 12–17 years in boys. The biggest annual growth rates occur at the age of 13–16. In girls the sensitive periods of legs power development was at the age of 10–12. During these 2 years (10–11 and 11–12) 81.9% of standing long jump and 77.2% of vertical jump results occur out of the total growth at the age of 11–17.

Table 4 shows that in boys the sensitive periods of hands power development was at the age of 13–17 and in girls at the age of 10–13.

Table 5 gives the sensitive periods of running speed development.

In boys the sensitive period is at the age of 12–17 and in girls of 10–13. In girls the sensitive period mainly falls on the period of 10–13 years of age.

Our research has shown that the sensitive periods of different physical abilities are concentrated in boys on the age of 12–17 and in girls on the age of 10–13. Henceforth emphasized attention should be paid to developing the abilities at the given age levels. It results in

Table 5

Annual growth increases in running speed (m/s)

Age	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18
Boys	–	0	20.0	20.0	20.0	20.0	20.0	0
Girls	50.0	25.0	25.0	0	0	0	0	0

the maximum increase of abilities.

Conclusion

1. Our research has shown that the sensitive periods of static strength, power and running speed development are at the age of 12–17 in boys and 10–13 in girls.

	Static strength	Power		Running speed
		Legs	Hands	
Boys	13–16	12–17	13–17	12–17
Girls	11–13	10–12	10–13	10–13

2. Special attention should be paid to the development of the abilities that were examined in certain age groups (sensitive periods) because training during these periods leads to the maximum growth of abilities.

3. Awareness of the critical periods enables us to explain the process of physical preparation of students of different age and sex scientifically, to determine the optimum growth for specialization and to plan the training schedule of young sportsmen.

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CARRIAGE ON THE PERIOD OF PREGNANCY

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Bearing of a person is the basis for carriage. During the lifetime, the spine shapes itself according to the individual's moving or holding of the posture. If the posture is correct, the load which falls on the muscles is balanced. Such posture doesn't tire or cause any troubles. The right carriage is guaranteed by trained muscles of the stomach, buttocks, back and legs. The bearing of a woman of good carriage is natural and free. The centres of shoulder, hip joint and heel are on the same vertical. Legs are straight from the knees, the look is straight, shoulders free of tension, hands down [4].

During pregnancy the natural curves of the body are amplified because the place of the centre of gravity changes and by the agency of hormones the stability of joints. The centre of gravity of the body moves forward, the load on the spine grows bigger. To balance the body, the woman tends to stand back on her heels, pushing also her hips back too far. In this case, back muscles are too much pressed together and overstrained. Stomach muscles stretch out and losen and the result is a saddle-like back and backache. Keeping the posture right during pregnancy is made difficult also by the fact that by the agency of hormones joint ligaments soften, joints become more movable. If the stomach and buttock muscles are not strong enough, they are not able to keep the pelvis in the right position and the result is the wrong bearing as mentioned above.. In the case of wrong carriage, wrong tension may arise also in the shoulder girdle if the head is dropped to the breast and shoulders are moved forward to balance the body. In this case breast kyphosis is increased. Thorax is sunken and breathing becomes more difficult. To maintain the right posture the stomach muscles must support the stomach from the front and buttock muscles must quarantee the right angle of inclination of the pelvis so that the pelvic girdle would stay exactly below the shoulder girdle [1, 2, 3, 5, 6, 7].

The aim of the investigation was to study the dynamics of the changes of carriage during pregnancy and compare the carriage of nonpregnants with the carriage of pregnants.

Methods

57 women in primary pregnancy at the age of 17 to 31 (average 22.2 ± 0.3 years) were investigated. To characterize the carriage, the profile of the spine was drawn both in standing at ease and at attention. The Abalakov contourograph was used. The exact but lessened shape of the spine was got [9]. To get further data, the 7th cervical vertebra was taken as the central point from where a prependicular was drawn and the following characteristics were determined:

A — the 7th cervical vertebra;

K — distance between the peak of kyphosis and the perpendicular;

KK — distance (mm) between the K characteristics and the 7th cervical vertebra of the spine on the perpendicular;

L — distance between the peak of lordoses and the perpendicular (if L intersects the perpendicular, it has a + mark, if it doesn't intersect, it has a – mark);

LK — distance between L characteristics and the 7th cervical vertebra of the spine on the perpendicular;

KÜ–LO — straight line which joins the peaks of kyphosis and lordoses; straight line of sacrum — the extension of the projection of the sacrum;

KÜ–LO angle — the angle between the straight lies of KÜ–LO and the sacrum (Figure 1).

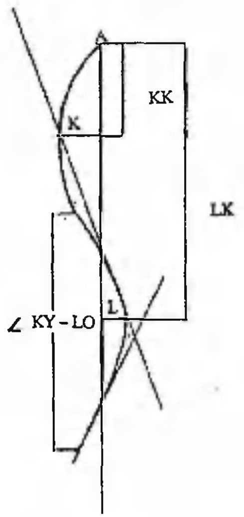

Fig. 1. The profile of the spine.

The measurements were carried out on the 13th, 20th, 32th and 38th week of pregnancy. As comparative data, U. Sahva's [9] data about the carriage of female students were used.

In the analysis of correlation the coefficients whose absolute value was bigger than 0.5 were taken under observation.

Results

1. Comparison of ordinary carriage and carriage during pregnancy.

On the analyses the data obtained from carriage measurements on the 38th week of pregnancy were used. The results are shown in Table 1. Comparing the carriage during pregnancy with the ordinary one, the following differences can be brought out. The size of kyphosis (K) of an ordinary carriage was 12.12 ± 4.89 mm, on the pregnant 14.22 ± 5,2 mm; the distance of the peak of kyphosis from the 7th cervical vertebra (KK) 61.1 ± 19.9 mm and 58.3 ± 14.31 mm respectively. The size of lumbar lordosis in ordinary women was 3.04 ± 6.49 mm, in the pregnants –2.93 ± 12.0 mm, the distance of lordoses from the 7th cervical vertebra (LK) 152,6 ± 12.5 mm and 150.1 ± 8.0 mm respectively.

Table 1

Characteristics of the carriage of non-pregnants and pregnants in standing at ease and at attention $\bar{x} \pm \delta$

	Non-pregnants		Pregnants	
	at ease	at attention	at ease	at attention
K	12.12 ± 4.89	8.04 ± 4.4	14.22 ± 5.2	12.0 ± 6.8
KK	58.38 ± 14.31	49.67 ± 17.64	61.1 ± 19.9	63.4 ± 16.6
L	3.04 ± 6.49	5.53 ± 6.88	–2.9 ± 12.0	–3.15 ± 8.7**
LK	152.62 ± 12.51	146.65 ± 13.6	150.1 ± 8.0	137.3 ± 38.6
KÜLO angle	150.67 ± 7.99	149.99 ± 8.37	154.3 ± 7.0	154.0 ± 6.9*

* — statistically significant difference (p < 0.05) in relation to non-pregnants;

** — statistically significant difference (p < 0.01) in relation to non-pregnants.

In the case of standing at attention the changes were going in the same direction as in the case of standing at ease, but the shift was more noticeable. The pregnant has a bigger kyphosis ($p < 0.01$) and a longer distance of kyphosis from the 7th cervical vertebra ($p < 0.001$), a smaller lumbar lordosis ($p < 0.001$) and a shorter distance of lordosis from the 7th cervical vertebra ($p < 0.001$). The angle of inclination of kypho-lordosis is bigger ($p < 0.01$).

2. Dynamics of the carriage changes during the different periods of pregnancy.

Observing the changes of carriage during the 38 weeks of pregnancy we may notice the following (Table 2). In standing at ease there was a tendency towards the increasing of kyphosis on the 20th week of pregnancy. In other periods the size of kyphosis did not differ from the one at the beginning of pregnancy. KK practically did not change during pregnancy. On standing at ease there was a tendency towards the lessening of the saddle-like back at the lumbar region. LK was the shortest on the 20th week of pregnancy (139.1 ± 30.9 mm $p < 0.05$). In other periods LK did not differ from the one at the beginning of pregnancy. The angle of kypho-lordosis on standing at ease practically did not change during pregnancy.

On standing at attention no statistically significant change of kyphosis was observed, although there was a tendency towards the increasing of kyphosis. If compared with the one in standing at ease, it was smaller ($p < 0.01$). KK was the smallest in the I ($p < 0.001$), the biggest in the III period ($p < 0.001$). Lordosis was the biggest on the 20th week of pregnancy (5.0 ± 29.1 mm, $p < 0.05$) and the smallest on the 38th week ($-3{,}15 \pm 8.7$ mm, $p < 0.001$). LK was the same in the 1st, 2nd, 4th periods of measurement, in the 3rd period there was a tendency towards the increasing of the LK. The biggest angles of inclination of kypho-lordosis was registered in standing at attention in the 20th (152.8 ± 15.2 mm, $p < 0.05$) and the 38th (154 ± 6.91 mm, $p < 0.05$) week of pregnancy. Correlation analyses brought out the following correlations (Figure 2).

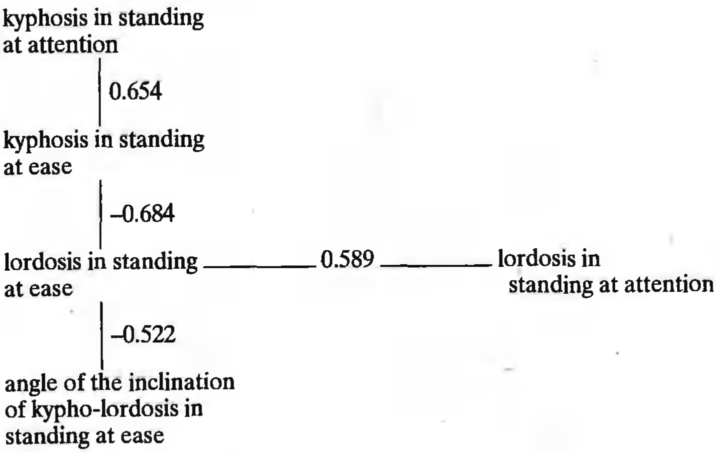

Fig. 2. Correlational relations of the characteristics of the carriage.

Table 2

Characteristics of the carriage in the different periods of pregnancy $\bar{x} \pm \delta$

	I period		II period		III period		IV period	
	at ease	at attention	at ease	at attention	at ease	at attention	at ease	at attention
K	14.62± 6.9	10.68± 7.97	17.12± 9.4	11.96 ± 9.1	14.9±2.9	11.02± 4.9	14.2± 5.2	12.0± 6.8
KK	66.03±13.6	57.65±16.4	66.25 ±10.8	59.96±13.9	68.4 ±9.8	68.4 ± 9.3***	61.1±19.9	63.4±16.6**
L	−2.42±10.1	1.33±11.5	0.97±21.3	5.01 ±29.14*	−5.24±7.1	−1.83±7.9**	−2.9±12.0	−3.2± 8.7
LK	150.38±12.8	139.16±18.22	139.1±30.9	138.87 ±19.4*	149.69±7.2	144.2 ±10.9	150.1± 8.0	137.3±38.6
KÜLO	148.87±16.5	144.4 ±24.26	143.3 ±34.6	152.8 ±15.2*	151.64±7.1	140.5 ±39.9	154.3± 7.0	154.0± 6.9*

* — statistically significant difference ($p < 0.05$) in relation to the first period.
** — statistically significant difference ($p < 0.01$) in relation to the first period.
*** — statistically significant difference ($p < 0.00$) in relation to the first period

Discussion

Comparison of carriage during pregnancy and the ordinary carriage showed that the pregnant's spine suffers certain changes. The reason may be the forward shift of the centre of gravity [5, 6]. To balance her body, the woman increases the angle of inlication of the pelvis by turning the pelvis forward from below. In consequence, her back straightens. Forward vaulting of the stomach is tried to be compensated by a somewhat increased kyphosis. The acquired results are different from the data found in literature, where it is assumed that the lumbar lordosis increases during pregnancy [8].

Observing the dynamics of carriage changes during pregnancy, it becomes evident that the changes of carriage are most numerous on the 20th week of pregnancy. This kind of difference of the carriage characteristics of the second period from other periods can presumably be explained by the fact that at this time pregnancy (growing embryo) and shifts in the hormonal system start to influence the carriage [5, 6]. By the 3rd trimester of pregnancy the woman has adjusted herself to her new condition and she is able to balance her body correctly. In the change of carriage it was expressed by the tendency to increase kyphosis and decrease lordosis.

The correlation analyses brought out the fact that if a woman has a tendency towards increasing kyphosis in standing at ease, then she maintains this carriage fault also in standing at attention. The same kind of shift was observed in the case of lumbar lordosis. There was a negative correlation between kyphosis and lordosis. The bigger the kyphosis in standing at ease, the smaller the lordosis in the same standing. The smaller the lordosis, the bigger the angle of inclination of kypho-lordosis. Consequently, standing, the woman compensates the forward vaulting of her stomack by the increasing of kyphosis and the straightening of her back during pregnancy.

Conclusions

1. Standing at ease, the carriage of the pregnant does not essentially differ from the carriage of non-pregnant, although there is a tendency to the increase of kyphosis and decrease of lumbar lordosis.

2. Standing at attention, kyphosis of the pregnant increases and lumbar lordosis decreases.

3. Most noticeable shifts in the carriage occur on the 20th week of pregnancy.

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ON THE INFLUENCE OF THE THICKNESS OF THE WAX LAYER ON THE SLIPPING CHARACTERISTICS OF A SKI

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The cumulative effect of a waxed ski and snow depends on various factors which come into being on the extreme surfaces of the ski sole and snow and are brought about by external conditions (snow temperature, air humidity, the pressure on the ski) [2, 5, 9, 13, 15, 17, 24], the area of the ski's support surface [1, 2, 16] and its contact conditions with snow [1, 2, 11, 14, 19, 21], kinetics (stopping time, slipping speed of the ski) [2, 4, 6], and by static electricity [1, 2, 7, 10, 13, 23].

Today, the evolution of skiing sports is closely connected with technical progress. Skis and their slipping and stopping characteristics play an enormous role on big international competitions such as the Olympic and World Championships and the World Cup series, where a hundredth part of a second may mean triumph or misery. Different ski manufacturers produce large quantities of ski waxes, paraffines, and powders, the recipes and usage of which are kept in top secret.

Investigations have shown that when slipping on snow, skis get into contact with only the topmost particles of it [18]. In those spots, lubricating force comes into being. The interaction of ski and snow causes the formation of a thin film of water [16], which consists of microscopic drops situated at the contact surfaces of ski and snow. The thickness of this film is measured in microns and it acts as liquid wax when ski slips [18].

Slipping is optimal at the temperature –4°C. As the temperature rises to –2° and even –1°C, the film of water between the ski and the snow may get too thick, whereas at temperatures –5° to –10°C the formation of the film is very difficult. On still lower temperatures, the film becomes practically nonexistent.

The structure of the snow that falls also has an impact on the slipping characteristics, and it must be pointed out that the important thing about it is the build-up of individual crustals. The shape of the crystals may be pretty different, depending on the temperature: at the temperatures 0°C to –4°C the crustals are thin and plate-like; at the temperatures –4°C to –10°C they are prism- or needle-shaped; at –10°C to –20°C they are thick and plate-like; at –20°C to –35°C they resemble hollow columns [16, 24].

The slipping characteristics of skis have been relatively little investigated. Our knowledge in this field is limited to general understandings and, as a rule, intuition is the ultimate criterion in the selecting of waxes and paraffines.

One of the more available methods in judging the slipping and stopping characteristics of skis is still testing, the measuring of slipping speed under constant (unchanging) circumstances.

The aim of the present study was to compare skis ("VISU" and "ESTONIA") and the dependence of their slipping characteristics on the thickness of the layer of stopping wax ("thin", "average", "thick"), on the grooving of the paraffine layer (with grooves of the widths 1 and 2 mm), and on the structures of snow (dry fine-grained snow, dry large-grained snow, old snow, fresh snow).

Methods

The test was carried out in January and March, 1993, in Kandalaksha. In the test, we used the competition skis of "VISU" and "ESTONIA" and the waxes and paraffines of "VISTI". The characteristics of the skis are shown in Table 1.

Table 1

	Free flexure mm	Weight flexure (75 kg) mm	Nominal length cm	Contact length cm
1. "VISU FIBER"				
left	21	~1	200	171.4
right	23	~1.5	200	172.8
2. "ESTONIA"				
left	24	2.5	200	175.8
right	24.5	2.5	200	176.2

The thickness of the wax layer was conditionally determined as follow: a "thin" layer is what you get when you apply the wax without pressure to the ski sole and after rubbing it on the wax is not visible; than the wax is applied again, but this time it is not rubbed any more;

an "average" layer is applied as follows:

one "thin" layer, then another "thin" one on cooled ski sole;

a “thick” layer consists of two “average” layers applied onto a cooled ski sole.

Table 2

The testing chart of waxed skis

	“VISU” skis	“ESTONIA” skis
I	“thin” wax layer	“thin” wax layer
II	“average”	
III	“thick”	checkup
IV	10 km distance	checkup
V	paraffine	paraffine
VI	1 mm grooves	checkup
VII	checkup	2 mm grooves
VIII	10 km distance	checkup
IX	paraffine	paraffine
X	paste	
XI	checkup	paste

The skis were tested on descent. Figure 1 illustrates the testing procedure.

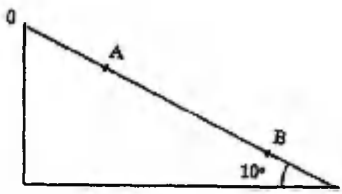

Fig. 1.

In point 0, the skier took in the basic descent position and started descent without pushing off. The time it took him to cover the distance AB was measured with a secondometre, by hand.

Each waxing variant was tested 14 times, the two best and two worst times were omitted when the results were analyzed. In addition, the snow and air temperatures, the structure of snow, and the kind of wax and manner of waxing were taken into account.

Analysis of Results

The results of the test are presented in Tables 3 and 4.

The testing of skis with a different thickness of wax layer proved that there is a basic difference in the slipping characteristics of “VISU FIBER” and “ESTONIA” skis ($Td_1 = 3.85$), which can be explained by the characteristic features of the slipping surface [12].

Results of testing competition skis (sec)

Snow t^o	Snow	"VISU" skis $\bar{x} + m_x$	δ	"ESTONIA" skis $\bar{x} + m_x$	δ	t_d
–11°C	I	6.29 + 0.15	0.48	7.02 + 0.11	0.36	3.85
	II	6.21 + 0.14	0.45	–	–	–
	III	6.89 + 0.13	0.41	7.03 + 0.13	0.40	0.77
	IV	7.02 + 0.11	0.36	7.36 + 0.10	0.33	2.27
–7°C	V	5.97 + 0.11	0.33	6.83 + 0.10	0.33	5.73
	VI	5.88 + 0.11	0.36	6.56 + 0.13	0.40	4.00
	VII	5.85 + 0.14	0.44	7.67 + 0.09	0.30	10.81
	VIII	6.80 + 0.15	0.48	7.43 + 0.12	0.37	3.29
–2°C	IX	5.94 + 0.12	0.37	6.92 + 0.13	0.41	5.41
	X	5.77 + 0.10	0.32	–	–	–
	XI	7.13 + 0.11	0.34	7.47 + 0.09	0.28	2.44

$T_{student} = 2.101$ ($\alpha = 0.05$)

Neither with "VISU" nor with "ESTONIA" skis was there any great difference noted in slipping with either the "thin" or the "average" wax layer ($Td_1 = 0.44$), whereas with the so-called "thick" wax layer ($Td_1 = 2.72$ and $Td_1 = 2.80$, correspondingly) the same skis slipped far worse. The thickness of the wax layer bears a considerable impact on the coefficient of friction of slipping [3]. Enlargement of the stopping surface always decreases slipping, a fact that proves the importance of the exact determining of the stopping surface.

After covering the 10 km distance on "VISU" skis, no trustworthy difference in the results of the slipping test was acquired, as compared to the starting level ($Td_1 = 0.74$). A certain shifting of the ski wax towards the heel of the ski was noted, in connection with which it is advisable to bring the edge of the stopping wax somewhat further up towards the ski toe. The "ESTONIA" skis which were used as control skis during the checkup, lost their slipping characteristics during pauses ($Td_1 = 2.84$), which can be explained by the influence of air humidity on a waxed ski sole. Therefore it can be recommended to keep skis after wax checkup in contact with snow [1].

The grooving of waxed ski soles with 1 mm wide grooves did not improve the slipping characteristics ($Td_1 = 0.43$), nor was any difference in slipping recorded after the 10 km distance was covered ($Td_1 = 0.60$). When the ski soles were grooved with 2 mm wide grooves, slipping worsened dramatically ($Td_1 = 6.30$), which can be explained with the too great roughness given to the slipping surface that is not suitable on large-grained snow (snow temperature was –7°C).

Grooving with wide grooves is advantageous in case a large amount

Table 4

Criteria of the trustability of testing skis (Td_1)

		I	II	III	IV	V	VI	VII	VIII	IX	X	XI
1.	I											
	II	0.44										
	III	2.73	2.80									
	IV	5.03	5.30	0.74								
	V											
	VI					0.43						
	VII					0.82	0.11					
	VIII					0.60	0.80	0.74				
	IX											
	X									0.93		
	XI									7.11	8.56	
2.	I											
	II											
	III	0.02										
	IV	6.30		2.84								
	V											
	VI					1.45						
	VII					6.30	5.66					
	VIII					3.97	5.99	1.80				
	IX											
	X											
	XI								3.31			

$T_{student} = 2.262$ ($\alpha = 0.05$)

of water is formed under slipping skis [20]. On the temperatures –5°C up to –10°C, the forming of the water film is obstructed [19]. Thus, the width of the grooves should be in correspondence to the content of free water in the snow cover.

The comparison of the slipping characteristics of waxed skis depending on weather conditions showed that in case of "VISU" skis, there is no great difference in slipping on dry fine-grained or dry large-grained snow (temperatures correspondingly –7°C and –11°C, $Td_1 = 0.93$), whereas if fresh snow starts to fall, slipping worsens considerably (Td_1 ='8.56). "ESTONIA" skis behave similarly to "VISU" skis. Fresh snow requires the using of strong waxes, especially when the temperatures are low [11]. The strength of the wax must correspond to the "microstrength" of the snow crystals [18].

The difference in the slipping characteristics of the tested skis in case of fresh falling snow decreases ($Td_1 = 2.44$), which can be explained by the somewhat bigger weight flexure of "ESTONIA" skis. To the contrary it has been found that skis with a smaller weight flexure slip better [12], but those experiments were made with solid or semisolid waxes, never with pastes.

Conclusion

The results of the test allow to conclude that a too thick layer of stopping wax worsens significantly the slipping characteristics of skis if the stopping wax expands over the limits determined by the weight flexure zone of the ski. Grooving with 2 mm wide grooves is not advantageous when the snow temperature is –7°C.

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PHYSICAL WORKING CAPACITY AND BLOOD LIPID AND LIPOPROTEIN CONCENTRATIONS IN YOUNG AND MIDDLE-AGED WOMEN WITH DIFFERENT PHYSICAL ACTIVITY

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Introduction

Lots of evidence on the individual role of physical activity as the primary prevention of coronary heart disease (CHD) has appeared [3, 22]. Physically active individuals live on the average 2 years longer than those who are inactive [15], the meta-analysis indicates that inactive individuals are 1.9 times more likely to develop CHD than the active ones [17].

The role of low physical activity as a risk factor of CHD in women is not well-known since this matter of women has been discussed only in a couple of studies and the results of the studies are note consistent [9, 10, 13, 19].

Cooper et al. [5] in a civilian male population and Patton et al. [16] in 40-year-old and older military males demonstrated an inverse relationship between aerobic power and examined all the CHD risk factors. The same data is not available on females.

Several studies insist that, especially in endurance sport events in males the concentration of plasma high-density-lipoprotein cholesterol (HDL-C) is high [2, 20], whereas the concentrations of total cholesterol (CHOL), low-density-lipoprotein cholesterol (LDL-C) and triacylglycerols (TG) are reduced [6], all in all decreasing the CHD risk. The high aerobic capacity is revealed to correlate negatively with CHOL and TG [14] and positively with HDL-C [2]. Relatively little information is available regarding the effects of regularly performed aerobic exercise on lipid metabolism in women [8, 12].

The aim of the study was to compare some CHD risk factors in young and middle-aged women with different physical activity.

Methods

128 females were studied, divided into 4 groups: 1. university students (18–25 years), physically moderately active, doing mostly aerobic exercises 3–4 times a week (n = 34), 2. university students (18–24 years) who had not exercised after graduating from secondary school (n = 37), 3. middle-aged females (40–50 years), physically moderately active, doing aerobic exercises 3–4 times a week (n = 27), 4. middle-aged females (40–50 years), never gone in for sports (n = 30). Only participants with no history of chronic diseases were included into the study.

The body height and weight were measured and the body mass index (BMI) was calculated (weight/height^2). The body composition was measured using the bioelectrical impedance method (BODYSTAT –500, United Kingdom). Physical working capacity was estimated with graded submaximal cycle ergometer test that was performed only in the morning. The initial load was set at 50 W (or 100 W) and the other one at 150 W (or 200 W), the duration of both loads was 4 minutes with a rest break of 1 minute between the loads. The heart rate of the women during the exercise was measured on the last 10 seconds of both loads (SPORTTESTER, PE –3000, Finland). Physical working capacity was defined as a work load at HR 170 beats $\cdot$ min^{-1} (PWC_{170}) and were calculated by interpolation. The PWC_{170} per one kilogram of body weight was calculated, too.

Subjects were fasted for 12 h and were prohibited to perform any vigorous activity for at least 24 h before visiting laboratory early in the morning for venous blood samples. In the blood plasma the CHOL, HDL-C and TG were measured by the enzymatic methods using a commercial reagent kit (LABSYSTEMS OY, Finland). The LDL-C was calculated with the help of the Friedewald et al. [7] equation. The HDL-C/CHOL ratio was calculated, too. Plasma glucose (GL) concentration was measured enzymatically using the BOEHRINGER MANNHEIM GmbH DIAGNOSTICA (GERMANY) kits.

Means ($\bar{x}$), standard deviations ($\pm$ SD) and linear correlation coefficients were calculated using statistical methods. Differences between the groups were tested for significance using one-way ANOVA.

Results and discussion

The baseline characteristics of the groups are presented in Table 1. There were no significant differences between young and middle-aged females with different physical activity in age, body height and weight. There were no significant differences in the body fat % between active and inactive groups, either.

Table 1

The mean anthropometrical measurements, physical working capacity and blood lipid and lipoprotein concentrations in females (means ± SD)

	Young females		Middle-aged females	
	Active (n = 27)	Passive (n = 30)	Active (n = 34)	Passive (n = 37)
Age (yrs)	21.2 ± 3.4	20.4 ± 2.4	42.4 ± 6.8	44.1 ± 7.4
Height (em)	166.7 ± 5.4	168.6 ± 6.0	164.3 ± 5.3	163.2 ± 5.8
Weight (kg)	60.0 ± 8.1	61.3 ± 10.7	64.3 ± 9.8	66.2 ± 9.6
B M I	21.5 ± 2.1	21.5 ± 2.7	23.9 ± 3.2	24.8 ± 2.7
F A T %	19.5 ± 4.4	20.4 ± 3.9	27.4 ± 5.9	29.3 ± 5.0
PWC_{170} ($kgm \cdot min^{-1}$)	919.9 ± 157.5	825.8 ± 183.1**	1042.8 ± 265.6	845.8 ± 119.6***
PWC_{170} ($kgm \cdot min^{-1} \cdot kg^{-1}$)	15.6 ± 2.4	13.5 ± 2.3***	16.0 ± 3.0	13.0 ± 2.3***
CHOL ($mmol \cdot l^{-1}$)	4.54 ± 1.16	4.21 ± 0.70	5.29 ± 1.14	5.27 ± 1.09
HDL-C ($mmol \cdot l^{-1}$)	1.65 ± 0.30	1.61 ± 0.30	1.74 ± 0.29	1.73 ± 0.30
LDL-C ($mmol \cdot l^{-1}$)	2.68 ± 1.08	2.49 ± 0.66	3.41 ± 1.17	3.37 ± 1.00
HDL/CHOL RATIO	37.7 ± 8.8	38.6 ± 8.7	33.9 ± 8.0	33.7 ± 6.9
TG ($mmol \cdot l^{-1}$)	0.73 ± 0.25	0.64 ± 0.18	0.80 ± 0.26	0.86 ± 0.21
GL ($mmol \cdot l^{-1}$)	4.28 ± 0.50	4.28 ± 0.44	4.12 ± 0.38	4.46 ± 0.52**

** $p < 0.01$
*** $p < 0.001$

The mean absolute and relative (per 1 kg body weight) value of PWC_{170} was significantly lower in both control groups (Table 1). If compared with others the PWC_{170}/kg was relatively high in both active and inactive young and middle-aged females [21].

There were no significant differences in the blood lipid and lipoprotein concentrations between active and inactive groups (Table 1). There are data available that only relatively high running training loads (30 miles/week) may increase HDL-C concentrations in the blood in females [18] and as a rule, moderate exercise did not cause changes in HDL-C and LDL-C concentrations [1, 11]. It is well-known that women have normally higher values of HDL-C than men [4]. It seems reasonable to infer than moderate physical activity does not cause significant changes in blood lipid and lipoprotein concentrations in the blood in either young or middle-aged females.

We must conclude that there are no significant differences between the moderately trained and untrained young and middle-aged groups of females in blood lipid concentrations. On the other hand, the physical activity increased physical working capacity.

ACKNOWLEDGEMENTS. The author would like to thank the BODYSTAT LIMITED (GREAT BRITAIN) managing director I. J. Meeuwsen for his help with the apparatus for measuring body composition.

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THE BLOOD LIPID AND LIPOPROTEIN CONCENTRATIONS AND FLEXIBILITY (PRELIMINARY STUDY)

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Introduction

Numerous studies have reported of associations between plasma lipid and lipoprotein concentrations and coronary heart disease [CHD, 3, 9]. A positive relationship between serum total cholesterol (CHOL) and low-density-lipoprotein cholesterol (LDL-C) and a negative correlation between high-density-lipoprotein cholesterol (HDL-C) and CHD risk have been established [4].

The relevant components of fitness are aerobic, muscular and motor abilities and flexibility. Especially regular aerobic exercises increase physical fitness, improve lipid metabolism and reduce body fat, in total decrease CHD risk. There is no direct evidence to show a significant relationship between blood lipid concentrations and flexibility. It is well-known that habitual physical activity improves the structure and function of ligaments, tendons and joints [7]. On the other hand, the individuals are likely to have a lower risk of orthopedic injuries and lower back problems if they have normal flexibility. The loss of flexibility may result in serious muscoloskeletal problems that can result in poor posture and excessive pain [1]. Are there any relationships with atherosclerotic processes?

The purpose of this research was to study the relationships between blood lipid and lipoprotein concentrations and flexibility in middle-aged males and females.

Methods

The subjects were 21 middle-aged (40–50-year-old) males (n = 7) and females (n = 14).

Flexibility measurements. The active range of motion (ROM) of the neck joint was measured by the gravity goniometer according to the positions of AAOS [7]. For measuring the neck extension and flexion (ROM) the instrument was fastened to the side of the head over the ear (auditory meatus). The scores for neck flexion were taken when the subject lowered the head forward to a position as near to the chest as possible and the neck extension when the head was lowered to the backward maximum position. For measuring the lateral flexion to the left and right directions the instrument was fastened to the head so that its center was aligned with the occiptionasal line. The scores for lateral neck flexions were taken with the head moved to both directions as far as possible. For measuring the neck rotation the instrument was fastened on the top of the head and the center of the instrument was aligned with the occiptionasal line. The subject was in a supine position on a bench so that head and neck projected over the edge of the bench. The scores for left and right rotation were taken when the head moved to both direction as far as possible. For measuring the shoulder flexion and extension the instrument was fastened to the lateral side of the left upper arm and the center of the instrument was on the line joining the lateral epicondyle of the humerus and the glenohumeral joints' centre. The subject was in the standing position at a projecting corner of a wall. The scores of the extension and flexion were taken when the arm moved accordingly downward and backward and forward and upward.

For measuring the shoulder rotation the instrument was fastened to the left ulnar side of the forearm and the center of the instrument was on a line from the decranon process to the ulnar styloid process. The subject was in a standing position of a corner of a wall.

Blood samples. Venous blood samples were enzymatically analyzed for total cholesterol (CHOL), high-density-lipoprotein cholesterol (HDL-C), triacylglycerols (TG) and glucose (GL). The low-density-lipoprotein cholesterol (LDL-C) was calculated using the Friedewald *et al.* [5] equation, the ratio of HDL-C/CHOL was calculated, too.

Statistical analysis. Standard SYSTAT statistical packages were used for estimating means and standard deviations. Pearson product — moment coefficient of correlation between test scores were established.

Results and discussions

The subjects mean blood lipid and lipoprotein concentrations are presented in Table 1. If compared with others [8] we must conclude that the mean concentration was relatively low. Nobody of our subjects was hyperlipidemic.

The flexibility of the neck and shoulder are presented in Ta-

Table 1

The mean blood lipid and lipoprotein concentrations and neck and shoulder flexibility parameters of the subjects ($\bar{x} \pm SD$)

CHOL ($mmol \cdot l^{-1}$)	4.27 ± 0.40
HDL-C ($mmol \cdot l^{-1}$)	1.54 ± 0.31
LDL-C ($mmol \cdot l^{-1}$)	2.46 ± 0.58
TG ($mmol \cdot l^{-1}$)	0.73 ± 0.22
HDL-C/CHOL ratio	36.2 ± 1.3
Neck flexion (degrees)	54.95 ± 13.10
Neck extension (degrees)	81.81 ± 18.51
Neck lateral flexion to the right (degrees)	49.52 ± 13.52
Neck lateral flexion to the left (degrees)	45.00 ± 5.81
Neck rotation to the right (degrees)	79.05 ± 12.22
Neck rotation to the left (degrees)	84.10 ± 9.52
Shoulder flexion (degrees)	183.00 ± 17.71
Shoulder extension (degrees)	56.86 ± 27.00
Shoulder internal rotation (degrees)	159.71 ± 17.00
Shoulder external rotation (degrees)	28.00 ± 12.10

ble 1. The mean results were relatively similar with the others [6, 10]. The results of the correlation analyses indicate that there are significant relationships between neck rotation to the left and CHOL (r = –0.567), LDL-C (r = –0.644) concentrations and HDL/CHOL ratio (r = 0.605). The neck rotation to the right correlated significantly with CHOL (r = –0.544) and LDL-C (r = –0.498) concentrations on the blood. The mechanism of the relationships is not known. Maybe it is possible to explain it with the fact that the flexibility is dependent on the elasticity in muscle fibers and tendons [2].

In conclusion, mostly the neck flexibility has a close relationship with different blood lipid and lipoprotein concentrations. The influence of flexibility to the different CHD risk factors needs more research.

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A PILOT STUDY OF INTERRELATIONS BETWEEN GROWTH, FITNESS DEVELOPMENT AND SEXUAL MATURATION IN 10 TO 14 YEAR OLD GIRLS

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Abstract

The study was aimed to compare the growth and physical fitness level with the stadium of sexual maturation in 10 to 14-year old girls. Subjects were 58 girls, divided into 3 groups by Tanner's stages (I, II or III). In addition to anthropometric measurements the persons performed 9 fitness tests in January and May. Significant differences were found between girls of stages I and III in height, weight, sitting height, chest, suprailiac and bicondylar circumferences, and biacromal, bicristal and bicondylar breadths. Between stages II and III significant differences were in sitting height, biacromial and bicristal breadths. Significant differences were found in skinfold measured at medial thigh and on the abdomen. The differences between results of fitness tests were insignificant in January. In May significant improvements in results of the 4 × 9 m shuttle-run were detected in stadium II and of the 20 m run in stadium III. In conclusion, the development of physical abilities is different in various stadiums of sexual maturation.

Introduction

The uniform organization of physical education ignores biological age and sensitive periods of the individual ontogenesis [10, 17]. It has been demonstrated that the training effect is most pronounced when exercises influence a concrete physical ability in the sensitive period of ontogenetic development of functions constituting a background for the ability [6, 8]. The sensitivity of ontogenetic development to influencing factors may alter during sexual maturation. A great variability has been found in trainability of aerobic work capacity in prepubescent girls [1, 2, 14, 19]. At least in part this variability can be related to the dynamics of sexual maturation. A comparatively low aerobic trainability before puberty has been reported [1]. It was suggested that the increase in absolute values of maximal oxygen uptake prior to the age of peak height velocity is caused by growth in body size with only a negligible effect of such factors as physical activity [15]. Accordingly an increased maximal oxygen uptake response to training was found at the time of the adolescent growth spurt [12]. In prepubescent children dynamic strength training is less effective than in older children [20]. In girls a pronounced increase in strength occurs during the peak of height velocity [5]. These results constitute a background for the hypothesis that the effect of physical education varies in dependence of stadiums of sexual maturation. This pilot study was aimed to compare the growth and physical fitness level with stadium of sexual maturation in 10 to 14-years old girls.

Material and methods

Subjects were 58 girls of 10 to 14-years old. None of the subjects suffered from chronic diseases. They were considered to be practically healthy by the medical control in school. Subjects participated in school physical education twice in week. The studied girls did not participate in sports training.

Physical education classes consisted of exercises for improved endurance, skill, coordination, flexibility, speed and power. Various gymnastic exercises, including aerobic gymnastics and acrobatics, as well as running, skiing, jumping were used.

Methods: The degree of sexual maturation was evaluated by Tanner's stages [18] and bone age. The latter was evaluated by x-ray picture of the wrist [7]. Growth was assessed by height, weight, sitting height (up to the suprailiac level), chest, suprailiac and bicondylar circumferences, biacromial, bicristal and bicondylar breaths. Skinfold was measured at 7 points on the right side of the body, using a caliper produced in University of Tartu (Estonia).

The fitness tests were Cooper's test, Harvard step-test, 4 $\times$ 9 m shuttle run, 20 m run, sit-ups in 30s, squats in 30s, trunk forward flexion, and standing broad jump. Fitness test was performed in January and again in May. After the Cooper test, the heart rate recovery was estimated by an index analogical to the Harvard step-test index [11].

Statistics: The results were analyzed with the aid of the ANOVA procedure.

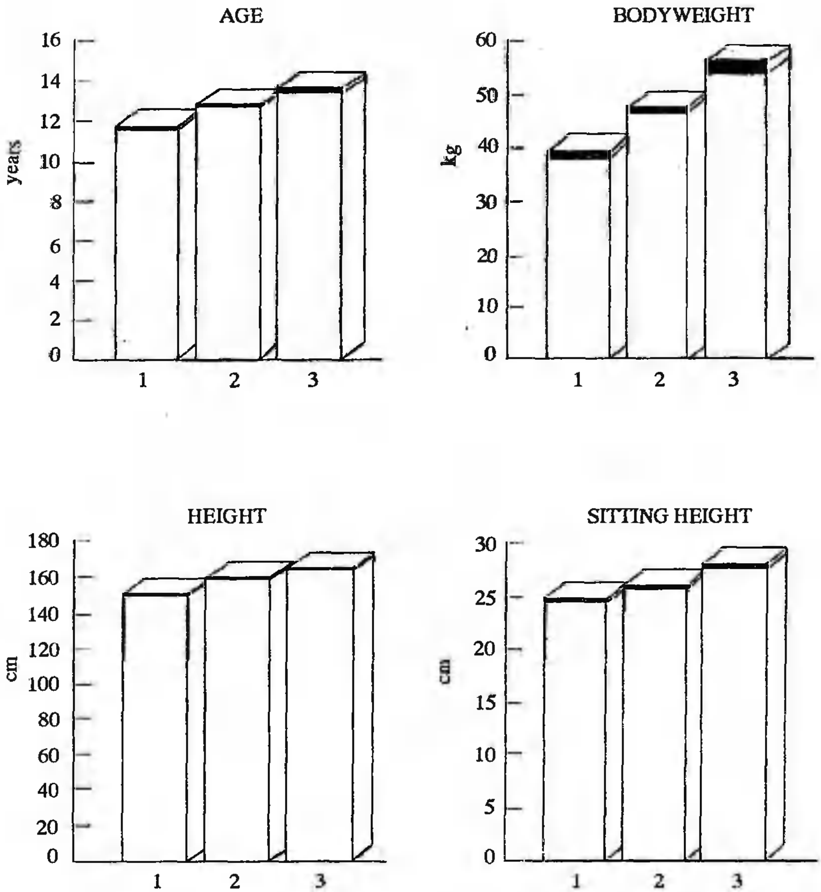

Fig. 1. Age, weight, height and sitting height (up to suprailac level) in dependence on the maturation stadiums. Numbers under the columns indicate the stages. Means ± SEM are indicated.

Results

According to Tanner's criteria the stage I was detected in 23 girls, stadium II in 22 girls, and stadium III in 13 girls.

Significant differences were found between girls of stages I and III in height, weight, sitting height (Fig. 1), chest, suprailiac and bicristal circumferences, and biacromal, bicristal and bicondylar breadths (Fig. 2). Between stages II and III significant differences were found

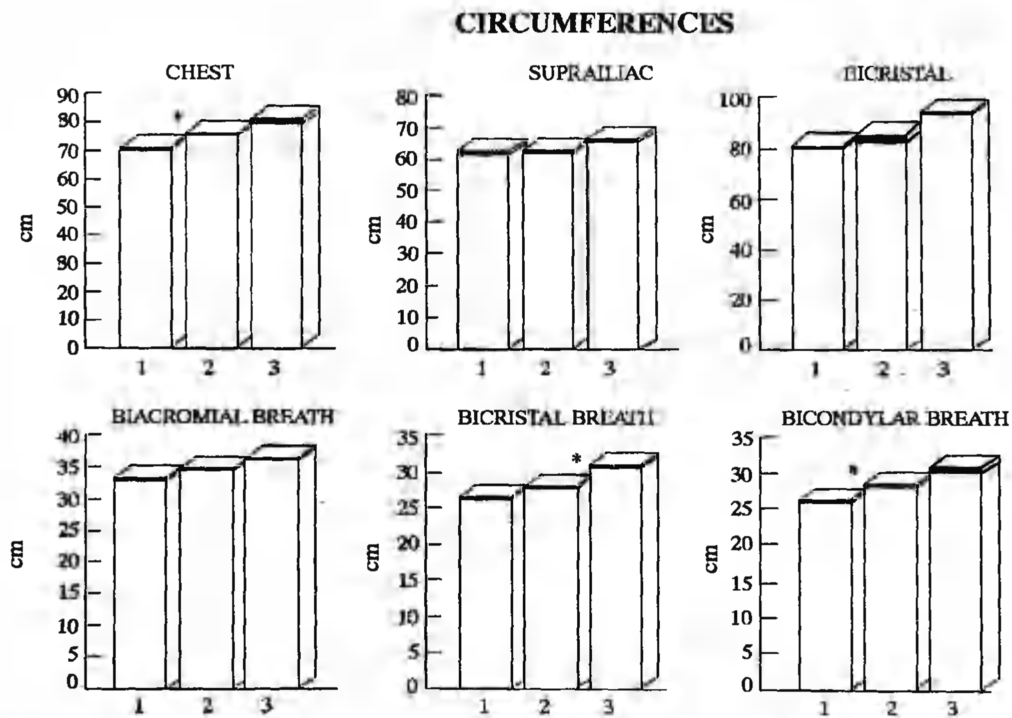

Fig. 2. Circumferences and breadth in dependence of the maturation stages. For further explanation see Fig. 1.

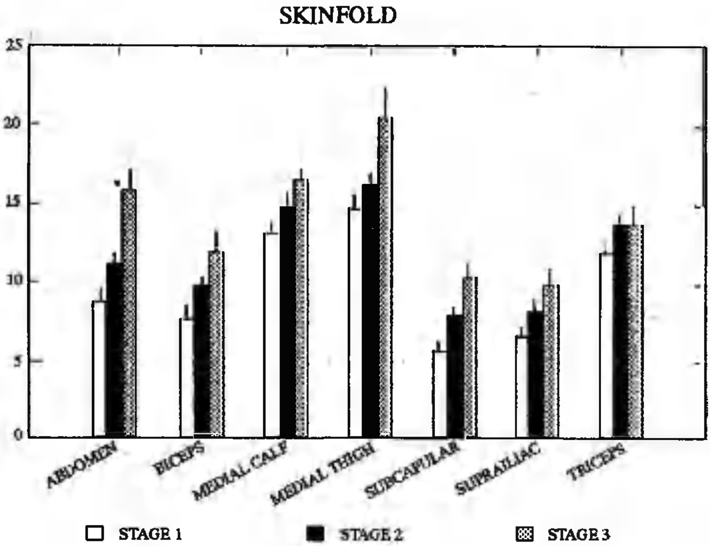

Fig. 3. Skinfold measurement in girls of different maturation stages.

in sitting height, biacromial and bicristal breadths. Significant differences were found in skinfold measured at medial thigh and on the abdomen (Fig. 3). The differences between results of fitness tests were insignificant in January (Table 1).

Table 1

Results of fitness test in January in dependence of the maturation stages

Test	Sexual maturation stages		
	I	II	III
1. Cooper 12 min test	2278 ± 47.3	2367 ± 58	2170 ± 59.1
2. HR index after Cooper test	83.4 ± 5.1	99.7 ± 3.9	93.5 ± 4.8
3. Harvard steptest index	114.4 ± 22.9	94.9 ± 2.7	92.8 ± 3.7
4. Shuttle run	12.0 ± 0.3	12.1 ± 0.1	12.0 ± 0.3
5. 20 m run	4.3 ± 0.1	4.2 ± 0.1	4.5 ± 0.1
6. Sit-upr 30 sec	20.0 ± 0.8	19.4 ± 0.9	18.3 ± 1.2
7. Standing board jump	1.6 ± 0.1	1.7 ± 0.1	1.7 ± 0.0
8. Squats in 30 sec	29.5 ± 0.7	28.0 ± 0.6	28.4 ± 0.6
9. Trunk forward flexions	10.8 ± 1.1	14.1 ± 0.9	13.5 ± 1.6

Comparison of results obtained in January and May revealed significant reduction of endurance judged by Cooper's test (Fig. 4). How-

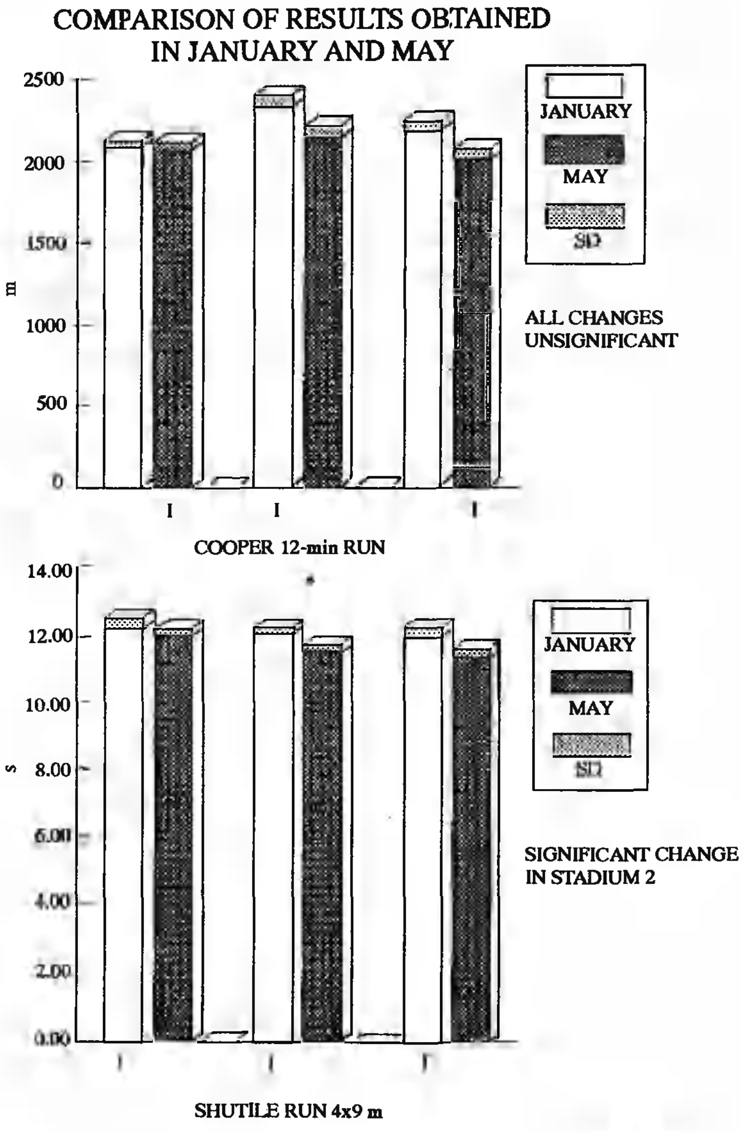

Fig. 4. Comparison of results of Cooper's test and shuttle run, obtained in January (white columns) and May (striated columns). Means ± SEM are indicated.

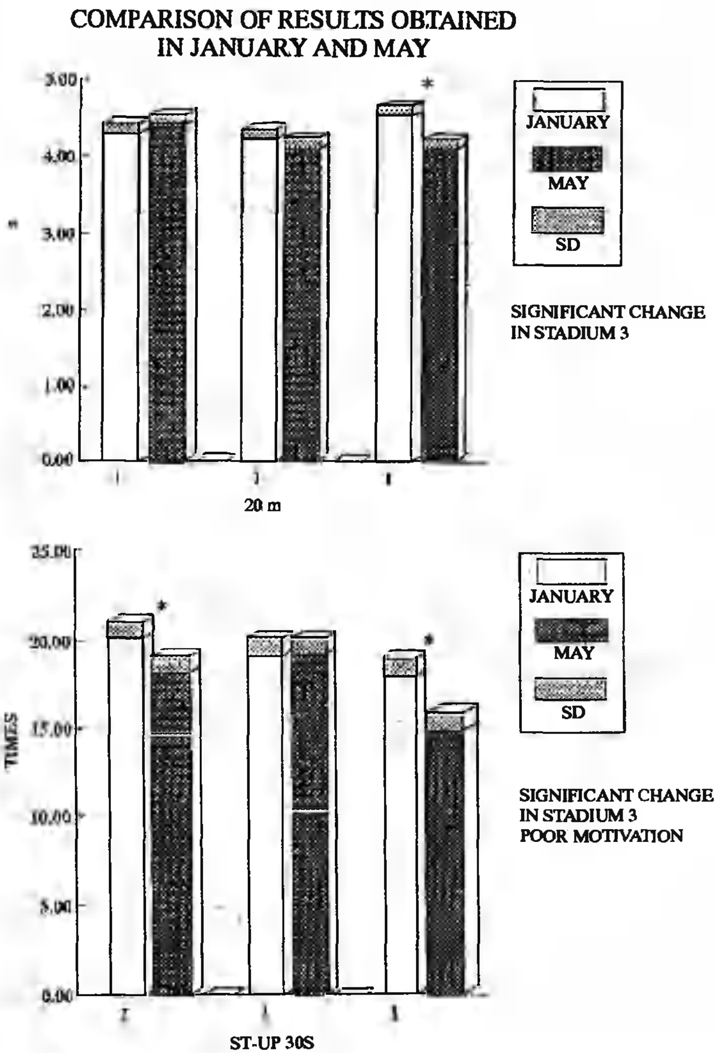

Fig. 5. Comparison of results of 20 m run and sit-ups in 30s, obtained in January (white columns) and in May (striated columns). Means ± SEM are indicated.

ever, heart rate recovery after the test did not change. Significant improvement in the results of shuttle run (Fig. 4) was detected in stage II and of 20 m run in stage III (Fig. 5). Significant changes were not found in results of standing broad jump and Harvard step-test index. The number of sit-ups in 30s decreased in stage I and III.

Discussion

The used contingent of girls fits well by height, weight, sitting height and skinfold measures with the results generalized in the manual written by M. Malina and C. Bouchard [13]. Neither are there any significant differences in the results of most fitness tests referred to in various issues [9, 13, 16]. Thus, the studied contingent may be considered to be representative. The results of anthropometric measures agrees with the general opinion about growth dependence on sexual maturation.

In tests performed in January no significant difference was established between girls with maturation stages I, II or III. This result is in agreement with a conclusion that correlations between sexual maturation and performance are low in girls [3, 4]. However, by the obtained results the changes within a period of 5 months of ordinary physical education were different in dependence of sexual maturation stages. Girls of stage II seemed to be the most sensitive to influences promoting the improvement in the result of the shuttle run. Girls with stage III exhibited an improvement in the results of 20 m run.

In conclusion, the results confirmed the hypothesis that the development of physical abilities is different in various stages of sexual maturation. Nevertheless, the results have to be considered as a product of a pilot study. Further studies are necessary.

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PECULIARITIES OF PERIPHERAL AND SYSTEMATIC BLOOD CIRCULATION AT LOCAL STATIC WORK

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Abstract

Changes in systematic and peripheral circulation of the blood have been registered after work of submaximum intensity. With the help of venous occlusive plethysmography by the method of peripheral circulation of the blood and reography, indices of systematic circulation of the blood were registered (systolic and minute heart volumes, frequency of heart contractions).

Persons under investigation were 18–21 year-old healthy students who were regularly training.

Static work at 75% maximum determined force was performed till inability to continue. It was performed (for the sake of convenience) holding the equipment and not holding it. Maximum determined force of shin muscles was essentially higher when persons under investigation were holding the equipment. This shows that active work of other muscles gave more favorable conditions for performing attempts of local nature.

When persons under investigation are holding the equipment, changes in systematic circulation of the blood are bigger and, at the same time, a larger amount of muscles participate in the work. Changes in peripheral circulation of the blood are bigger in performing more definite local physical charge, when fewer groups of muscles participate in this work.

Introduction

Training and adaptation of circulation of the blood and respiratory system organs for physical work is one of the most important factors de termining oxygen supply speed. Training of tenacity sports is mostly directed toward developing these physiological mechanism. A coach usually has no possibilities to estimate directly the adaptive changes in these systems, that is why various testing exercises on estimating the working capacity are applied. In choosing the testing exercises it is necessary that the selected exercise should characterize, as precisely as possible, the working capacity and adaptive indications of these systems. The goal of this work is to investigate the informativeness of local static exercises by estimating changes in circulation of the blood, when work of submaximum intensity is performed.

Material and methods

With the help of venous occlusive plethysmography the following blood amount in the shin muscles was registered. By tetrapolar reography method the systolic, minute heart volumes and frequency of heart contractions were registered. The muscle force and working capacity were estimated by registering a maximum determined force. With the help of a special leg ergographer a static foot bending work was estimated. The tests were performed in the following sequence:

1. Local static work at 75% maximum determined force until inability to continue without holding the equipment.
2. Local static work at 75% maximum determined force until inability to continue holding the equipment.

In both tests two static charges were carried out with the interval of 20 minutes. 10 persons under investigation participated.

Results

The maximum determined force when persons under investigation were holding the equipment was 778.6 ± 28.4 N. Without holding the equipment it was 662.9 ± 23.5 N ($p < 0.01$, Figure 1A).

During the second test after the 20 minute rest the maximum determined force was accordingly: 774.7 ± 30.4 N and 665.9 ± 23.0 N ($p < 0.025$).

Duration of static work after charge holding the equipment was 75.9 ± 3.8 s, without holding the equipment — 78.0 ± 4.25 s ($p > 0.05$, Figure 1B).

During the second test after the 20 minute rest the duration of static work was accordingly: 70.8 ± 2.8 s and 73.6 ± 4.6 s ($p > 0.05$).

Before the static work in a resting state systolic and minute heart volumes and frequency of heart contractions (Figures 2, 3, 4) were 77.0 ± 7.0 ml, 5.1 ± 0.5 liters/min, 66.0 ± 3.0 beats/min (holding the equipment), 71.0 ± 3.6 ml, 5.0 ± 0.3 liters/min, 70.0 ± 3.0 beats/min (without holding the equipment).

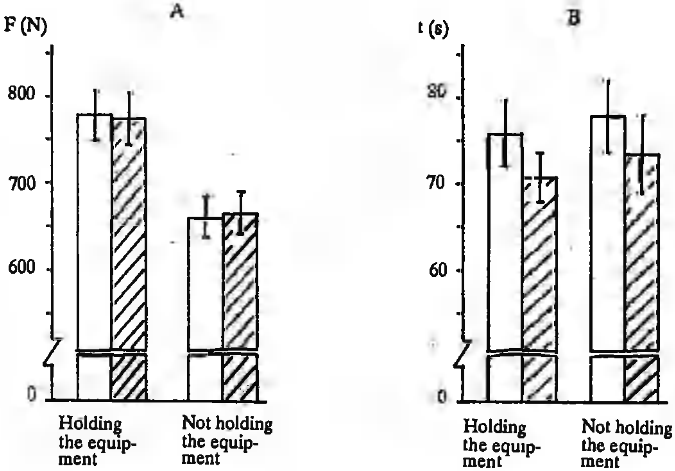

Fig. 1. Maximum determined force of shin muscles (A) and static work duration (B).
□ – The first test ▨ – The second test after 20 min

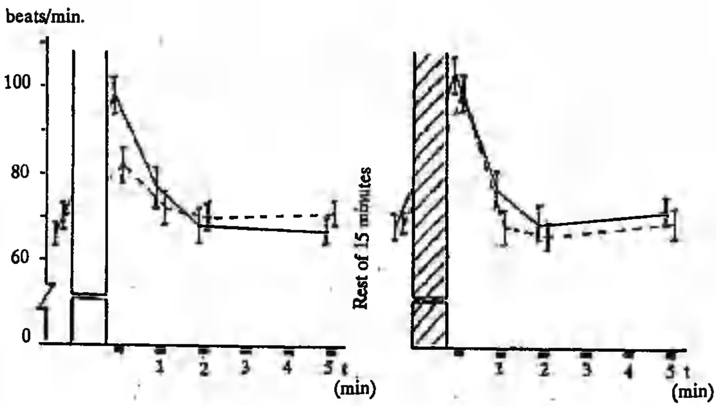

Fig. 2. Dynamics of heart contraction frequency.
—— – Holding the equipment ---- – Not holding the equipment
□ – The first static work ▨ – The second static work

Indices of systematic circulation of the blood after static work: systolic, minute heart volumes and frequency of heart contractions when holding the equipment increased up to 107.0 ± 8.0 ml, 20.4 ± 0.8 liters/min, 98.0 ± 4.0 beats/min. Without holding the equipment accordingly: 206.0 ± 7.0 ml, 8.7 ± 0.6 liters/min, 82.0 ± 4.0 beats/min. When persons under investigation were holding the instrument during the first and second minutes after static work, systolic and minute heart volumes were smaller and recovering was quicker than with persons who were holding the equipment. Frequency of heart contractions when holding the equipment was essentially bigger ($p < 0.025$, Figure 2) only after the static charge.

Before the second static work in both tests indices of systematic circulation of the blood were the same, as before the first one in a resting state. After the repeated static work the systolic and minute heart volumes and frequency of heart contractions also increased. After the second static work systolic and minute heart volumes and frequency of heart contractions were 107.0 ± 7.7 ml, 11.0 ± 0.7 liters/min, 103.0 ± 4.0 beats/min (holding the equipment).

Recovery indices of systolic and minute heart volumes and frequency of heart contractions were performed similarly to after the first work.

Peripheral circulation of the blood (Figure 5) in working muscles was activized more when persons under investigation performed a static work, by activizing foot bending muscles without holding the equipment. It increased from 2.8 ± 0.2 ml/min/100 cm^3 up to 68.7 ± 4.0 ml/min/100 cm^3. When persons under investigation were holding the equipment, circulation of the blood increased from 2.3 ± 0.2 ml/min/100 cm^3 up to 55.4 ± 4.4 ml/min/100 cm^3. Differences of intensity in circulation of the blood were observed up to 50 seconds. In the further course of recovery no essential differences were observed. Circulation of the blood was registered for 5 minutes and its increase more than twice was observed in both tests even on the fifth minute. After 20 minutes of static work the amount of flowing blood (before the second work) was essentially bigger when holding the equipment: 3.5 ± 0.4 ml/min/100 cm^3 ($p < 0.05$), and without holding the equipment: 3.7 ± 0.3 ml/min/100 cm^3 ($p < 0.025$). After the repeated charge in both tests circulation of the blood increased even more: up to 62.9 ± 4.2 ml/min/100 cm^3 (holding the equipment), and 78.5 ± 4.8 ml/min/100 cm^3 (without holding). Recovery character of circulation of the blood in shin muscles after the second static work was performed in similarly to after the first one.

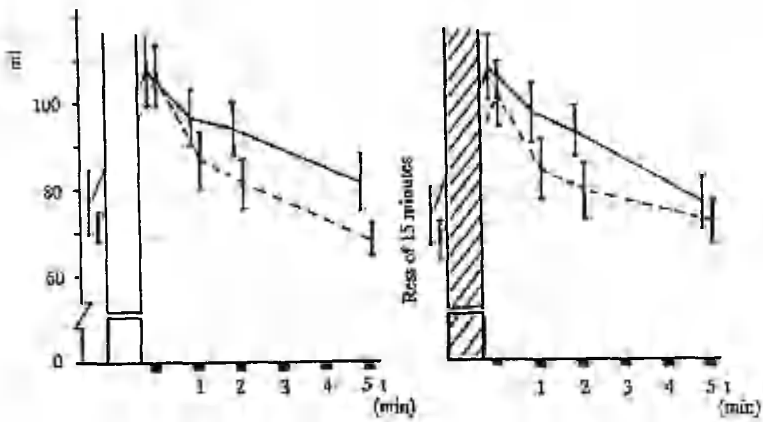

Fig. 3. Dynamics of systolic heart volume.
___ – Holding the equipment ---- – Not holding the equipment
[ ] – The first static work /////– The second static work

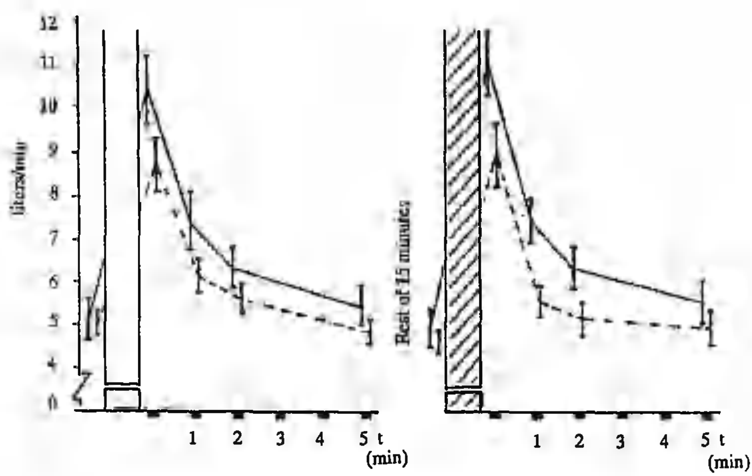

Fig. 4. Dynamics of minute heart volume.
___ – Holding the equipment ---- – Not holding the equipment
[ ] – The first static work ///// – The second static work

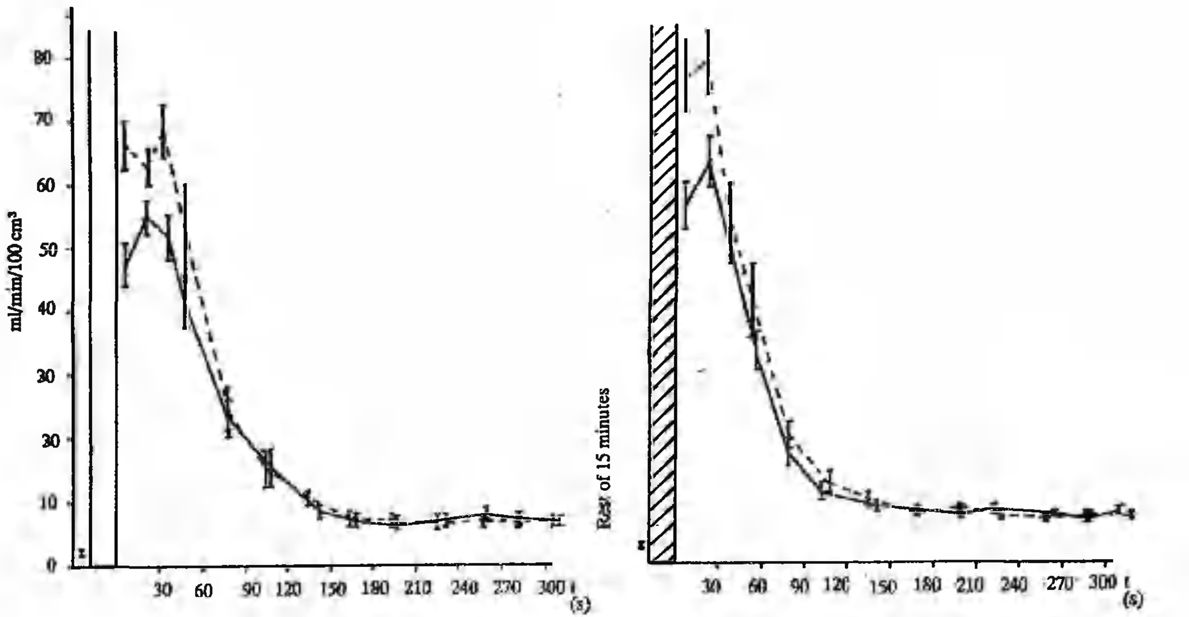

Fig. 5. The flowing blood amount of shin muscles after static work consisting of 75% of the maximum determined force.
— – Holding the equipment
- - - - – Not holding the equipment
▭ – The first static work
//// – The second static work

Discussion

Muscle force is one of the integral indices of the muscle capacity for work. Force is a very important functional state index in the nerve-muscle apparatus [14]. Force tests demand conditions of standard force measuring. Depending on the amount of the participating muscles, the registered force quantities may differ essentially [4, 6, 8]. Lower quantities of force indices are achieved when the person under investigation is not holding the equipment; that is why foot bending muscle work is of a strictly local nature. Higher force indices are achieved when holding the equipment (for the sake of convenience). This creates better conditions for the working muscles.

Testing results of muscle weariness are more reliable than force measurings. Static work until inability to continue is applied to estimate the working capacity and to characterize physiological adaptive changes [1, 2, 3]. The estimation criterion of static work duration is the time during which the person under investigation manages to maintain the planned muscle contraction force. Quantity of the performed work is expressed by $F \cdot t_{max}$ [8]. Duration of static work in both tests (holding and without holding the equipment) differs very slightly. In choosing the estimation criterion of working capacity, it is important to know which functional systems activities determine the working capacity level. By submaximum intensity work we estimate functional and adaptive changes, limiting working capacity in systems of respiratory organs and circulation of the blood [10].

Changes in systolic heart are valued differently by various authors. Systolic heart volume has a great influence on the increase of minute heart volume [9, 13]. Others note that systolic heart volume increases very slightly. Increase of the minute heart volume is linked with significant changes in the frequency of heart contraction [11, 16]. After the first and the second local static work the minute heart volume increased with changes in systolic heart volume and frequency of heart contractions. In the recovery process (after 1, 2 minutes) the minute heart volume remains increased and this increase is determined by systolic heart volume.

Muscle contraction squeezes blood vessels and stops up circulation of the blood. Thus, the reaction of blood vessels is expressed by metabolic mechanisms in distension of blood vessels, nervous effect and mechanic obstructions of blood vessels. The effect of mechanical factor is displayed by powerful isometric muscle contraction (i.e. 70% of maximum determined contraction). Circulation of the blood is stopped up, weariness develops rapidly and because of muscle loosening, a clearly expressed post-work hyperemia is developing [15].

Repeated work challenges more striking changes in systematic and peripheral circulation of the blood and shows reiteration and informativeness. After the 20 minute rest, the duration of static work is slightly shorter, and changes in systematic and peripheral circulation of the blood are greater. Peripheral circulation of the blood before the second repeated charge is not recovered up to the background level and is essentially bigger. This shows that such a testing exercise in estimating working capacity could be applied as a single test. Estimating efficiency in applying various measures, it is necessary to take into consideration the degree of non-recovery of working capacity. Indices of peripheral and systematic circulation of the blood show different value of physiological working capacity. Changes in circulation of the blood occur depending on work nature. Post-work hyperemia occured in the chiefly working muscles in principle of re-division in circulation of the blood [5, 7, 12, 17]. When more muscle groups participate, changes in systematic circulation of the blood are more evident. When less muscle groups (i.e. working with one leg) participate, the greatest changes are in working muscles and little changes occur in systematic circulation of the blood [5, 7, 10].

Conclusions

1. Static work until inability to continue in the area of submaximum intensity can be performed (for the sake of convenience) by using pose muscles or without them.

2. Changes in systematic circulation of the blood are more considerable in work when more groups of muscles participate. Changes in peripheral circulation of the blood are more distinct when local physical work is done.

3. In estimating working capacity in local working muscles and their blood supply it is expedient to perform work without other muscle groups participating there.

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FACTORS INFLUENCING THE COMPETITION RESULT AND FUNCTIONAL PREPARATION STRUCTURE IN DIFFERENT RUNNING DISTANCES

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The competition result in middle- and long distance running is first of all determined by the level of specific endurance. Depending on the distance, it can be based on the aerobic, lactic (glycolytic) or alactic energy supply or on their combinations. Thus, the components of functional preparation, at least on the specialized preparation stage, have to correspond as accurately as possible to the concrete competition activity [2, 9, 12, 16].

The coach whose aim is to attain success has a narrow target in the planning and management of training — the competition result. In a wider sense, the term "performance prognosis" has been applied recently [1, 3]. Performance diagnosis and process diagnosis contribute to the prognosis validity, accuracy and attainability [3]. The performance diagnosis identifies the performance — limiting factors, helps to establish individual variability in the observed factors etc. The process diagnosis characterizes individual performance development and development trends concerning both functional preparation as well as different training parametres in the course of a longer period. By uniting the biological and pedagogical criteria of the training management, the process diagnosis creates an objective basis for process prognosis as well.

As concerns the management of developing the functional possibilities of the organism in the sports training process, the starting point has for a long time been developing the set of physical abilities (strength, velocity, endurance, coordination). These components, however, give only a general idea of specialized working capacity and do not proceed from its biological essence and characteristic features. Being based on the empirical-analytical thinking ("from the part to the whole"), the comparison of collected facts and the establishment of the most suitable ones via the trial-and-error method, this approach has exhausted itself.

In training and competition activity we have to deal not with single, isolated motor abilities and physiological functions, but with a whole, living organism, representing a unified motor-functional system. These functional systems, specific for every distance, are formed and develop on the effect of the corresponding motor activity, the dominant muscle work regimen. Proceeding from this, it is necessary to know the biological essence of the competition and training activity and to elaborate pedagogical concepts on its basis.

The aim of the present study is to give theoretical grounds for the set of generalized physiological indices of middle- and long-distance runners' preparation and for its applicability in the biologically grounded structure of training for different running distances.

Functional preparation

The functional preparation of athletes can be observed as the integral characteristics of man's functions and abilities that either directly or indirectly conditions the competition activity efficiency [13].

It is expedient to differentiate between the functional possibilities and the functional abilities as factors of sports performance capacity [18]. A functional possibility is the potential possibility for the maximal intensification of a function, whereas a functional ability consists in the largest part of the functional possibility that can be used in a concrete situation and concrete activity.

Expedient functional preparation guarantees efficient adaptation to the training and competition conditions — morphofunctional specialization [17]. The biological basis of the latter is formed by the functional universality and selective adaptive activity of the organism. Increasing the functional possibilities of the organism is closely connected with the set of certain basic physiological properties - components of the functional preparation. Only the multicomponent analysis makes it possible to give an adequate estimation of the functional preparation and the reserve possibihties of the organism [5, 7].

Components of functional preparation

The studies by A.Korobov and N.Volkov [11] have revealed that the results of a middle- and long-distance runner are influenced by the power, capacity and efficiency of bioenergetical processes. The mentioned criteria characterize aerobic, glycolytic, as well as alactic processes. For example, aerobic power is characterized by $V.O_2max$ or critical velocity. Aerobic capacity is characterized by the time of maintaining the critical velocity. Aerobic efficiency shows the usage level of aerobic and anaerobic energy processes on performing specific loads and is characterized by the velocity of the anaerobic threshold.

V.Mishtshenko [13] has distinguished between 5 components in the functional preparation structure:

1) power, determining the upper limit of functional systems;

2) mobility, determining the speed and recovery of the branching of functional and metabolic processes in the course of work;

3) economy determines the functional and metabolic "price" of the given loads;

4) stability — the ability to maintain high levels of the functioning of energetical and functional systems, avoiding the shifts in inner environment basic constants;

5) realization level of the functional potential in dependence on various conditions.

In concrete athletes the mentioned components may vary in a large range. In topclass athletes the functional stability is the most and the functional power the least changeable characteristic in the annual training cycle.

As a rule, large training volumes improve economy. The rivalling relations between the functional power and economy occur relatively often — an athlete possessing high maximal O_2 uptake (aerobic power) can be uneconomic in energy expenditure and vice versa. The studies conducted by D. Conley *et al.* [4] have revealed that the success of S. Scott, the middle-distance runner of high international level, was guaranteed by the simultaneous development of both aerobic power and metabolic economy prior to performing a top result.

The components of functional preparation are tightly connected with and dependent on each other. E.g. the functional stability depends on power and economy, the more efficient realization of the functions are connected with their stability. The level of the basic components of the functional preparation can be estimated on the basis of the characteristic indices set for each component. Depending on the specific properties of an event, a narrow or wide range of tests is applied for this purpose. The wide range of tests makes it possible to assess in a detailed way the corresponding component, helping to establish single shortcomings, but is work-consuming. It proves first of all expedient in the events where anaerobic energy production has an important role as well. The narrow range of tests is directed more towards single integral indices.

Physiological factors limiting specific endurance

The mechanisms of specific endurance in concrete competition conditions differ in dependence on the distance — covering duration [8, 10, 15]. On the latter depends the maximal intensity of energy expenditure and the strength component of the work of cyclic nature. The latter is expressed in the percentage from the maximal strength that can be developed in one movement cycle [13].

On the distances of 1–2 min. duration, the main factors limiting the working capacity are the power of glycolysis, the ability to endure heightened lactate level and low pH, the inhibiting effect of lactate on glycolytic enzymes, the amount of glycogen reserves. The value of the strength component is 50–30%.

On the distances of 3–10 min. duration, the working capacity is limited by the aerobic power, efficiency of central hemodynamics, the power of buffer systems and the ability to endure acidose, the ability to maintain the critical velocity, the efficiency of lactate utilization. The value of the strength component is 30–20%.

On superlong distances of 2–3 hour duration the factors limiting the working capacity are the metabolic productivity of the organism, the level of anaerobic threshold speed, efficiency of fat metabolism, the amount of energy, water and salt reserves in the organism, the stability of body temperature. The value of the strength component is less than 15%.

Subordinate relations between the competition result and functional preparation structure

Fig. 1 presents the functional preparation process as a system in which the competition result is both the aim of the system and the organizing factor of functional preparation components. The figure shows a possibility for the buildup of the training structure proceeding from its biological essence. The system is based on the generalizing physiological factors limiting the specialized working capacity in competition conditions as well as on the indices on the basis of which it is possible to compile the optimal programme for connecting training means for every concrete distance. In compiling the programme, the individual characteristic features of the runners have to be considered [6, 14], as well as the strong and weak points in their functional preparation that are determined in the course of testing. Estimation of the dynamics of both competition result and level of special endurance guarantees the necessary feedback for optimal function of the sys-

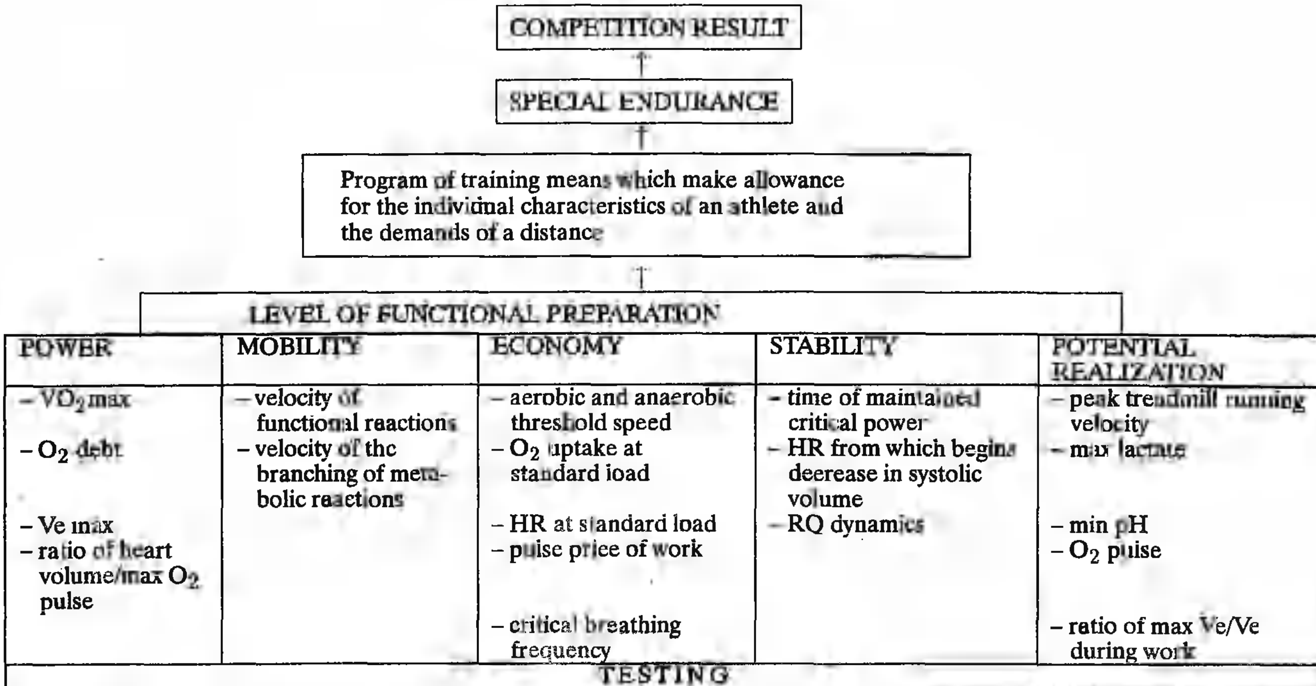

Fig. 1. Factors influencing the competition result and the structure of functional preparation (on the basis of data presented by V. Mishtshenko *et al.* [13]).

tem and enables to make alterations in the structure of functional preparation.

With this approach it is possible to avoid the onesidedness of the empirical-analytical way of thinking and consider the runner's organism as a motor-functional system, with its universality, high plastic and reactive properties.

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COST VERSUS ACCURACY: AN EXAMINATION OF THE RELIABILITY OF THREE SKINFOLD CALIPERS

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Abstract

Twenty four young, healthy, adult females with a mean age of 19.7 years were measured at four body sites using three different makes of skinfold calipers. Readings were also taken on constant materials of solid teak and sorbo rubber. Results showed a non-significant difference between the calipers at any site or material with analysis of variance F ratios well below the critical value required for significance at $p < 0.05$.

Introduction

The matter of what percentage of body weight is composed of fat is of great interest to many people because of the medical and fitness implications. Fat content of the body may influence morbidity and mortality. It may also alter the effectiveness of drugs and anaesthetics as well as the ability to withstand exposure to cold and starvation [4]. It is therefore of special interest to doctors, athletes and coaches.

Methods of making this assessment are many but two methods are generally popular because of their degree of efficiency, ease and practicality of application. These are hydrostatic weighing and skinfold measurements and much data have been collected using them.

These methods are based on considering the body to consist of two major compartments. The body fat which includes entire lipids of the body and the fat-free mass which includes all the rest of the body. According to Brozek and Keys, [2], hydrostatic weighing appears to be the best single criterion, with skinfold as the next best index.

Hydrostatic weighing has many disadvantages which include limited accessibility, expensive equipment and unacceptability to many subjects who are not water confident. Hence the more easily applied method of skinfold testing is being increasingly used by people with specialist interest such as doctors, physical fitness specialists and coaches. Indeed simple calipers are available for individuals to do their own testing, and one of these is included in the present study. Several workers have produced regression equations to enable calculations of fat to be made from sums of skinfolds. The values produced by Durnin and Wormersly [3], for males and females 17 years to 70 years are widely used, as are more specific values such as those produced by Seltzer *et al.* [9].

However, for this method to be acceptable on a scientific basis many sources of error need to be considered and eliminated. Inter-rater reliability seems to be the greatest source of error. One study by Kispert and Merrifield [7] found the reliability coefficients ranged from 0.62 to 0.85 at individual sites and clearly this is insufficiently accurate for scientific purposes. However, other workers have found higher correlations. Keys and Brozek [6] reported correlations of 0.92 to 0.96 for different testers. It would appear that training and standardisation of technique could reduce this error.

Interater error gives rise to technical measurement error which varies with site chosen, experience of technician, fatness of subject and method of error estimation [5]. Regarding the site chosen, triceps and subscapular is recognised by Brozek [1] to be good predictors of body fat as well triceps by Tanner and Whitehouse [10]. The experience of the technician is of course something that applies to any skill. The fatter the subject the greater the error source due to the variability in compressibility of fat. Lohman [8] commented on four different methods of error estimation with his own method rated at 0.95.

An additional source of error may be the reliability and accuracy of the equipment used. With growing interest in the topic more pieces of equipment are being introduced in various price ranges. This poses the question about cost versus accuracy. It is the purpose of this study to answer this question by examining three calipers across a wide price range.

Methods

All measurements were carried out by the same person.

The three calipers chosen were:

A. Holtain caliper — a well-established and widely used piece of equipment made of stainless steel and able to give to 0.1 mm. The cost is approximately £150.

B. Ponderal caliper — made of plastic with an accuracy of reading possible to 0.5 mm. The cost is approximately £20.

C. Slim Kit caliper — plastic and part of a self measurement kit with accuracy to 1 mm. The cost is approximately £10.

The study examined 10 trials using the three calipers on two standardised pieces of material of fixed dimensions to establish their initial validity. These were a piece of solid teak and a piece of firm sorbo rubber, to assess a solid and a flexible structure respectively. Measurements were carried out at marked anatomical sites over a number of days.

The calipers were then used to take measurements on 24 healthy female physiotherapy student volunteers. To reduce error, participants were all within 20% of recommended weight. None was doing regular resistive exercise which might dehydrate skin for two hours prior to testing. subjects gave age and were measured for mass and height. Descriptive statistics are shown in Table 1. Four sites were chosen and carefully measured and marked on the skin with a cross.

They were:

Triceps — halfway between acromion and olecranon at the midpoint of the posterior aspect of upper arm.

Biceps — halfway between acromion and olecranon at the midpoint on anterior aspect of upper arm.

Subscapular — immediately below the inferior angle of the scapula.

Suprailiac —2.5 cm above and medial to the highest point of the iliac creast.

All measurements were carried out as recommended by Tanner and Whitehouse [10], and were undertake on the left side of the body following an international convention established by anthropologists 92 years ago and re-emphasised in the protocol of the International Biological Programme [11].

The technique was standardised by using the right hand to lift a skinfold exactly at the marked site, then the left fingers and thumb took hold of this fold immediately above. The caliper was then positioned at the site of the mark on the skin and centred on the midpoint of thumb and finger nails at the neck of the fold. This fold was held whilst three measures were taken with the three calipers and only then was the fold released. Each of the four sites was examined in this way and then the whole procedure was repeated twice more. The order in which the caliper were used randomised at each of the three readings. The readings taken were to the maximum accuracy possible with each caliper. The three readings of each caliper at each site were averaged.

Statistical testing of the results consisted of undertaking a one way unrelated ANOVA test with each caliper on the wood and sorbo. This was repeated for the average readings for each caliper at each site on the models.

Results

Using the three calipers on wood and sorbo produced ten readings on each material with each caliper. The ANOVA showed a non-significant difference between calipers although the Ponderal caliper produced readings which averaged 0.5 mm less than the other two (see Table 2).

Table 1

Descriptive statistics of student subjects

	Age	Height in cm	Weight in kg	% Fat
Range	18–33	155–180	50-69	19–31
Mean	19.7	168.4	58.5	25.5
S.D.	3.18	6.5	5.6	3.3

Table 2

Mean values for each material

	A	B	V
Wood	11.0	10.5	11
Sorbo	21.0	20.5	21

Each of the ANOVA tests for the students at each site produced F ratios well below the critical value of 2.00 and thus producing a nonsignificant results for each caliper at each site.

Thus the three calipers are equally accurate and reliable and the cost therefore does not determine accuracy.

Discussion

It appears that all three sets of calipers are equally valid and thus it is not necessary to provide great expenditure for the purpose of skinfold testing. However, in general use of such equipment other aspects are worthy of consideration. Firstly, the durability of the equipment. The two plastic calipers may more easily be damaged by dropping them or something heavy falling on them. On the other hand the metal Holtain caliper has such a strong spring that when it is released it needs to be carefully controlled, otherwise in constant use the metal may be worn away and thus affect the accuracy. In addition this test did not investigate the durability or consistency of the spring of any of the calipers and this may need to be considered. The second point which arose during the testing was that many of the subjects commented on the discomfort of the Slim Kit caliper when it was in position in spite of great care which was taken to minimise this. The reason for this was inherent in the material used and the way it was cut revealing a very sharp edge of plastic to come in contact whith the skin. This caliper was also the most difficult to read for two reasons. The scale is the same colour as the background and therefore a very good light and excellent eyesight are needed. The other reason was that it had a very small scale graduated in 2 mm divisions so that 1 mm lay between two marks, which made it difficult to interpolate. The Ponderal caliper was much easier to use and read and no discomfort was experienced on testing. This therefore was worth the extra £10 cost.

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KNOWLEDGE OF BLOOD CHOLESTEROL WITHIN AN INNER CITY COMMUNITY

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Abstract

The purpose of this study was to ascertain the knowledge of blood cholesterol issues in an inner city environment before embarking on a health promotion campaign. One hundred subjects completed a simple questionnaire. It was shown that 39% of the respondents had been measured for blood cholesterol with over 20% knowing their own value. A similar percentage did not know the cause of high blood cholesterol nor did they know how to lower it. A very high percentage of subjects advocated a range of actions to control high blood cholesterol, some of the actions being erroneous. The study provides baseline data against which other similar studies can be compared and also indicates the need for public education on the issue.

Introduction

Although the incidence of coronary heart disease (CHD) in England has declined since the 1970s, it remains one of the highest in the world. Consequently, a primary target of the Health of the Nation [8] "to reduce death rates for both CHD and stroke in peope under 65 by at least 40% by the year 2000." With the accumulation of a plethora of evidence showing that high plasma cholesterol levels significantly contribute towards CHD, educational campaigns have attempted to increase the public's knowledge concerning this adverse relationship. A Consensus Conference [4] on the prevention of heart disease recommended that adults should know their blood cholesterol levels, and that they should aim for a target level of 5.2 mmol/l. The extent to which any recommendations are followed needs to be carefully examined and is particularly important in discovering how campaigns affect knowledge and behaviour. Many surveys have been conducted to ascertain changes over time, especially within the United States.

For instance, Schucker *et al.* [6, 7] found large improvements during the 1980s concerning cholesterol related dietary knowledge and interest in personal cholesterol levels. Niknian *et al.* [5] found that in 1981–1982, 11.6% of residents in a New England community had their cholesterol levels previously measured. By 1987–88, this figure had increased to 16.3%. Furthermore, the percentage stating that they know their cholesterol level increased from 65% to 75% within the same time period.

This particular survey therefore was designed to assess the degree of public knowledge relating to blood cholesterol in an inner city community.

Method

The information was based on a questionnaire completed by a face-to-face interview of approximately three minutes. It used an accidental sampling procedure. A reasonably representative cross section of the normal demographic population was achieved by interview delegation. The questionnaire was kept short and was constructed with the intention of comparing data from similar surveys.

Each subject was asked their gender, age, occupation, whether they ever had their blood cholesterol measured, if they knew the level, the effect if has on health, the cause of high blood cholesterol, whether they knew how to lower the blood cholesterol level and how, and a final question listing a number of actions to control high levels. For each of these (e.g. eat less fat) the subjects were required to respond with either "definitely help", "might help", or "would not help".

The survey was conducted in a shopping centre in the centre of Birkenhead, a town of 80,000 people in the North West of England.

Results and Discussion

100 questionnaires were completed with 51% of the respondents being male and 49% female. The overall mean age was 42.2 years (range 17–84 years). The mean age for males was 38.3 and for females 46.4 years. The socio-economic distribution, based on the occupation of the head of the household was as follows:

17%	professional
14%	managerial/technical
49%	skilled
13%	partly skilled
7%	unskilled

Table 1 shows the results of the open-ended question on high blood cholesterol and health.

Table 1

What effect does high blood cholesterol have on your health

Effect	% of respondents
Don't know	32
Heart attack/Stroke/CHD	34
Linked to the heart	14
Blocks the arteries	9
Other	11

The perceived cause of high blood cholesterol are shown in Table 2.

Table 2

What causes high blood cholesterol

Causes	% of respondents
Don't know	20
Lack of exercise	4
Stress	5
Diet	25
Fats	34
Animal/saturated fats	6
Others	6

The above values indicate the need for significant improvements in the level of education. As Frank *et al.* [2] states: "For many individuals, cholesterol education comes from a multiplicity of sources and consists of whatever the mass media and manufacturers of 'low-fat', 'low-cholesterol', and 'high-fibre' products choose to promote". More education must be available through organised campaigns in order to promote correct information.

Twenty three per cent of respondents report that they would not know how to lower their blood cholesterol level. This compares with 34% in the national survey by Schucker *et al.* [7].

Thirty nine per cent of respondents (41% of females and 35% of males) stated that they had their blood cholesterol measured in comparison with 46% in Schucker *et al.* [7] study population in 1986. No clear relationship existed when analysed by social class. Fifty nine per cent (50% of males; 67% of females) of those reporting that their blood cholesterol had been measured knew their own level. This corresponds to 22% of the total sample, compared with just 7% obtained by Schuker *et al.* [7]. These figures are reasonably encouraging given that the Consensus Conference (1985) [4] emphasized the importance of all individuals knowing their level of communication between the medical professionals and the patients, and by increasing the number of measurements taken. In this survey, the majority of individuals who knew their cholesterol level had values at or above 5.2 mmol/l (68%) suggesting that either physicians are only informing patients when their value is high, or alternatively, only those with suspected high cholesterol are undertaking tests.

Table 3

Actions people might take to control high blood cholesterol level and responses

Controlling actions that would 'definitely' help	Response
Eat less fat	94
Trim fat	91
Eat more fish	89
Eat less sausage, bacon and luncheon meats	87
Use skimmed milk	87
Eat less cholesterol	85
Get regular exercise	85
Replace meat with poultry/fish	82
Eat less cheese	77
Avoid stress/fatigue	70
Use less salt	69
Eat fewer egges	65
Eat less sugar	58
Eat more vitamins	57
Reduce calories	55

Table 3 shows ranked results from a list of actions presented to respondents that people might take to control high blood cholesterol levels. The first point of interest is that the majority of respondents (i.e. over 50%) believed that all of the actions listed would definitely help in controlling high blood cholesterol, compared with only seven of the actions in the study by Schucker *et al.* [7]. Furthermore, all percentages notably exceeded those obtained in the latter survey. Unfortunately it is difficult to determine whether the use of such closed questions overestimates respondents knowledge. For instance, the National Health Interview Survey of 1985 [9] in using a closed list found that 90% of respondents identified smoking as a CHD rist factor. However, Frank *et al.* [3] found that only half mentioned smoking when asked spontaneously to identify risk factors. Davison [1] stated that "the term knowledge indicates that there is a high degree of certainly in the individuals mind about the data in question". Therefore, it may be more suitable to apply open-ended questions, although these may provide more "conservative measures of respondents knowledge" [3].

Of all the controlling actions, eating less fat (94%), trimmig fat (91%) and eating more fish (89%) received the greatest proportion of respondents believing that they would be effective. Less than 60% of respondents stated that they thought eating less sugar, eating more vitamins, and reducing calories would definitely help (58%, 57% and 55% respectively). In the Schucker *et al.* [7] study, eat more vitamins and eat less sugar were also ranked within the bottom three actions, although the percentages were considerably lower (18% and 34% respectively). These latter values would suggest an inferior knowledge base within the sample obtained in this survey, even though values for the other actions were considerably higher. Again, this is most probably explained by an overestimation of knowledge.

With reference to gender, a greater proportion of women, for the majority of actions, reported that they would definitely help. The most profound differences were on the following actions:

eat fewer eggs (78% of females and 52% of males);
eat less cheese (88% and 66%);
reduce calories (65% and 45%) and
avoid stress/fatigue (76% and 64%).

Frank *et al.* [2] found that the most consistent disparities in cholesterol related knowledge and behaviour were education related. Higher scores were obtained in the better educated, which were also found to improve more over time. Less education is closely associated with socioeconomic status and social class. In this particular study however, no clear pattern emerged when values were analysed by social class.

To conclude, this study has measured baseline values of cholesterol knowledge on a small sample of the local population. Comparisons with the national survey conducted by Schucker *et al.* [7] produced favourable results, although two potential limitations exist. Firstly, the latter study took place in the United States eight years earlier. Secondly, the use of open-ended questions may significantly overestimate true values. However, its use as a tool to measure changes over time may prove beneficial.

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ABOUT THE POSSIBILITIES TO DETERMINE REACTION OF CONNECTIVE TISSUE'S STRUCTURES IN THE LOCOMOTIVE APPARATUS IN GYMNASTS

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Abstract

The possibility to determine the reaction of connective tissues of the locomotive apparatus to the training load was inquired. 14 high-qualified female competitive gymnasts from age 9 to 14, took part.

The parameters were determined which indirectly reflect the functional state of the locomotive apparatus in gymnasts. The difference in heigth was found ($\triangle$ 1 mm), measured with Martin's anthropometer in lying and upright positions (accuracy ± 0.5 mm) before and immediately after training [39, 40]. The characteristics of training load were registered: capacity Q (elements), intensity J (relative unit of measurement [1]), per cent of stroke load in total capacity of training U%.

It was found that the locomotive apparatus of gymnasts can react differently to the equal training load. 2 main types of reaction of the intervertebral fibrocartilage locomotive apparatus of gymnasts became evident: the positive and the zero type. In case of positive reaction, the value of the $\triangle$ 1 mm increases significantly relative to the initial position: 14.15 ± 0.64 mm before and 16.74 ± 1.05 mm after the training load ($p < 0.05$) by Student's criterion; in case of zero reaction there are no changes 10.79 ± 0.94 mm before and 10.69 ± 0.80 mm after the load.

The analysis made possible the conclusion that during the training session, determination of difference in height $\triangle$ 1 is one of the possibilities to dose individually the stroke load and to avoid injuries.

Key words: locomotive apparatus; stroke load; competitive gymnasts.

Introduction

The development of complicacy and originality of programs in competitive gymnastics evokes a constant growth of training loads. Loads in this kind of sport have the character of strength and speed and are monthly connected with strokes to the locomotive apparatus (LA). These are mainly jumps, dismounts, landings [12, 45, 47]. The impact load has an effect both on upper and lower limbs. Accordingly, the gymnast is repeatedly under the compression causing forces during 6–7 kouse Lours training, which exceed many times the sportsman's own weight.

It was established by Vain [41] that the main-load during the landing influences on the ankle joint but the acceleration arisen in leg during the collision of lower limb and rigid surface is 5–10 g (acceleration of gravity).

Studies of american scientists [23] showed that high jumps in aerobic dance cause many injuries of LA as they evoke twice as big a vertical force on the knee-joint as low jumps. Kurys [20] has established that the load on lower limbs in the first phase of back flip is 270–350 kg, the load to upper limbs during stay is 250–300 kg . The total load to the whole LA during the pushing off pirouettes is 700 kg.

Many authors have established that intensity of training-loads cause big changes in LA of sportsmen, that lead to microinjuries. The latter, in turn, cause pathological phenomena [4, 7, 14, 24, 28, 32]. Bak *et al.* [3], Hamel [15], Bashkirov [4, 5], Mironova *et al.* [25] direct attention to the fact that the weakest parts are the points where muscles are passing over to tendons and tendons are fixed on bone tissue. These are the parts of high tensions. In connection with that, the whole LA and its connective tissues deform under the influence of intensive impact loads.

Chenegin [47], Zaikin *et al.* [45], Belyakova *et al.* [6] found out that after intensive training the foot of the gymnast is flattened. Results of that are disturbances of the restoring function of the arch of the foot. Great attention to the function of the arch of the foot in softening strokes and impacts was also showed by Lesgaft [21], who stvessed the consequence in mastering jumping exercises [22].

Researchers [10, 29, 34] showed that intensive loads of impact character cause early synostosis of knee-joint fissure, disturbances in normal feeding of gristle tissue, also lower resiliency of gristle tissue.

Rokitjanski [31], Ehricht [11], Tager, Dyachenko [36], Raichinshtein [30], Vital *et al.* [42], Stupakov, Oksagoyef [35], Yumanov [18] and others have shown that degenerative changes in intervertebral fibrocartilage of the spinal column are connected with impact loads to the spinal column.

Burukhin [43], Naylor [26], Ehricht [11] have explored the functional condition of the intervertebral disk in the spinal column and have found that the nucleus pulpous is able to stand only small and medium loads. Big loads on the axle disturbe the metabolism of the nucleus pulpous. The collagen structure is changed to fibrous tissue, causing lower flexibility and disturbances of amortisation.

The above given data affirm that intensive training loads of impact character cause abatement of amortisation of LA; the flexibility of LA disappears. Further intensification of training loads can cause injuries and degenerative changes of LA, that force sportsmen to leave sport and make them invalid [5, 8, 25].

In connection with these data the most troublesome fact is that female competitive gymnasts specialize very early. The highest results are shown already at an age when the LA is physiologically not yet prepared for standing impact loads and it is extremely flexible [5, 27, 33].

Researchers have stressed that forced training, drilling of talented children for getting quick results is impermissible. The level of the physical loads must not exceed the functional qualities of LA [13, 25, 44, 47].

But, as noted by Dembo [9], the level of permissible load is individual and to determine its optimality is quite difficult.

The above given material makes clear that determination of the function of connective tissues in LA (i.e. amortisation ability of LA) in competitive gymnasts and its connection with training load is actual.

The aim of the present work was to control one of the possibilities to determine the reaction of connective tissues in the gymnast's LA to training loads of impact character.

Subjects and methods

The research work was carried out on the basis of Tallinn's Specialized Gymnastic School. 14 highly qualified female competitive gymnasts from age 9 to 14 took part in the research.

Throughout some years the data of training loads had been periodically registered: capacity Q (elements), intensity I (relative unit of measurement, Afonin, [1]), per cent of impact load in the whole capacity of training — U%, and anthropometrical indices: height (with Martins metal anthropometer) with ± 0.5 mm and weight with ± 0.1 kg accuracy.

The index $\triangle$ l mm, which reflects indirectly the functional condition of connective tissue in LA, was determined [6, 39, 40].

Every observation was usually carried out in 3 days. Before and immediately after the training the change in height of the gymnast was measured on a special stand in lying and standing positions $\triangle$ 1 mm (before the training) and $\triangle$ 1 mm (after the training). There was also determined the arithmetical mean L mm of instability in height differences per gymnast during the whole day.

On the ground of the arithmetical mean in height differences we got the general estimate on the functional condition of LA per day, on the ground of △ l mm dynamics we explored the shifts, which took place in the functional condition of connective tissues in LA under the influence of training load.

As is generally known, the enlargement of curves in the spinal column and diminishing of thickness of its intervertebral fibrocartilage are the negative indices of supernumerary physical loads and cause residue deformations [16, 37, 38]. In this case △ 1 mm decreases. The received results were treated statistically.

Results and discussion

The analysis was carried out on the ground of data gathered in 3 years. All girls were divided into 2 groups. Criterion for differentiation was the minimal index of arithmetical mean L mm, which was 6.89 ± 3.94 mm from the variation row. The latter was composed of arithmetical means' indices of height-differences L mm per gymnast during the whole experimental period.

Group A consisted of 6 gymnasts (mean age 10.8, height 1344.1 ± 70.47 mm, weight 29.81 ± 1.26 kg, whose L mm arithmetical mean excuded the minimum value twice: 15.29 ± 0.81 mm.

Group B consisted of 8 gymnasts (mean age 12.1, height 1364.8 ± 59.12 mm, weight 31.89 ± 1.65 kg), whose L mm arithmetical mean excuded the minimum value 1.6 times: 11.06 ± 0.69 mm.

Comparing arithmetical means of the received results by Student's criterion gave the following results:

Afterwards the indices of height differences were compared before △ l mm and after △ I mm the training load: group A before training 14.15 ± 0.64 mm, group B before training 10.79 ± 0.94 mm; group A after training 16.74 ± 1.05 mm, group B 10.69 ± 0.81 mm. Differences between the groups in the above given indices are statistically significant ($p < 0.01$). (Fig. 1).

In training load indices — Q, I, Uimportant differences. Neither were there significant differences in anthropometrical indices of both groups — height, weight.

Comparison of indices of arithmetical means △ l mm inside groups before and after training load: in group A the differences in △ l mm during the training are statistically significant ($p < 0.05$). In group B no essential differences were found in △ l mm before and △ l mm after the training load.

We can assume that in group A the height differences during the day L mm (i.e. index of arithmetical means during the whole research)

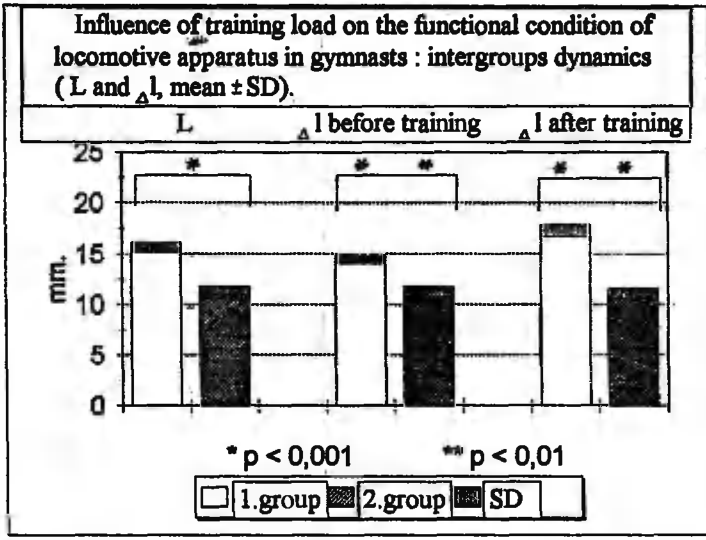

Fig. 1. Differences between the groups in L mm index are statistically significant ($p < 0.001$).

was 15.29 ± 0.81 mm. It means that LA functions normally and the reaction of connective tissues to loads is satisfactory. This is indicated by the statistically significant increase of Δ 1 mm after the training load. (Fig. 2).

The situation in group B is different. The index of height differences during the day L mm (i.e. arithmetical mean during the whole research) was 11.06 ± 0.69 mm. Therefore the reaction of LA to training load is not satisfactory, because no positive shift was found in its functional condition after the training. This is indicated by the lack of statistically essential difference between arithmetical means Δ 1 mm before and immediately after the training load. (Fig. 2).

It is evident that the amortisation function of LA is disturbed in group B, i.e. LA cannot soften strokes. In that case the impact wave reaches almost without obstacles the above-situated body segment at the very moment of collision between metatarsus and rigid surface [2, 17, 46] expressing negative influence on ligaments, joints, and intervertebral fibrocartilage of the spinal column. This creates real danger of microinjuries, further also of severe injuries.

The previous analysis showed that the arithmetical mean of unit L mm has correlation with striking-load U

Correlation analysis inside groups made evident that there is connection between striking-load Uof group A gymnasts is durable to the chosen training load i.e. the latter does not significantly influ-

Table 1

Data of gymnasts investigation in the period 1986–1988 years (means ± SD)

	Age (years)	Weight (kg)	Height (mm)	Elements Q	Relative unit I	U (%)	L (mm)	Before training loads l (mm)	After training loads l (mm)
I group n = 42	10.8±3.08	29.8±1.26	1344.1±70.47	265.5 ±30.95	0.24±6.54	69.47±1.39	15.39±0.81	14.15 ±0.64	16.74±1.05*
II group n = 60	12.1±0.48	31.9±1.65	1364 ±59.12	232.3 ±14.16	0.23±0.02	67.15±3.08	11.06±0.69	10.79 ±0.94	10.69±0.81
	NS	NS	NS	NS	NS	NS	$p < 0.001$	$p < 0.01$	$p < 0.01$

* $p < 0.05$

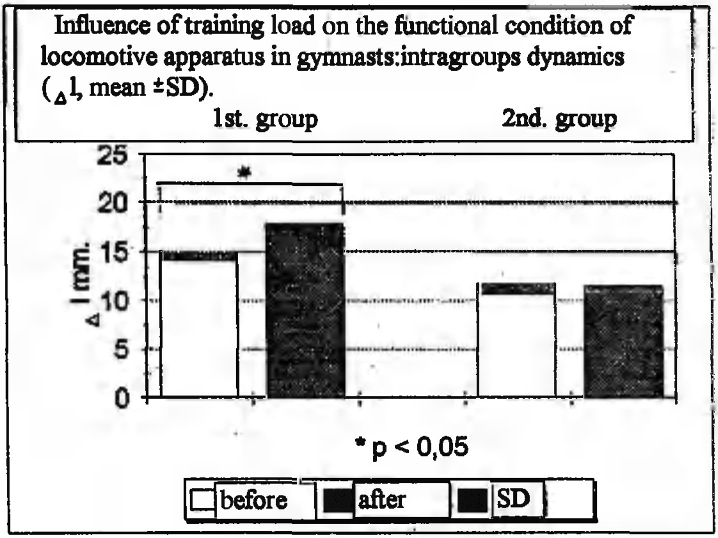

Fig. 2.

ence the unit characterizing the functional condition of LA in these sportswomen.

Correlation between impact load and L mm in group B was 0.24 ($p < 0.05$). Consequently, the impact load influences essentially the LA of group B gymnasts. Therefore reaction to impact load was different.

In group A (mean age 10.8 ± 3.1) positive shifts were found in reactions of connective tissues in LA to impact load i.e. the positive type of reaction was found. Arithmetical mean of Δ l mm shows significant enlargement after the training compared with the initial position, which speaks about the adequacy of training load to the function of connective tissues in LA in gymnasts of group A.

In group B (mean age 12.1 ± 0.48) the reaction of connective tissues in LA to training load lacked statistically essential shifts. It is indicated by the lack of statistically essential differences in arithmetical means of l mm before and after training. Connective tissues of LA showed zero-type reaction to the training load. This fact gives us reason to assert that the amortisation function of LA has been disturbed. The given training load is not adequate to the functional condition of connective tissues in LA in this research group.

Real danger for injuries of LA results from here. The received data coincides with scientific literature. Simakov [34] has shown that LA of 12–13 years old children is unable to stand intensive training loads of impact character. Loads of this kind cause disharmony between the intensive development of muscles and skeleton. Fyodorova [13] analyzed reasons of injuries in gymnasts and made a conclusion that the first culmination point of injuries for female competitive gymnasts is at about age 12.

Our conclusions were verified by the fact that there were no serious injuries of LA in group A. In group B there were 2 serious injuries of achilles tendon (tendon's rupture and rupture of connective tissues of achilles in germination zone), also serious injuries of foot and knee-joint.

Conclusion

The present study allows to declare that difference in the height of gymnasts, measured in lying and upright position as the parameter Δ l mm before and after the training, is an informative showing. On the ground of this it is possible to appraise indirectly the reaction of the gymnast's connective tissues in locomotive apparatus to the training load.

The dynamics of parameter Δ l mm allows to explore shifts in the functional state of connective tissues of the locomotive apparatus. It became evident that the zero type of reaction informs about disturbances of amortisation capacity in the locomotive apparatus. This is closely connected to risk of injuries.

Female competitive gymnastics are characterized by big impact load and that causes notable individual differences in the reaction of the locomotive apparatus. During the training session the determination of Δ l mm is one of the possibilities to dose individually the stroke load and to avoid injuries.

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