

TARTU ÜLIKOOL  
TOIMETISED



ACTA ET COMMENTATIONES UNIVERSITATIS TARTUENSIS

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BIOLOGICAL AND PEDAGOGICAL  
PROBLEMS OF PHYSICAL  
EDUCATION AND SPORT

IV

TÕID KEHAKULTUURI ALALT



TARTU 1994

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## CONTENTS

L. Peake. An overview of the spectrum of teaching styles . . . .	5
Zhi-qi Yu. An examination of immunity of middle-aged persons practicing qigong . . . . .	11
Li Hongzi, Li Xuefei. Sports injuries of eyes . . . . .	15
A.G. Kochetkov, N.I. Petrova, I.G. Stelnicova, M.Y. Samarin. Morphofunctional foundations of endocrine function perfection in training process . . . . .	18
T. Jürimäe, S. Goltermann, K. Karelson, T. Smirnova. Metabolic and hormonal changes in blood during bicycle ergometer load at critical power level in male students . . . . .	28
T. Jürimäe, R. Jüriso. The reliability of different methods for body composition measurement in female university students. . . . .	42
M. Kull, T. Jürimäe. Using the EUROFIT test battery in Estonian 16-18 years old adolescents . . . . .	49
T. Kaasik, T. Jürimäe. Frame size and body composition of female university students and their trait anxiety . . . . .	53
M. Pääsuke, J. Ereline, J. Gapejeva. Twitch potentiation after maximal voluntary contractions of human plantarflexor muscles . . . . .	58
A. Viru, V. Õõpik. Evaluation of the rate of protein synthesis in muscle after exercise: significance of the specific activity of labelled amino acid . . . . .	70
G. Konovalova, R. Masso, A. Viru. Exercise-induced activation of thyroid function in hypothyroid rats . . . . .	85
A. Vain. Estimation of the functional state of skeletal muscle according to its new model . . . . .	92
J. Pärnat. Relationships between oxygen uptake and cardiac output during graduated loads in untrained pubertal boys . . . . .	99
I. Neissaar, T. Kuningas, S. Pulk, M. Kikas. General fitness training with the aid of aerobic gymnastics . . . . .	104
M. Sallo. Trainability of the cardiovascular system in preschool children . . . . .	110



L. Raudsepp, M. Pääsuke, J. Ereline, J. Gapajeva. Connections between neuromuscular performance characteristics and the features of their manifestation in 8-year-old children . . . . .	118
V. Redpap. Students opinion about physical education . . . . .	126
S. Oja, L. Suurorg, P. Kaldmäe, H. Oja, V. Sirge, A. Oja. Health education in the Nõmme Children's Hospital . . . . .	132
G. Jagomägi, I. Ilchenko. On the connections between the efficiency of leg's work variants in breaststroke and joint mobility . . . . .	146
M. Aarik. Lactate diagnostics for evaluation of aerobic and anaerobic capacities in Estonian sportsmen . . . . .	151
<b>Reet Ann Howell (Nurmberg)</b> In memory . . . . .	162

# AN OVERVIEW OF THE SPECTRUM OF TEACHING STYLES

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## Introduction

For the purpose of this paper, a spectrum may be defined as a range or scale of possibilities which has no finite boundaries. So far as teaching-coaching styles are concerned, the outlines presented here define the presently known spectrum from one end, which is strictly formal or "closed" and under strict teacher-coach control, to the other end where the opposite is true — the learner takes full responsibility for their own learning. In between these two extremes there is a cluster of styles, all of which have been subject to research studies and proved to be viable in their own right.

The spectrum is a theory of relationships between the teacher and the learner, the tasks that are performed, and the effects on the development on the learner. Initially, the use of the spectrum was focused on providing versatility to the teaching of activity-based physical education classes within educational institutions such as schools, but now its use has been broadened to include both theory and laboratory situations. It is even used as a base to include the latest educational thrust — the development of higher order thinking skills in students at all levels — elementary, secondary, college, and university. At the present time, eleven inclusive teaching styles have been recognized for their individuality because each style has its own set of objectives and learning outcomes. The role of the spectrum, therefore, is to present each of the styles so that there is an understanding not only of the structure of each style, but an intent to incorporate these into a repertoire of teaching behaviours. Once this has taken place, the issue facing a teacher who wishes to adopt versatility, is to select the appropriate style to match the appropriate learning behaviour desired.

Let us now consider each individual teaching style within the repertoire of styles presented here.

## **Style A: The Command Style**

In every teacher-learner transaction there are two decision makers – the teacher and the learner. The command style is characterized by the teacher making all decisions in every phase of a presentation. Precise replication of demonstrated instruction is the sole requirement of this particular style. For obvious reasons, this has been noted as being the most commonly-used style. The main points are:

1. an immediate response by learners to instruction
2. uniformity among learners
3. conformity among learners
4. replication of a model
5. efficiency in the use of time
6. there is a single standard of performance

## **Style B: The Practice Style**

In this style there is a shift in some of the decisions from the teacher to the learner. For this reason this style has been adopted by some teachers as a stepping stone to other changes within the spectrum. The main points are:

1. the performance is replicated as in the Command style.
2. more practice is allowed so that individuals work privately for a period of time. This is the beginning of the independence phase.
3. there is no comparison of performance with others.
4. the teacher learns to trust the learner to make some appropriate decisions.
5. the teacher offers advice to individuals as they perform, usually using task sheets with the appropriate information.

## **Style C: The Reciprocal Style**

The shift towards independence continues in this style but this is achieved via a socializing process by giving and receiving feedback on performance not from the teacher as in Style B but from a peer. The main points are:

1. comparing and contrasting a peer's performance against pre-set criteria placed on task cards.
2. the ability to analyze performance by a peer.
3. the ability to communicate results of this analysis, peer-to-peer, and the trusting relationship that evolves — hence the name reciprocal style.
4. while it takes time for learners to adjust to this style, particularly at the school level, this is not necessarily the case at the post-secondary level.

5. the style involves quite a bit of teacher preparation time in evolving the learning criteria to be used by the learning pair or small group, but once this is done it can be a time-saving device for future episodes.

### Style D: The Self Help Style

Before embarking into this episode of learning style, it is suggested that learners be initiated into Style C first. The reason for this is that analytical experiences are necessary, but apply learning criteria independently to oneself. This style calls for more self responsibility and being frank about ones own performance. As in the Reciprocal Style there is a predetermined set of criteria in regard to a performance to be mastered. The main points of the style are:

1. more decisions are shifted to the learner
2. self awareness is heightened — that is, accepting of ones own assessment with honesty
3. being objective with oneself and being more self-reliant
4. to use criteria for self improvement
5. learners must have already achieved a basic competency in a task before proceeding with this style
6. the self checking procedures provides the mechanism for feedback to the learner.

### Style E: The Inclusion Style

Whereas the previous four styles represents a single standard for any tasks that are performed, this style introduces multi-level performance within the same task. This constitutes a shift in responsibility to the learner in that they make choices, based on prior experience and ability, as to which level they enter the task. In essence, the prime objective is to include all learners by accommodating individual differences. The main points of this style are:

1. the learner has choices on the entry level into a task
2. the style signifies the inclusion of all learners
3. the style accommodates individual differences
4. the learner decides what further placement they can cope with, within the range of levels
5. the teacher prepares all task levels criteria and gives feedback on an individual basis
6. is non-competitive except against oneself
7. allows for more personal practice time.

**NOTE:** Styles A–E represent the **REPRODUCTION** of knowledge set by the teacher, whereas the forthcoming styles represent the **PRODUCTION** of knowledge. The area of discovery now plays an important factor.



## **Style F: The Guided Discovery Style**

The teacher-learner relationship changes because the teacher's role is to **ask questions** and the learner's role is to respond, in their own way, to one task at a time. The main points of this style are:

1. it takes time for an adjustment to be made to this style
2. the style delves into concept teaching — the what, the how, and why, of performing tasks
3. the teacher designs a logical series (steps) of questions, clues, or problems
4. each step is based on the response to the previous step
5. short episodes, using this style, are easier to conduct with learners; it is useful at the beginning of a topic
6. as a rule of thumb, questions move from the general to the specific
7. can be applied to all "in class" task situations.

## **Style G: The Divergent Style**

In this style, the learner is involved in discovering and producing options within a task-related topic within certain parameters. The field of physical education, sports, and dance are rich in opportunities to discover, design and invent. Unlike Style F, the difference here is the **discovery of alternatives** to a problem, question, suggestion, or situation. The main points of this style are:

1. the learner seeks a variety of solutions, i.e. multiple and divergent responses
2. the teacher designs problems which tap the cognitive capacities of the learner as well as themselves
3. the teacher accepts the fact that learners are capable of producing novel ideas within a given task, topic, or subject area
4. the style is applicable to all areas — fundamental skills, tactics, strategies, and organizational formations.
5. can be easily combined with other styles
6. the interaction among students is high as they move from the known to experience the unknown.

## **Style H: The Individual Program**

In styles F and G there has been a deliberate shift towards some independence on the part of the learner. The teacher remains in control but more for "stage setting" than the rigidity seen in Style A. Style H goes one step further in the spectrum toward independence in learning. The main points are:

1. the teacher decides the subject area and pertinent topics as with the previous styles; however...
2. the learner makes the decisions in regard to which problems *et cetera* are to be addressed and what solutions to seek
3. previous experience and knowledge of previous styles (A-G) is regarded as necessary prerequisite before embarking with this style
4. the objective is to give the learner the opportunity to develop a self-imposed program
5. the respective roles and expectations of both the learner and the teacher must be clearly defined
6. best done by a series of episodes over a period of time.

### **Style I: Learner's Initiated Style**

In previous styles the initiation of learning has come from the teacher and the follow-up experiences have been shared, but with more independence being handed over to the learner. In Style I, the difference now is that the learner initiates the whole process and takes responsibility for conducting the episodes for learning. It is entirely individualistic. Other main points are:

1. self development is based upon the readiness to conduct self-initiated learning episodes
2. the learner checks in with the teacher to share in decisions to be made and the directions that these make
3. the role of the teacher is that of a supporting mentor
4. evaluation is done based on the criteria set in the preperformance stages
5. the final product can come in a number of different ways — a physical performance, a document, *et cetera*.

### **Style J: Self Teaching Style**

The title is self explanatory. A learner assumes all the decisions previously assumed by the teacher and the learner. There are no dependencies whatsoever and can occur anytime.

### **Concluding remarks**

Each style has its own characteristics and these should be reviewed carefully before any decision is made upon its use. Too, the style should match the objective of any learning experience but in order for this to happen it is imperative that a teacher become skillful in the use of a variety of styles. Since no one style is best for all learners in all situations, the introduction of a variety of styles is

particularly appealing. For this reason, all teachers should seriously consider incorporating two or more styles into a series of sessions or even into a single session.

Of course, another consideration is the make-up of the learners themselves. While we may be aware that differences among groups do occur, it does take time to "tune in" to a learning style(s) that is most suitable to the group. As an interim measure, a wise course may be to do one of two things — introduce two styles from the production cluster of styles, or as an alternative, introduce a style from the production cluster (A-E) and a style from the reproduction cluster (F-J). Some styles take longer to implement than others, and by the same token, some may have to be introduced in gradual stages so that learners can adjust to this transition.

Figure 1 gives an overview of the spectrum and shows the shift towards learner independence as well as the respective roles of the teacher and the learner.

Figure 1. The Shift in the Spectrum of Teaching Styles

A	B	C	D	E	F	G	H	I	J
T	T	T	T	T	T	L	L	L	L
				/	/	/	/		
(L)	L	L	L	L	L	T	T	(T)	
Reproduction Cluster					Production Cluster				
→ → shift toward independence → → →									
T = Teacher as the major decision maker									
L = Learner as the major decision maker									
(L)	} = each as a minor decision maker								
(T)									
T/L	} = each as a minor decision maker								
L/T									

The goal of the spectrum is to present an integrated theory of teaching that can lead recipients to become more flexible, more versatile, more effective, and more deliberate in decision making.

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# AN EXAMINATION OF IMMUNITY OF MIDDLE-AGED PERSONS PRACTICING QIGONG

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More and more attention is being paid to the effect of Qigong exercise on men's health and reports on their electroencephalogram (EEG), cerebral blood flow and cardiovascular disease are fruitful. But there are no achievements concerning its effect on immunity. This paper studies the E rosette of some middle-aged people who practice Qigong, observes the change in immunity and makes a brief study of the mechanism of health promotion, disease prevention, disease treatment and senescence delay.

**Examinees and testing method.** All examinees are divided into two groups. The first group consists of 30 middle-aged people who have been practicing Qigong for 5 years, in the second group there are 30 persons who hardly do any physical training. Having similar working and living conditions, all deny having taken or injected any immunity-promoter or immunity-reducer in at least 5 years.

The whole testing procedure was carried out between 8 and 10 a.m. at an average temperature of 18°C. After all examinees had been sitting still for 5 minutes, blood samples were taken from the tip of the third finger of the left hand of each person. Soon after the first group finished 30-min exercise, 0.1 ml and 0.01 ml of blood was taken separately from the tips of the third fingers of the right hands to make smears. With the help of FQXQ-102 blood cell calculator, we found the percentage of active E rosette (EA), total E rosette (ET), WBC/mm<sup>3</sup> and of lymphocytes (LC). The formula is:

$$A. LC/mm^3 = WBC/mm^3 \times LC\%$$

$$B. EA(ET)mm^3 = LC/mm^3 \times EA(ET)\%$$

The data in the Tables was processed statistically.

**The change of E rosette before and after the exercise:** After the exercise, the first group's EA%, the quantity of EA and ET increased plainly and the difference was soon shown. The increase of ET% has no meaning statistically.



Table 1

Group	Sex	n	Age	State of practice			
			$\bar{X} \pm SD$	t	p	years	hrs per day
I	male	15	$50.4 \pm 4.12$	1.37	0.05	$3.7 \pm 2.1$	$0.68 \pm 0.35$
II	male	15	$51.6 \pm 3.98$				
I	female	15	$48.2 \pm 4.03$	0.242	0.05	$4.2 \pm 2.83$	$0.72 \pm 0.31$
II	female	15	$48.7 \pm 3.96$				

Table 2

## Comparison of E rosette when sitting still

Quota	I group	II group	t	p
EA%	$27.2 \pm 1.2$	$16.1 \pm 0.8$	7.422	< 0.01
EA + mm <sup>3</sup>	$665 \pm 41$	$292 \pm 24$	8.662	< 0.01
ET%	$59.8 \pm 1.4$	$42.8 \pm 1.6$	9.124	< 0.01
ET/mm <sup>3</sup>	$447 \pm 87$	$723 \pm 48$	7.641	< 0.01

Table 3

The change of E rosette shown in the I group  
before and after exercise

Quota	Before exercise	After comparison	t	p
EA%	$27.2 \pm 1.2$	$42.2 \pm 1.8$	7.615	< 0.01
EA/mm <sup>3</sup>	$665 \pm 41$	$1987 \pm 131$	11.241	< 0.01
ET%	$59.8 \pm 1.4$	$60.1 \pm 1.6$	0.744	< 0.05
ET/mm <sup>3</sup>	$447 \pm 87$	$2802 \pm 176$	3.762	< 0.01

**Discussion.** The body organs and functions of middle-aged people tend to become weak and senile. Therefore, nutrition and physical training in this period are significant for enhancing health and delaying senescence. But the pressures from both life and work which reinforce weakness of the organism and of immunity, are

extremely tense especially for those people.

The result of our test is that the EA%, the quantity of EA and ET of the first group are higher than those of the second group ( $P < 0.001$ ). It is comforting that Mr. Yan Juaqi [1], who has long studied old people doing long-distance running, and Mr. Sun Xusheng [2], an expert on the aged who practice TaiJi boxing, have come to the same conclusion. The total amount of T cell of the first group is clearly higher than that of the second group, which means that the organic cell immunity of the first group is stronger than that of the second group. As we have known, the thymus-dependent lymphocyte is a kind of active cell, functioning as the chief immunity cell, while E rosette is the typical symbol of T cell. It is possible that the active rosette is the subgroup which is highly compatible to T cell.

Clinically, the percentage of the absolute quantity of E rosette is used to reflect the existence and state of the active T cell.

Although many factors are involved in the change of immunity, according to our test, with all the examinees having similar background except that some of them practice Qigong while the others do not, the differences of EA%, ET%, EA and ET quantity between the first and the second group are just the result of Qigong.

Non-specific immunity is a kind of general function which has been formed through its acting on the harmful molecules and other biologically foreign bodies that have invaded the human body during the course of the evolution. After the formation of immunity, it works to get rid of the harmful and foreign molecules. And specific immunity develops its power in the evolution while contacting with antigens. It is made up of body fluid and cell immunity, the latter referring to the immunity produced by cell immunity medium. The movement amount of the Qigong exercise is moderate and proper, with an emphasis on the combination of motion and stillness. It is also slightly irritable to the human body. Doing such exercises will get people in a state of being infectious and thus finally cause unidentified endogenous thymus-dependent lymphocytes, which stimulate T cell to derive from the marrow and become hyperplastic and get inverted so that a biologically acquired immunity response is obtained. So when sitting still, both the number and activity of T cell increased. In other words, Qigong exercise is probable of enhancing specific cell immunity, which can partly explain one of the main mechanisms of its power to promote health and to prevent diseases.

The organic immunity system will be aging with years passing. The normal immunity always reports a man's state of health. When immunity becomes sensitive to stimulations from outside the body, its resistance to various virus and fungus infections is much reduced. An animal test showed that constant motion can help to enhance T cell function. Here we have got the same conclusion.

From the consideration of promoting cell immunity and senescence-delay, Qigong exercise suits middle-aged people well. It must be pointed out that research on the effect of different Qigong exercises and different amount of motion on immunity is still wanting.

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## SPORTS INJURIES OF EYES

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53 cases of sports injuries of eyes were investigated and treated by the author when he worked at the OPD of sports medicine as medical supervisor during the recent 10 years. These injuries involved eyelid, orbit, lachrymal meatus and eyeball, etc.

### Statistics of data

Sport	No. of cases
Ice hockey	38
Basketball	4
Football	5
Wrestling	3
Cycling	2
Volleyball	1

Location of injury	No. of frequency
Eyelid	31
Brow arch	12
Orbit bone	2
Lachrymal meatus	1
Eyeball	
bulbar conjunctiva	15
iris	12
cornea	2
lens	1
retina	4



## Clinical treatment

Among these injuries, contusion of eyelid and brow arch were most commonly seen (53.8 %). Blunt contusion of soft tissue, subcutaneous ecchymosis and local swelling, open trauma of protruding skin of orbit and brow arch were not rarely seen. These traumata were formed usually due to directly fighting with sports gear: subconjunctival bleeding or breach, even involving sclera layer, but the penetrating injury was not seen. There were 2 cases of depressive fracture of orbit bone due to ice hockey fighting at a high speed. Different injuries influenced eyeball and lead to contraction or dilation of pupils due to irritation. A cyclist had a trauma of skull complicated with injuries of eyes leading to changes of fundi. Besides, there were other symptoms and signs of severe injuries such as nystagmus, edematous macula lutea, optic nerve atrophy, retinal dissociation and impaired vision for long time.

**Management:** The wounds were treated firstly, including contaminants cleared up, antisepsis and then bound up. Early debridement and suture were used for subcutaneous fissures. Sometimes adhesives were used instead of suture. One case of conjunctival fissure (a basketball player) of this group was sutured once with 13 stitches and then cured. The conjunctival sac was washed with warm NS and one drop of atropine and antibiotics solutions was dripped into it in order to control infection. Penicillin and antitetanus serum injection were necessary for cases of severe contamination. For cases of closed contusion, the emergent managements included local cold compress, hemostatics such as Yunnan Baiyao, vitamin C and K to stop bleeding. Rivanol wet dressing, warm compressing 48 hrs, later, infrared ray and electric diathermy etc. were necessary to improve absorption.

## Discussion

All 53 cases of this group were instrumental injuries, equal to 1-2 % of sports injuries at the same period, and it is higher (5.4 %) in the ice hockey.

The condition of the wounds of this group was better than that of ophthalmologic clinic data. Most of them cured and recovered. Only a small part of cases retained some sequales such as impaired vision, dilated pupils not recovered, and changes of optic disc.

Causes of injuries in this group: most cases were beaten and injured in gruelling matches, but there were other factors such as listless and not orderly in training classes, rough movements or breaking the rules of the game during the match, unskilled technique etc. Therefore, strengthening education against trauma, enhancing

class discipline and strictly mastering the sport's rules are necessary.

About treatment: in cases of closed contusion, subcutaneous swelling disappeared usually within 3-4 days after the above described measures. The color of ecchymosis turned from violet-blue to green-blue to light yellow, and absorbed completely within two weeks. Puncture and suction of blood would be not only unnecessary but also contraindicated. For open breaches, if the wounds are short, clean, and regular, adhesives may be applied. Otherwise, the wounds could be contaminated and infected due to the incomplete drainage if the adhesives are applied. The chronic changes after injury of eyeball may be treated as in ophthalmologic clinic. For dilated pupils due to injury and impaired vision, polyvitamins and injections of ATP and creatine etc. had a definite effect.

# MORPHOFUNCTIONAL FOUNDATIONS OF ENDOCRINE FUNCTION PERFECTION IN TRAINING PROCESS

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## Abstract

In our research the original method of the individual dosage of moving activity was used. This method is neither based on the time of running nor on the distance but on the diagnosis of the conditions of the cardiorespiratory system during running.

The state of endocrine glands (adenohypophysis, adrenal glands, thyroid gland) in experimental animals (39 mongrel male dogs) with different models of motion activity (single and systematic physical exercises) was studied. A complex of physiological, histological and histoenzymatic methods was used.

It is shown that the high and low efficiency level of the organism is characterised by various morphological equivalents of response of the endocrine organs and the system in total.

It was established that the most important moment of the organism's adaptation to motion regimens is the state of the structures providing microcirculations in the system. Peculiarities of the latter in many aspects are due to individual-typological organization level. It can appear to be a limiting factor and reflect the training process efficiency.

**Key words:** Endocrine function, training, dogs.

Any training regimen is realized through adaptation processes. The basis of adaptation processes is recognition of acting factors (in our case it is motor activity) by the living system (organism). The recognition of acting factors takes place in conditions of appropriate change of living system states: the novelty effect of acting factor, the primary desintegration and integrative state of functioning elements of the system. Morphofunctional changes in endocrine organs in different efficiency level are described [1, 2, 3].



In these studies the dose of physical exercises according to time, velocity or duration is used. But there were no experimental studies on the revealing of morphofunctional equivalents of the improving of endocrine regulation of high and low efficiency levels, based on the dose (diagnosis) of integrate and disintegrate states of the cardio-respiratory system, during running. The purpose of the investigation is to establish morphofunctional reaction equivalents of adenohipophysis, thyroid gland (TG), and adrenal glands (AG) in high and low efficiency levels in conditions of individual movement dosages in a single effect and in a special training regimen.

### Materials and methods

39 mongrel male dogs were investigated. All animals were divided into the following groups: 12 dogs performing single exercise, treadmill running at 15km/h until exhaustion, 15 dogs performing a systematic training and 14 animals constituting the control group. The measurement of heart rate and respiratory capacity was performed in the process of the animal's running on a treadmill [4]. Besides, bioelectric heart activity and some findings of central and peripheral hemodynamics were investigated before and after running [5]. To reveal the specific features of endocrine organ reaction to exercise load on the background of preliminary training (i.e. adopted to load factor) the experiment was carried out using training by A.P. Sorokin's method [6]. The training regimen consisted of 3 parts. The first one was a cycle of integrative character loads (up to the 4th stage). A.P. Sorokin and co-workers found [7] the organism's reaction in the running to develop by stages. Oxygen transfer system research has shown a high level of integration at the 4th stage of adaptation to running.

The first part is one of the running cycle of integrate nature (up to the 4th stage) up to reaching the first efficiency peak. The primary peak is considered to be the increase of running time on the treadmill and the stability of the achieved result during 3 days at least. Heart rate stability and reduction on the maximum low level were marked (both before and during the running on treadmill). The second part of training consisted in reduction of the daily running volume (intensity) during 10-15 days. These exercises resulted in desintegration of the elements of the cardiorespiratory system. According to the load's nature, the third part was the same as the first training part and was aimed at the formation of functional state of the animal's organism up to the secondary efficiency peak (Figure 1).

To determine the effect of training, coefficient of efficiency in-



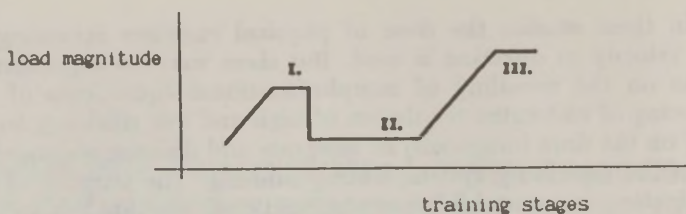


Figure 1. Experiment building scheme on the forming of secondary peak of the organism's working capacity.

crease was calculated, because the efficiency level, determined by the time of running in all dogs, was different both at the last training day and at the first one (initial level). The coefficient was determined by the formula  $q = X_n/X_1 * 100 \%$ ,

where  $q$  — coefficient of efficiency,

$X_1$  — the time of running in the first day of the training regime,

$X_n$  — the time of running in the last day of the training.

Specimens of tissues of adenohypophysis, thyroid gland (TG) and adrenal glands (AG) were treated and studied using histological and histoenzymatic methods. Celloidin-paraffinic section were stained by hematoxilin-eosin, also by Van-Gizon for revealing of collagen structures and by Halmi-Dyban [8] for differentiation of adenohypophysis cells. Indices typical for gland parenchyma state (the number of cells, nucleus value, epithelium height etc.) and blood vessel bed (capillary diameter, space between them) were measured. Cryostatic sections were incubated in medium for alkaline phosphatase in TG [9], for assessment of  $3\beta$ -ol-steroid-dehydrogenase ( $3\beta$ -OH-SD) in AG [10]. Data were treated using statistical methods of variation [11], including correlation analysis.

## Results

In our experiment, the time of running until exhaustion varied from 10 to 225 minutes (mean  $\pm$  s.d.,  $81.7 \pm 19.7$  min). After running the studied endocrine organs had individual heterogenous structure in accordance with the running time (level of organism efficiency). Dogs with long running time (from 147 to 225 min) had a decrease of thyroid gland functional activity, and morphological parameters indicating it: squamous epithelium, dense colloid filling follicle completely (Table 1).

A strong positive link ( $r = +0.5$ ,  $p < 0.05$ ) between the time of running until exhaustion and colloid volume has been revealed by correlation analysis. The special feature of thyroid gland in

Table 1

**Characteristic of thyroid gland in dogs after running  
until exhaustion ( $\bar{X} \pm S\bar{x}$ )**

Indices	Running time	
	147-225 min(n=3)	10-91 min (n=9)
Relative colloid volume (%)	$70.40 \pm 1.73$	$54.32 \pm 3.37^{***}$
Relative volume of epithelium (%)	$22.50 \pm 1.40$	$28.09 \pm 1.57^{**}$
Height of epithelium ( $\mu\text{m}$ )	$5.63 \pm 0.40$	$7.85 \pm 0.67^{**}$
Relative volume of enzyme-active capillaries	$1.90 \pm 0.43$	$3.23 \pm 0.32^*$

Differences between group are indicated by asterisks:

\* —  $p < 0.05$ , \*\* —  $p < 0.01$ , \*\*\* —  $p < 0.001$

dogs running for a long time is the decrease of enzyme-active transcapillary metabolism. The relative volume of enzyme capillary (in endothelium of which alkaline phosphatase is being revealed) of long time running dogs is 58 % less ( $p < 0.05$ ) than that in dogs with shorter running time (Table 1). Adrenal glands were characterized by high activity of glomerular and fascicular zones, wide lumen of capillaries, small distance between them, intensive reaction of revealing  $3\beta\text{-OH-SD}$  enzyme (Table 2).

Dogs with short running time until exhaustion (from 10 to 90 min.) had a marked functional activity of thyrocytes in thyroid gland. It was indicated by high epithelium. Along with this, the intensification of colloid mobilization takes place, and that is confirmed by vacuolization of colloid and morphological picture of capillaries. Capillaries are widened, filled with blood. Stasis of erythrocytes indicated a decrease of circulation rate and intensification of transcapillary metabolism [12]. The increase of contacting capillary surface with follicular wall goes on at the expense of capillary widening and their invagination in follicular wall, that result in irregular form of follicular basal membrane. Adrenal glands are characterized by considerable activation of the medulla: widening of the zone and capillary diameter. Distance between capillaries is

Table 2

Characteristic of adrenal gland in dogs with different running time until exhaustion ( $\bar{X} \pm S\bar{x}$ )

Indices	Running time	
	147-225 min	10-91 min
Width of zones ( $\mu\text{m}$ )		
G. Z	202.00 $\pm$ 4.70***	171.60 $\pm$ 13.00
F. Z	1019.00 $\pm$ 5.90***	954.00 $\pm$ 10.20
S. M	727.70 $\pm$ 17.60**	874.20 $\pm$ 25.50
Distance between capillaries ( $\mu\text{m}$ )		
G. Z	22.14 $\pm$ 1.01*	26.72 $\pm$ 2.37
F. Z	11.70 $\pm$ 0.70***	17.80 $\pm$ 2.13
S.M	28.22 $\pm$ 1.08*	19.70 $\pm$ 2.39
3 $\beta$ -OH-SD		
G.Z	0.392 $\pm$ 0.07	0.165 $\pm$ 0.01*
F.Z	0.296 $\pm$ 0.09	0.111 $\pm$ 0.003*

\* —  $P < 0.05$ , \*\* —  $p < 0.01$ , \*\*\* —  $p < 0.001$

Statistically valuable differences concerning the intact group

G.Z — glomerular zone

F.Z — fascicular zone

S.M — substantia medullaris

less than that in the long time running group (Table 2). In the adenohypophysis the dependence of capillary capacity on individual efficiency (running duration) is marked: animals with long time of running having this index higher than intact animals. On the contrary, as a rule, animals with short time of running have it lower. In all cases signs of alteration of transcapillary metabolism and parenchymostromal interrelations are marked. Along with the decrease of capillary capacity, the separation of glandular cells as an edema of intercellular space, the thickening of capillary basal membrane and the increase of adenocytes contacting with pericapillary space directly are marked. To the above mentioned alterations also widening of pericapillary space is added.

Correlation analysis between parameters of thyroid and adrenal glands has revealed the unequal number of linear links in the group with different running time. Long time running animals have the



adrenal-thyroid correlative system with a great number of significant links. The character of links indicates the integration of this system functioning in dogs with high efficiency.

Thus, endocrine organ reaction to a single exercise shows that the limit of the organism's possibilities has individual character in dependence on the initial level of the organism's efficiency.

After the training exercises forming the secondary increase of efficiency level, individual variety of thyrocytes height decreases. Follicle epithelium form is mainly plane, that indicates to decreased functional activity. Dense colloid fills follicles completely, that indicates to the decrease of its intensive mobilization from the depot. As in the case of single physical running, considerable ( $r = 0.8$ ,  $p < 0.05$ ) positive link between relative capacity of depot colloid and last day running was revealed by correlation analysis.

In the adrenal glands of the animals with a marked training effect the prevailing indices are: fasciculata widening, increased cell volume and medullar capillary diameter, decrease of volumes occupied with adrenocytes. Noradrenocytes were revealed more frequently in comparison with those of the control group and of the animals with a less pronounced training effect. Distinctive features of the group with a marked training effect are also high indices of specific enzyme synthesis ( $3\beta$ -OH-SD), and low indices of cortical cells nuclei volume (Table 3). All these facts testify to the activation of adrenal medullar elements, forming catecholamine mechanisms of quick adaptation of the organism to physical activity, that render influence on the adrenal cortical cell in the production of gluco- and mineralocorticoids that provide for the prolonged work of the organism [13].

In adenohipophysis signs of rebuilding in the limiting link (haemocapillary and pericapillary space) that become apparent in the change of interrelations between capillary and pericapillary space width were found. The open lumen of capillary is increased and the width of pericapillary space is decreased in absolute significances (Table 4), thus the precondition for stimulation of metabolism processes in adenohipophysis and for mobilisation of its structural and functional reserve is created. The main mechanism of rebuilding is likely to be the increase of circulation capacity throughout the gland, caused by physical activity. The decrease of distance between blood and the glandular cells is the morphological equivalent of the decrease of blood-tissue barrier, making the realization of endocrine function easier. These changes are clearly marked in dogs with a high efficiency training and may be considered to be the signs of adaptative rebuilding of the adenohipophysis. Dogs with a low efficiency training have similar, but less pronounced changes. In total they cannot be considered to express directly an adaptive rebuilding



Table 3

Characteristic of adrenal gland in dogs  
with different level of working capacity ( $\bar{X} \pm S\bar{x}$ )

Parameters	Zones	Groups		
		High working capacity	Moderate working capacity	Intact
Width of zones (mkm)	G.Z	132.0 $\pm$ 5.6*	182.0 $\pm$ 31.0	161.3 $\pm$ 10.8
	F.Z	860.0 $\pm$ 12.9	721.0 $\pm$ 12.9	796.7 $\pm$ 46.7
	S.Z	811.0 $\pm$ 12.2	855.0 $\pm$ 11.8	631.7 $\pm$ 10.8
Diameter of capillaries	G.Z	12.2 $\pm$ 0.2***	12.7 $\pm$ 0.5***	9.8 $\pm$ 0.1
	F.Z	11.8 $\pm$ 0.7	15.7 $\pm$ 1.7**	10.4 $\pm$ 0.5
	S.M	24.8 $\pm$ 1.0*	22.6 $\pm$ 0.8	20.5 $\pm$ 1.6
3 $\beta$ -OH-SD	G.Z	0.194 $\pm$ 0.025*	0.041 $\pm$ 0.006**	0.115 $\pm$ 0.023
	F.Z	0.136 $\pm$ 0.001**	0.054 $\pm$ 0.006	0.084 $\pm$ 0.014
Volume of cell nuclear (mkm <sup>3</sup> )	G.Z	66.9 $\pm$ 9.0	83.0 $\pm$ 4.3	83.1 $\pm$ 3.9
	F.Z	65.3 $\pm$ 10.2	75.6 $\pm$ 4.5	74.9 $\pm$ 2.6
	S.Z	88.6 $\pm$ 15.4	81.0 $\pm$ 3.5	80.3 $\pm$ 5.0
%A-cells	S.M	49.2 $\pm$ 3.8*	61.7 $\pm$ 5.0	62.6 $\pm$ 3.3
%N-cells	S.M	10.8 $\pm$ 0.7*	11.9 $\pm$ 1.7	15.4 $\pm$ 2.1

\* —  $p < 0.05$ , \*\* —  $p < 0.01$ , \*\*\* —  $p < 0.001$

Statistically valuable differences concerning the intact group

G.Z — glomerular zone

F.Z — fascicular zone

S.Z — substantia medullaris

of the adenohypophysis.

It is remarkable that both in the group of animals with a high efficiency training and in the group of animals performing a single exercise, the number of correlation between parameters of investigated organs was greater than in the group with a low efficiency training. The character of correlation of the parameters is reverse. Significant correlative links were found between thyroid and adrenal gland parameters in dogs with a marked effect of training (Table 4).

Table 4

The square of capillary lumen and pericapillary space ( $\mu\text{m}$ )  
in adenohipophysis after the cycle of systematic exercises

Parameters	Groups		
	High working capacity	Moderate working capacity	Intact
The mean square of capillary lumen	260.9 $\pm$ 29.1	239.1 $\pm$ 30.6	229.2 $\pm$ 24.6
The mean square of pericapillary space	237.6 $\pm$ 31.4*	257.1 $\pm$ 56.4	314.0 $\pm$ 32.4

\* — the differences between control group, true if  $p < 0.05$

### Conclusion

The description of morphological equivalents of the perfection of endocrine regulation may be advanced on the basis of the methods of the individual dosage of moving activity [4]. These methods diagnose the conditions of the organism, that are formed during the running. The studies [14] show, that different conditions with various morphological complications in myocard develop in experimental animals during the equable running for 15 min. The researchers of our laboratory [15] described the conditions that are obligatory, developed during the running and may be diagnosed according to the response of the cardiorespiratory system. Each of these conditions has its morphological equivalent in the endocrine organs response [16]. Using our methods, one is able to describe morphological specimens, that are determined by the organism's constitution and to show the morphofunctional differences of the high and low efficiency level in the studied endocrine organs. The most responsible chain in adaptive rebuilding of adenohipophysis, adrenal gland and thyroid gland is the microcirculation system.

Among the structures ensuring metabolism the alterations referring to the penetrability of epithelium and to the value of metabolism surface, to the distance between blood and glandular cells are revealed (the value of capillary capacity and pericapillary space).

## Summary

1. The repeated influence of factor of the motor activity (training) determines the decrease of individual variability of response of the studied endocrine organs.

2. The decisive factor in improving endocrine regulations of the organism in training is the condition of structures, ensuring metabolism in microcirculation system.

3. The high level of capacity for work is provided by low functional activity of thyroid gland, high functional activity of adrenal cortex, by large volume of capillary bed of adenohypophysis, by large amount of correlations between indices of adrenal and thyroid glands.

4. In transition to a higher level of efficiency a considerable degree of activity of adrenal cortex (formation of glucocorticoids) and the increase of volumetrical blood flow in adenohypophysis with a simultaneous decrease of pericapillary space plays an important role.

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# METABOLIC AND HORMONAL CHANGES IN BLOOD DURING BICYCLE ERGOMETER LOAD AT CRITICAL POWER LEVEL IN MALE STUDENTS

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## Abstract

The aim of the present investigation was to study the changes on selected biochemical parameters of blood during 30 min exercise test on bicycle ergometer at the individual critical power (CP) level in relatively untrained male students ( $n = 10$ ,  $21.6 \pm 1.6$  yrs,  $185.8 \pm 7.0$  cm,  $77.5 \pm 4.3$  kg, fat %  $8.1 \pm 3.0$ ,  $\dot{V}O_2\text{max/kg}$   $49.1 \pm 8.1$  ml·min<sup>-1</sup>·kg<sup>-1</sup>). CP was measured using 3 bicycle ergometry tests of fatigue at 280, 340 and 400 W separated by rest periods of at least 3 h. The mean CP was  $242.5 \pm 13.5$  W. During 30-min test at the individual CP level, air samples were collected every 5 min and heart rate (HR) was recorded at the same time. The mean  $\dot{V}O_2$  at CP test was 78.9 % of  $\dot{V}O_2\text{max}$  and the mean HR was  $170.6 \pm 8.3$  beats·min<sup>-1</sup>. The calculated CP was extremely high in 7 persons and their exercise intensities were reduced by the minimal amount necessary to ensure continued exercise over the 30-min period. The mean power attained was 8.5 % below that estimated by CP. Venous blood was sampled immediately before exercise, on the 10th minute of the load, immediately after exercise and after 30 min of recovery. In blood plasma the concentrations of lactate, glucose, cortisol and insulin were measured. After 30-min load, lactate level was the highest:  $8.46 \pm 1.30$  mmol·l<sup>-1</sup>. There was an insignificant increase of glucose concentration ( $p > 0.05$ ) during the second part of exercise. Immediately after the load, cortisol concentration increased significantly ( $p < 0.05$ ) compared with initial level ( $679.2 \pm 192.2$  and  $985.0 \pm 311.3$  nM·l<sup>-1</sup>). There was no significant change of insulin concentration of blood during exercise and recovery.

In conclusion, in our relatively untrained students the intensity of bicycle ergometer load at individual CP levels was relatively high for a 30-min exercise period. There were no steady-state levels and

there was a need for corrections in the methods of determining CP. During the intensive CP level exercise mostly carbohydrates were used as a fuel and exercise activates the adreno-cortical system.

**Key words:** Exercise test — Critical power — Hormones — Substrates — University students

## Introduction

In exercise physiology, endurance capacity has been measured using different threshold indices determined either from blood lactate (LA) or from ventilatory data in incremental exercise tests [Wassermann and McIlroy 1964; Kindermann et al. 1979; Stegmann and Kindermann 1982]. For measuring physical working capacity above different anaerobic thresholds (AT) and below maximal  $O_2$  consumption ( $\dot{V}O_{2max}$ ) it is recommended to measure critical power (CP) which is a noninvasive and inexpensive measure. Monod and Scherrer [1965] identified CP as the intensity of exercise which could be maintained "for a very long time without fatigue". The asymptote of the hyperbolic relationship between power output and the time of fatigue has been defined as CP, which, in theory, represents the highest metabolic rate where a steady-state response can be achieved during prolonged exercise. Theoretically, CP is analogous to the concept of lactate threshold. Moritani et al. [1981] developed a bicycle ergometer analogue of the CP test proposed by Monod and Scherrer [1965] for synergic muscle groups. Analogous CP tests were presented on treadmill [Hughson et al. 1984] and swimming flume [Wakayoshi et al. 1992] too.

The metabolic response to muscular work is dependent upon its mode, intensity, duration and upon availability of adequate precursors for energy metabolism. Intensive exercise with great energy expenditure and lasting for 30–60 min depends entirely on compulsive processes in the mitochondrions and on the availability of fuels [Saltin 1973; Keul 1975]. Carbohydrates are the primary energy sources during intense exercise. At a work load higher than 90 % of  $\dot{V}O_{2max}$ , muscle glycogen is the most important substrate [Saltin and Karlsson 1971; Wahren 1979]. During the initial stages of moderate-intensity exercise, blood glucose (GL) levels are maintained or may even increase slightly [Coyle et al. 1986], in most cases during intensive exercise the GL concentration in blood increased [Kindermann et al. 1986].

During work at the individual CP level the LA concentration in blood will be relatively high. According to Jenkins and Quigley [1990] during 30 min of cycle ergometry test at or near CP level the mean LA concentration in blood was  $8.9 \pm 1.6 \text{ mmol}\cdot\text{l}^{-1}$ . The LA

concentration rose rapidly during the first 5–10 min of exercise after which there was a levelling off during the last 20 min of exercise, in spite of the fact that only two (total 8) individuals completed the 30 min exercise at CP. Others were unable to maintain CP and the work rate was reduced progressively. According to McLellan and Cheung [1992] at 15 min test on the CP level the mean LA of the blood was lower — only  $6.8 \pm 1.9 \text{ mmol}\cdot\text{l}^{-1}$ . Then the methods recommended for determining CP somewhat overestimated the metabolic rate associated with a maximal steady-state blood LA. The correlation between the mean exercise LA concentration and CP was insignificant. The correlation was significant between exercise LA concentration and the y-intercept of the CP function. Then the y-intercept is related to anaerobic capacity [Moritani et al. 1981; Nebelick-Gullett et al. 1988; Vandewalle et al. 1989; Jenkins and Quigley 1991].

Normally the endocrine functions increase when the intensity of exercise is near the AT level [Virtanen 1985]. As a rule the “stress hormone” cortisol concentration in blood increased when the intensity of exercise was higher than 60 % of maximal aerobic power [Davies and Few 1973; Luger et al. 1987; Kjær et al. 1988] or higher than 70–75 % [Galbo 1983]. However, during 30-min running at individual lactate threshold level cortisol concentration in the blood did not increase significantly [Järnå et al. 1990]. Significant increase will occur already after relatively short periods of exercise [Luyckx et al. 1980] and the increasing level is dependent on the intensity of exercise [Virtanen 1985]. There is a significant correlation between the concentrations of cortisol and LA in blood [Luger et al. 1987].

There will be different reactions to insulin concentration in blood during different duration and intensities of exercises. The insulin concentration will decrease after 10 min [Nilsson et al. 1975; Hilstedt et al. 1980] or 20–30 min of exercise [Schmid et al. 1983]. On the other hand, during intensive exercise (85–90 %  $\dot{V}O_2\text{max}$ ) during the first 10 min of exercise the insulin concentration somewhat increased [Pruett 1970]. Very intensive anaerobic exercises, as a rule, increased insulin concentration in blood moderately [Järnå et al. 1990]. There are no answers yet to the question if there are any differences between the metabolic and hormonal adaptation to relatively intensive and long bicycle ergometer load at individually calculated CP level.

The aim of the present investigation was to study the changes in selected biochemical parameters in blood during 30 min exercise on bicycle ergometer at the individual CP level in relatively untrained male students.



## Methods

**Subjects.** 10 healthy male recreationally trained (but not training for competitive sport) university students took part in the study. Their physical and physiological characteristics are given in Table 1. Body composition was measured using a bioelectrical impedance method (Bodystat — 500, England).

Table 1

Age, height, weight and parameters of body composition and aerobic working capacity of all subjects (n = 10)

	$\bar{x} \pm SD$
AGE (years)	21.6 $\pm$ 1.6
HEIGHT (cm)	185.8 $\pm$ 7.0
WEIGHT (kg)	77.5 $\pm$ 4.3
L B M (kg)	71.2 $\pm$ 3.9
FAT %	8.1 $\pm$ 3.0
$\dot{V}O_2\text{max}$ (l·min <sup>-1</sup> )	3.776 $\pm$ 0.516
$\dot{V}O_2\text{max/kg}$ (ml·min <sup>-1</sup> ·kg <sup>-1</sup> )	49.1 $\pm$ 8.1
AT (W)	210.3 $\pm$ 10.8
AT - $\dot{V}O_2$ (l·min <sup>-1</sup> )	2.597 $\pm$ 0.317
AT - $\dot{V}O_2\text{max}$ (%)	69.1 $\pm$ 6.2

**Determination of  $\dot{V}O_2\text{max}$  and AT.**  $\dot{V}O_2\text{max}$  was conducted on a bicycle ergometer (electrically braked) test. The work load began at 100 W and increased by 40 W every 3 min until the highest possible load was reached (maintaining 70 rpm) and terminated by a 1-min sprint at maximum pedalling rate. Expiratory gases were collected at the end of each work load during 30 s. Concentrations of O<sub>2</sub> and CO<sub>2</sub> were analyzed using paramagnetic and infrared analyzers respectively. Ventilatory volumes were determined with a Tissot spirometer. Heart rate (HR) was recorded after each load with the help of SPORTTESTER PE-3000 (Polar Electro, Kempele, Finland). AT was estimated from gas exchange variables by load at which ventilation parameters began to increase nonlinearly [Wassermann and McIlroy 1964].

**Tests of CP.** CP was measured using a protocol established by Monod and Scherrer [1965] and adopted to bicycle ergometry by Moritani et al. [1981]. CP was measured using three bicycle ergometry tests in fatigue at 280, 340 and 400 W separated by rest periods of at least 3 h. Every test was preceded by a 5-min



warming-up at 100 W followed by 3 min of passive recovery. When the subjects could no longer maintain the required pedalling rate of 70 rpm for a period of 3 s, the test was terminated and the limits of work(KJ) and time (s) were recorded.

**Exercise for 30 min at CP.** After a few days rest a 30-min test at individual CP level was performed. The test was held in the morning between 9 a.m. and 12 at noon in a fasting state. A 5-min warming-up at 100 W was completed prior to imposing the predetermined exercise intensity after which the importance of maintaining the required W was stressed. However, if the required W could not be maintained, intensity was reduced by the minimal amount necessary to enable continuing. HR was recorded after every 5 min with the help of SPORTTESTER PE-3000. Air samples for  $\dot{V}O_2$  were collected during 30 s after every 5 min.

Blood samples were obtained from the antecubital vein immediately before exercise, on the 10th minute of the load, immediately after the exercise was finished and after 30 min of recovery. Plasma was separated by centrifugation and the samples were frozen and stored at  $-20^{\circ}\text{C}$  for subsequent analyses. Plasma LA and GL concentrations were measured enzymatically using Boehringer Mannheim GmbH Diagnostica (Germany) and Lachema (CSFR) kits respectively. Cortisol and insulin concentrations in plasma were determined using specific radio-immunoassays [Jaffe and Behrman 1979] with kits from the Institute of Bio-organic Chemistry of the Byelorussian Academy of Sciences.

Means ( $\bar{x}$ ), standard deviations (SD) and linear correlation coefficients ( $r$ ) were calculated using ordinary statistical methods. Differences between means were tested for significance using Student's *t*-test.

## Results

The subject's mean body composition and aerobic working capacity parameters are presented in Table 1.

The subjects performed 3 tests at well-separated work rates on bicycle ergometers to allow the linearity of the  $W_{\text{lim}}:t_{\text{lim}}$  relationship to be evaluated. The mean time to exhaustion ranged from 1 min 16 s to 3 min 31 s for the highest work rate (400 W) to 6 min - 13 min 25 s for the lowest (280 W). The mean CP was  $242.5 \pm 13.5$  W (222-263 W). The *y*-intercept was  $19.6 \pm 8.0$  KJ. During 30-min test at individually calculated CP level (W) the load was extremely high for 7 persons and their exercise intensities were reduced by the minimal amount necessary to ensure continued exercise over the 30-min period. The mean calculated power for the 30-min period was

20.8 W or 8.5 % below CP. Figure 1 illustrates the changes of HR during 30-min exercise. In the second part of the load, HR increased step-by-step and the mean HR was significantly higher than after 5 min of the load. The mean HR at 30 min of exercise was significantly ( $p < 0.01$ ) higher than at the 10th min of exercise. The mean HR during the test was  $170.6 \pm 8.3$  beats $\cdot$ min $^{-1}$  and the  $\dot{V}O_2$   $78.9 \pm 9.2$  % from  $\dot{V}O_{2\max}$ . There was a highly significant correlation ( $r = 0.920$ ) between  $\dot{V}O_{2\max}/\text{kg}$  expressed as  $\frac{1}{\dot{V}O_{2\max}/\text{kg}} \times 100$  and %  $\dot{V}O_{2\max}$  (Figure 2).

Blood LA concentrations rose rapidly during the first 10 min of exercise at CP (Figure 3). After the load, the mean LA was the highest —  $8.46 \pm 1.30$  mmol $\cdot$ l $^{-1}$ , while individual LA concentrations ranged from 6.84 to 11.12 mmol $\cdot$ l $^{-1}$ . During 30 min of recovery the LA concentration in blood decreased significantly ( $p < 0.001$ ), if compared with concentrations immediately after the load.

The changes in GL concentration in blood are presented in Figure 3. The mean concentration in blood increased insignificantly ( $p > 0.05$ ) during the second part of the bicycle ergometer load. Data provided in Figure 4 demonstrate that immediately after the 30-min test the mean cortisol concentration in blood was significantly increased when compared with the initial level ( $p < 0.05$ ). In the recovery period cortisol concentration decreased only moderately ( $p > 0.05$ ). After the 10th minute of the load, cortisol concentration had increased more than 50 nM $\cdot$ l $^{-1}$  in 4 cases, decreased in 3 cases and not changed in 3 cases. At the end of exercise, increasing was observed in 8 cases, no change and decrease each in 1 case. During the recovery period the concentration increased in 3 cases, did not change in 1 case and decreased in 6 cases, when compared with the levels immediately after the load. In most cases, cortisol concentration increased in the second part of the exercise and decreased moderately during recovery.

No statistically significant changes were obtained in insulin concentrations in blood during the experimental period (Figure 4). After 10 min of exercise the concentration mostly decreased more than 0.5 mg $\cdot$ ml $^{-1}$  ( $n = 8$ ). Only in 1 subject the concentration increased or did not change. On the 30th minute of exercise the concentration decreased in 7 cases and did not change in 3 cases if compared with initial values. During recovery period the concentration continued to decrease in 4 cases, increased in 4 cases and did not change in 2 cases when compared with the data immediately after the load.

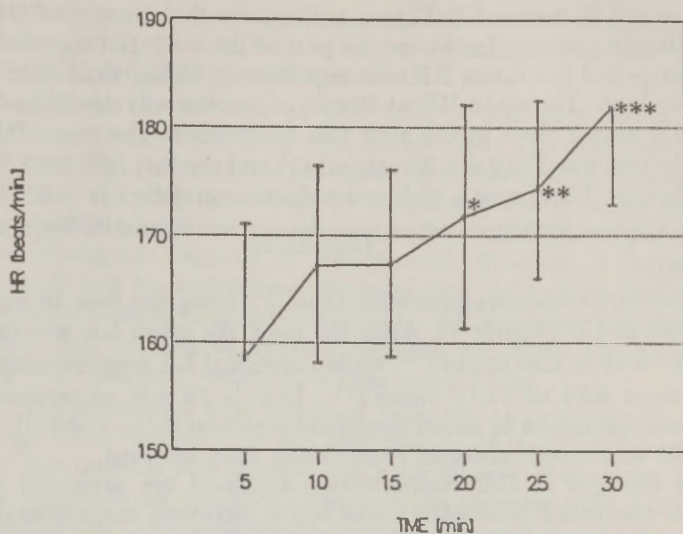


Figure 1. Changes of heart rate during 30-min load at CP level ( $\bar{x} \pm SD$ ).

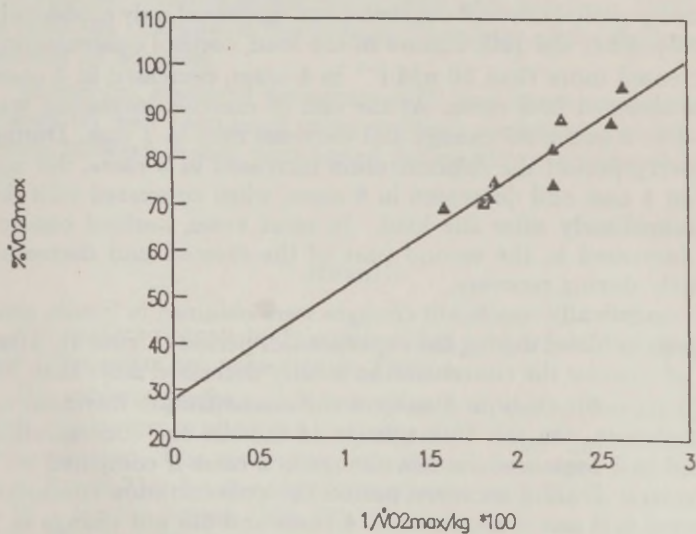


Figure 2. Relationship between  $\dot{V}O_{2\max}/\text{kg}$  expressed as  $\frac{1}{\dot{V}O_{2\max}/\text{kg}} \times 100$  and  $\% \dot{V}O_2$  from  $\dot{V}O_2 \max$ .

$$y = 24.4x + 28.0$$

$$r = 0.920$$

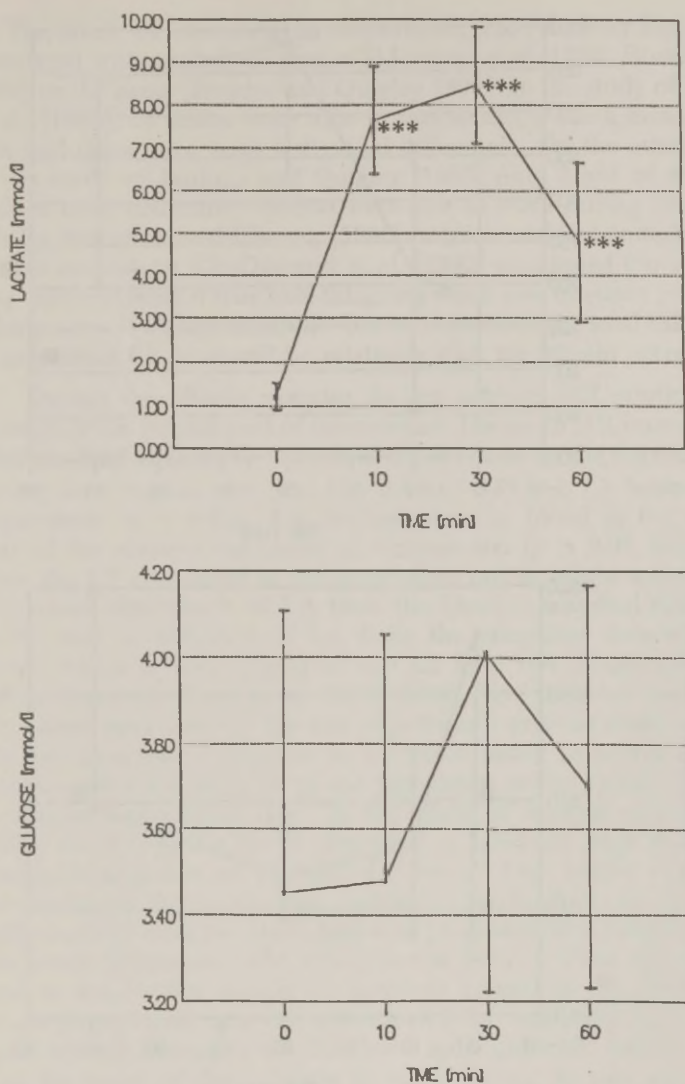


Figure 3. Changes in lactate and glucose concentrations in blood during 30-min test and recovery ( $\bar{x} \pm SD$ ).

## Discussion

It has been suggested that CP represents the maximal power load which can be maintained without exhaustion [Moritani et al. 1981; Nagata et al. 1983; Ginn 1988; Jenkins and Quigley 1990].



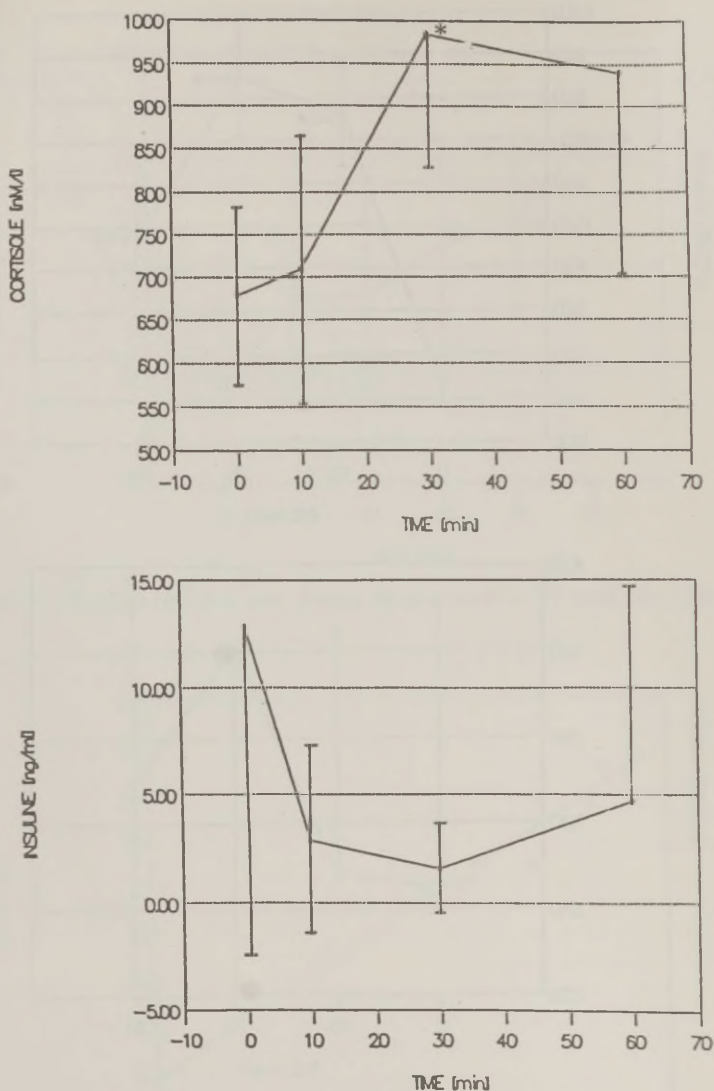


Figure 4. Changes in cortisol and insulin concentrations in blood during 30-min test and recovery ( $\bar{x} \pm SD$ ).

In our study only 3 subjects were able to work at the individually calculated CP level for 30 min. In others we reduced the load progressively by an average of 8.5 %. Somewhat surprisingly the subjects who had relatively high  $\dot{V}O_{2\max}/\text{kg}$  values worked during the 30-min test with a relatively low %  $\dot{V}O_2$  from  $\dot{V}O_{2\max}$  (Figure

2). The mean CP calculated in our subjects was relatively high when compared with analogous studies [Moritani et al. 1981; Housh et al. 1989] or the same [Jenkins and Quigley 1991]. In the study of Housh et al. [1989], 14 males were able to maintain CP for a mean of 33 min and there were large individual differences. On the other hand, in the study of Jenkins and Quigley [1990] only 2 out of 8 highly trained male endurance cyclists were able to work during 30 min at CP. By McLellan and Cheung [1992] only one subject completed 30 min of exercise at CP. Overend et al. [1992] concluded too that CP may not represent a true non-fatiguing work rate in either young or elderly men. We must conclude that in most cases the load calculated at individual CP level will be relatively high for 30-min exercise.

During the 30-min exercise, in our subjects HR continued to increase in the second part of the exercise. The mean HR immediately after the load (Figure 1) was relatively the same as the maximal HR during the  $\dot{V}O_2$ max test ( $181.9 \pm 9.4$  and  $189.2 \pm 7.1$  beats·min<sup>-1</sup> respectively,  $p > 0.05$ ). LA concentration in blood in the second part of the exercise continued to increase too ( $p > 0.05$ , Figure 3). Then the CP calculated in our study does not represent a metabolic rate where elimination of LA from the blood is maximal and equal to the rate of diffusion of LA from the exercising muscle to the blood, which is very typical of the AT level test [Stegmann et al. 1981]. However, Poole et al. [1988, 1990] have reported that blood LA values plateaued by the end of a 24-min exercise session at CP, whereas progressive increase in LA were noted at power outputs that exceeded CP at 5 % of the maximum power output attained during an incremental test. In the study of Jenkins and Quigley [1990] the LA in the blood plateaued at relatively high values too during 30-min test at or near CP level. Our results confirmed the results of one study that exercise at metabolic rates exceeding individual AT level are associated with progressively increasing blood LA levels [Stegmann and Kindermann 1982]. Then the exercise time to exhaustion should be inversely related to the amount by which the exercise intensity exceeds AT. In our study the exercise work rate at averagely 9.8 % above individual AT was extremely high for most of the subjects to work during 30 min on bicycle ergometer. Then during the 30-min load at CP there is classical steady rate to be found at which blood LA levels reach an elevated plateau [Stegmann and Kindermann 1982] and the methods used to determine CP overestimate the metabolic rate associated with maximal steady-state blood LA.

Blood GL and muscle glycogen are the primary energy sources during intense exercise. The rate of blood GL utilization during exercise is curvilinearly related to exercise intensity [Wahren 1971; Katz et al. 1986]. In our study, GL concentration in blood during

30-min test increased insignificantly. The mean values before test were relatively low (Figure 3), which may be in connection with the fact that our subjects came to the test in a fasting state. In our study the relatively high CP mean values (W) decreased GL concentration before the test too ( $r = -0.592$ ).

It has been shown that exhaustive exercise test at 90 or 120 % of  $\dot{V}O_2\text{max}$  and lasting less than 30 min results in approximately a 30 % depletion in muscle glycogen stores [Saltin and Karlsson 1971] and then the energy substrate availability in the form of muscle glycogen does not limit exercise endurance. Then the fatigue at CP results from LA accumulation or creatine phosphate depletion. The not significantly changed GL concentrations in blood in our study during the load we must explain with the circumstances that during high intensity exercises some of the GL taken up may accumulate within the muscle owing to inhibition of hexokinase by glucose-6-phosphate produced by rapid glycogenolysis [Katz et al. 1986].

Hepatic GL output is under hormonal control. A decreased plasma insulin level associated with increased GL output [Filig and Wahren 1979] or GL output is increased even when the plasma insulin level has not changed or has been elevated [Chisholm et al. 1982; Näveri et al. 1985]. In our study there was no significant change in GL and insulin concentrations during the load and recovery (Figures 3, 4). Our results agree with previous results, where in untrained young males during approximately 13-min load at 85 %  $\dot{V}O_2\text{max}$  the GL and insulin concentrations in blood changed insignificantly and there were great intraindividual variations [Karelson et al. 1991] as presented in our previous study too. In our study in connection with relatively high levels of relative CP (divided by body weight or lean body mass) at the end of the bicycle load the insulin concentration in blood will be increased ( $r = 0.649$  and  $r = 0.557$  respectively). Then during 30-min load at CP level the adrenergic inhibition of pancreatic insulin secretion is not expressed [Galbo 1981]. We must conclude that during 30-min exercise at CP level carbohydrates are mostly used as a fuel because for stimulation of lipolysis during exercise decreased level of circulating insulin and relatively low level of LA concentration is necessary.

As a rule the cortisol concentration in blood increased at an intensity of more than 60 %  $\dot{V}O_2\text{max}$  and the increase is linearly related to %  $\dot{V}O_2\text{max}$  [Davies and Few 1973; Luger et al. 1987; Kjær et al. 1988]. Our high intensity exercise increases cortisol concentration significantly at the end of the load in most cases. Cortisol concentration was extremely high after the load and it is not dependent on the relatively high level of LA concentration ( $H^+$  ions), which inhibits cortisol secretion [Barwich et al. 1982]. Maybe there were no inhibitions in connection with food intake



[Brandenberger et al. 1982], because our subjects came to the test in a fasting state. Then there are relatively quick possibilities to activate the adreno-cortical system during intensive exercise at CP level.

In conclusion, in our relatively untrained students the intensity of bicycle ergometer load at individual CP level was relatively high for 30-min exercise and there were no steady-state levels, and there is a need for corrections of the method of determining CP. We have also shown that during intensive CP level exercise mostly carbohydrates are used as a fuel and exercise activates the adreno-cortical system.

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# THE RELIABILITY OF DIFFERENT METHODS FOR BODY COMPOSITION MEASUREMENT IN FEMALE UNIVERSITY STUDENTS

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## Introduction

Body composition assessments have been undertaken by a number of investigators with the subsequent publication of population-specific equations to predict body composition. These equations are generally accurate but need extensive training in anthropometry and require specialized equipment such as anthropometers or skinfold calipers. However, Norgan and Ferro-Luzzi [19] compared 5 generalized equations and found them all to be statistically different.

The limitations of these skinfold thickness methods include the inability to control inter- and intrasubject variation in skinfold compressibility, the inability to palpate the fat-muscle interface and the impossibility of obtaining interpretable measurements on very obese subjects [4, 5, 6]. Additionally, interobserver variability as well as the use of different types of skinfold calipers may contribute to measurement errors [16]. Test-retest reliability may vary from 0.85 to 0.90 for skinfold measures [24] or often exceed 0.95 [2]. Interobserver correlations from  $r = 0.96$  to  $r = 0.98$  [26] or from  $r = 0.92$  to  $r = 0.96$  [12] have been reported.

The principles of body impedance have been applied to the measurement of human body composition [17, 21]. Bioelectrical impedance analysis is a rapid, noninvasive and inexpensive field method for evaluating body composition. The method is based on the relationship between whole body resistance and the length (height) and volume of the conductor and assumes that the conductor (human body) is cylindrical [17]. As a rule the bioelectrical impedance method is highly reliable [13, 18].

The purpose of the present study was to assess the reliability of three accepted skinfold thickness equations for determination of body fatness in female students, utilizing the bioelectrical impedance method as the criterion method.



## Methods

In total 24 female Tartu University (Estonia) students were studied ( $19.9 \pm 1.5$  yrs,  $165.8 \pm 6.8$  cm,  $58.9 \pm 7.8$  kg, BMI  $21.4 \pm 2.4$ ). Body composition was measured with the help of the bioelectrical impedance method (BODYSTAT-500, England) only once before the skinfold measurements. The subjects' skinfold thicknesses were measured three times with one day's interval (Monday, Wednesday, Friday or Tuesday, Thursday, Saturday) between 9.00 and 10.00 a.m. The skinfold thicknesses were measured on the right side of the body separately by two relatively unexperienced investigators using the same skinfold caliper (Holtain, England) on eleven sites (cheek, chin, thorax I, triceps, subscapular, abdomen, thorax II, suprailiac, thigh I, calf and thigh II). Three complete sets of measurements were made on each subject and the mean of the three measurements at each site was used. The body fat % was calculated by equations of Jackson et al. [9], Parizkova [20] and Sloan et al. [25].

Physical characteristics and body composition measures were expressed as means and standard deviations and a basic correlation matrix of all variables, t-test for paired observations was used for calculating the day to day differences between skinfolds and the bioelectrical impedance method.

## Results

Body fat percentage, calculated by different skinfold thickness equations and the bioelectrical impedance method is presented in Table 1. The lowest mean body fat per cent was during the bioelectrical impedance method, only somewhat ( $p > 0.05$ ) higher calculated by the skinfold equations recommended by Sloan et al. [25] and Jackson et al. [9]. The body fat percentage calculated with Parizkova's [20] method was significantly ( $p < 0.05 - 0.001$ ) higher than with other methods that were used. There were no significant differences in the body fat percentage between investigators. The correlations were high between the measurements of three different days (Table 1).

The mean skinfold thicknesses on three different days are presented in Table 2. The reliability ranged between  $r = 0.659$  (thorax II) to  $r = 0.985$  (abdomen). There were no significant differences between observers on different sites. The correlations between different skinfold thicknesses were relatively high — as a rule somewhat lower or higher than 0.9.



Table 1

The body fat percentage measured by bioelectrical impedance method and calculated by different skinfold equations in female students  
(I — first and II — second investigator)  $\bar{X} \pm SD$

	1 day	2 day	3 day	1-2 day	r 1-3 day	2-3 day
BODYSTAT-500 FAT %	20.4±3.8	20.3±3.9	19.6±4.3	0.925	0.866	0.887
SLOAN et al. [25] FAT % I	22.8±3.0	23.0±3.1	23.2±2.8	0.884	0.888	0.792
II	23.1±3.4	23.5±3.2	23.7±3.0	0.911	0.904	0.895
JACKSON et al. [9] FAT % I	22.9±3.7	23.1±3.4	23.7±3.0	0.932	0.929	0.893
II	23.0±4.0	23.3±3.7	24.4±3.1	0.911	0.899	0.865
PARIZKOVA [20] FAT % I	27.1±3.5	27.7±2.8	27.7±2.6	0.877	0.893	0.859
II	26.7±3.7	27.2±3.2	27.5±3.1	0.913	0.895	0.904

Table 2

Day-to day reliability of skinfold thicknesses at 11 sites  
(I — first and II — second investigator)  
( $\bar{X} \pm SD$ )

		1 day	2 day	3 day	1-2 day	r 1-3 day	2-3 day
CHEEK	I	17.4±2.9	18.2±2.4	17.6±4.1	0.897	0.944	0.773
	II	16.3±2.8	16.1±4.5	16.9±2.8	0.898	0.921	0.831
	r	0.897	0.827	0.917			
CHIN	I	11.6±3.7	11.3±3.8	12.1±3.4	0.824	0.800	0.774
	II	12.5±4.1	12.9±4.4	12.4±4.1	0.843	0.928	0.904
	r	0.944	0.847	0.886			
THORAX I	I	16.3±4.3	16.6±4.9	15.9±4.4	0.861	0.743	0.822
	II	16.1±4.5	16.4±5.2	16.4±4.8	0.794	0.900	0.888
	r	0.902	0.903	0.871			

Continued Table 2

		1 day	2 day	3 day	1-2 day	r 1-3 day	2-3 day
TRICEPS	I	19.7±4.1	19.9±3.5	20.7±3.9	0.692	0.704	0.727
	II	19.7±4.6	20.1±4.4	21.2±3.4	0.724	0.777	0.766
	r	0.915	0.883	0.922			
SUB-SCAPULAR	I	14.5±4.5	14.7±4.4	15.0±4.9	0.904	0.833	0.889
	II	14.9±5.6	14.7±5.2	14.6±6.1	0.931	0.923	0.940
	r	0.923	0.896	0.835			
ABDOMEN	I	21.4±3.1	21.4±3.1	21.4±3.5	0.985	0.968	0.980
	II	21.1±5.8	22.2±3.7	22.0±3.7	0.898	0.941	0.955
	r	0.931	0.947	0.947			
THORAX II	I	13.9±5.1	13.6±4.4	14.2±4.8	0.784	0.839	0.841
	II	13.2±5.1	12.3±5.3	12.5±5.4	0.659	0.741	0.893
	r	0.927	0.913	0.880			
SUPRAILIAIC	I	15.0±5.0	14.3±4.9	14.9±5.0	0.777	0.849	0.900
	II	15.8±5.1	16.3±5.0	16.0±5.2	0.821	0.840	0.869
	r	0.953	0.877	0.922			
THICK I	I	23.1±3.7	24.0±3.0	24.1±3.1	0.774	0.762	0.800
	II	21.5±3.6	22.5±4.0	23.3±3.2	0.804	0.783	0.811
	r	0.910	0.768	0.844			
CALF	I	19.7±4.1	21.8±3.7	23.1±3.6	0.821	0.840	0.743
	II	19.6±3.8	20.8±4.1	21.9±3.4	0.904	0.829	0.906
	r	0.904	0.884	0.874			
THICK II	I	23.4±6.2	24.4±3.6	25.3±3.2	0.798	0.831	0.901
	II	23.4±4.2	24.0±3.9	24.9±3.5	0.832	0.804	0.864
	r	0.980	0.977	0.981			

### Discussion

Skinfold measurement equations tend to be subject significant error that requires better standardization and refinement of techniques for improved validity. With over 100 skinfold equations available [14] all can be classified as either population-specific or generalized. In our subjects only Parizkova's [20] method really overestimated the body fat percentage. If the skinfold thickness method is used for prediction of body fat percentage, we would recommend to use both Sloan et al. [25] and Jackson et al. [9] methods,

especially the last equation developed on females with between 4 and 44 % body fat ( $\bar{x} = 24.0$  %).

The comparison of skinfold thickness equations (body fat %) with the results of the bioelectrical impedance method is somewhat questionable because the different methods of body composition measurement are usually compared with the "golden standard" — the hydrostatic weighing method. On the other hand, there is an acceptable close relationship between the bioelectrical impedance method and the hydrodensitometry method [3]. The lowest body fat % in our subjects with the bioelectrical impedance method (Table 1) we must explain with the fact that the body measurement was taken at the right side of the body where the relatively bigger muscle is located, resulting in a higher predicted fat free mass [18]. As a rule the bioelectrical impedance method is highly reliable [3, 10, 11, 13]. In our study the reliability was high too, but somewhat lower than in others (Table 1).

In our study the correlations between different skinfold thicknesses was, as a rule, above 0.9 as in the other studies [8] and there were no significant differences between investigators. The test-retest reliability of the first investigator was between  $r = 0.692 - 0.985$  and of the other investigator between  $r = 0.656 - 0.955$  (Table 2). The review by Katch and Katch [11] showed test-retest reliability to be above 0.85 and Pollock et al. [22, 23] somewhat higher — above 0.9 for seven measurements. We must explain our somewhat lower results with the fact that our investigators did not have any longterm experience.

Intra-tester reliability was relatively high. In most cases the correlation coefficients were between 0.85 – 0.95 (Table 2) in spite of the fact that the investigators were both less experienced than is recommended before serious experiments (which is 50–100 measured subjects) [11, 15]. We are agreed with other authors [7] that with minimal training, novice practitioners will estimate body fat reliably and with acceptable accuracy. Some researchers [1, 11] stress also the importance of multiple measurements of every skinfold site with a minimum of 2–5 trials being averaged. In our experiment 3 trials were used and the mean calculations of skinfold thickness were used in the calculations.

In our study the highest interobserver errors are in the thigh II, abdomen, suprailiac, thorax II and triceps, the lowest errors in thigh I and cheek. However, Lohman et al. [16] and Womersly et al. [27] noted that the triceps and subscapular measures have the lowest intra-tester variability and the thigh and suprailium the highest.

Summarily, we recommend to use the Jackson et al. [9] equation to predict body composition with the help of skinfold thickness. Parizkova's [20] method significantly overpredicted body fat %. All



the methods that were used are highly reliable and there are no significant inter-observer differences.

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# **USING THE EUROFIT TEST BATTERY IN ESTONIAN 16-18 YEARS OLD ADOLESCENTS**

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## **Introduction**

It is well known that physical fitness is an important component, not only of sports and physical education but also of health education, and is necessary for a state of general wellbeing. Many efforts have been made in the past to assess fitness and produce norms that describe the schoolchildren population. Landmark studies in this area are the national surveys conducted in the USA (American Alliance for Health, 1980) and Canada (Canadian Association for Health, Physical Education and Recreation, 1980). After several years of coordinated European research the EUROFIT test battery was built for the purpose of measuring and assessing the physical fitness of school-aged children (Eurofit, 1988). The aim of the present investigation was to measure motor abilities in Tartu (Estonia) 16-18 years old schoolboys and schoolgirls using EUROFIT tests.

## **Material and methods**

In total 132 schoolboys and 207 schoolgirls of ages 16-18 were measured. The subjects were selected from five schools in Tartu. Their physical parameters are shown in Table 1. The original EUROFIT test battery was used, except the bicycle ergometer test. Testing was carried out in a school gymnasium. Only pupils whose parents refused consent, or who were ill, absent or had medical contraindications were excluded from the eventual test sample. Subjects were required to wear sport clothing.

Means, standard deviations and correlation coefficients were calculated using ordinary statistical methods. Significance of the differences between schoolboys and -girls was tested with Student's t-test.

## Results and discussion

The mean results of the motor fitness tests are presented in Table 1.

Table 1

Physical parameters and the mean tests results of the subjects  
( $\bar{x} \pm SD$ )

	Schoolboys (n=132)	Schoolgirls (n=207)	p
Age (yrs)	17.1 $\pm$ 0.2	17.1 $\pm$ 0.3	NS
Height (cm)	180.5 $\pm$ 6.1	167.1 $\pm$ 5.2	< 0.001
Weight (kg)	69.2 $\pm$ 8.6	57.9 $\pm$ 7.2	< 0.001
Endurance shuttle-run	10.5 $\pm$ 2.1	6.3 $\pm$ 1.6	< 0.001
Handgrip strength	49.0 $\pm$ 7.6	26.5 $\pm$ 5.3	< 0.001
Standing broad jump	231.2 $\pm$ 17.7	172.5 $\pm$ 16.7	< 0.001
Bent arm hang	459.6 $\pm$ 158.9	125.6 $\pm$ 102.4	< 0.001
Sit-ups	25.7 $\pm$ 3.9	21.6 $\pm$ 4.0	< 0.001
Shuttle-run 10 $\times$ 5 m	188.5 $\pm$ 13.0	210.0 $\pm$ 13.3	< 0.001
Plate tapping	103.07 $\pm$ 12.61	111.95 $\pm$ 11.98	< 0.001
Sit and reach	25.66 $\pm$ 7.35	29.95 $\pm$ 6.07	< 0.001
Flamingo balance test	4.0 $\pm$ 3.2	3.4 $\pm$ 2.9	NS

In all fitness tests the mean results in boys were significantly better than in girls (except the Flamingo balance test and sit and reach). Unfortunately no studies have been published however that would describe the fitness of 16-18 years old schoolboys and -girls using the EUROFIT test battery. In this paper only the preliminary results are presented, because the measurements in this area continued. In future we want to develop national fitness norms according to sex and age and to monitor changes in fitness in time, to prescribe appropriate physical activity patterns and to evaluate their effectiveness. Unfortunately norms from such large surveys for the complete set of EUROFIT are not yet available.

The correlation matrix between physical fitness tests in boys and girls are presented in Table 2. There were not always close relationships between tests and only sometimes there were significant correlations between tests that indicate different motor abilities.

Table 2

## Correlation matrix between physical fitness tests

	Endurance shuttle-run	Handgrip strength	Standing broad jump	Bent arm hang	Sit-ups	Shuttle run 10×5 m	Plate tapping	Sit- and reach	Flamingo balance test
	Schoolgirls								
Endurance shuttle-run	1.000	0.094	0.188*	0.143	0.188*	-0.194*	-0.299*	0.002	-0.135
Handgrip strength	0.294*	1.000	0.190*	0.143	0.182*	-0.194*	-0.210*	0.100	0.030
Standing broad jump	0.255*	0.274*	1.000	0.358*	0.353*	-0.297*	-0.208*	0.100	0.125
Bent arm hang	0.182*	0.003	0.244*	1.000	0.226*	-0.242*	0.142	0.184*	-0.195*
Sit-ups	0.241*	0.109	0.207*	0.137	1.000	-0.157	0.197*	0.170	-0.122
Shuttle-run 10 × 5 m	-0.146	-0.140	-0.186*	-0.108	-0.207*	1.000	0.084	0.036	0.155
Plate tapping	-0.001	0.025	-0.158	-0.081	-0.002	0.123	1.000	-0.079	0.164
Sit-and-reach	0.129	0.153	0.217*	0.102	0.244*	-0.066	-0.141	1.000	-0.194*
Flamingo balance test	-0.152	-0.028	-0.202*	-0.202*	-0.077	0.054	0.133	-0.010	1.000
	Schoolboys								

\*p &lt; 0.05



There were no differences between boys and girls.

The mean skinfold thicknesses are presented in Figure 1. In girls the mean skinfold thickness was significantly bigger than in boys (except subscapular). In both groups the correlation coefficients between skinfold thicknesses were significant, the correlations were significant with body weight too. On the other hand, the skinfolds have no significant correlations with motor ability tests.

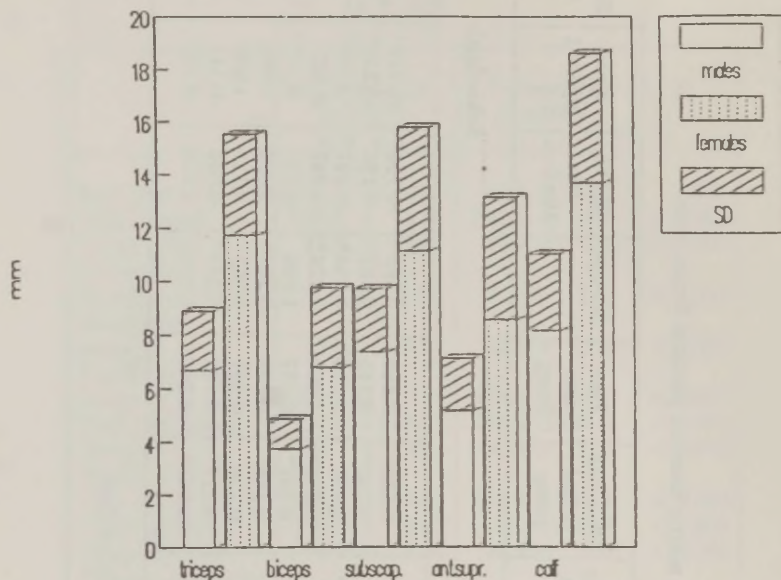


Figure 1. The mean skinfold thicknesses in schoolboys and -girls ( $\bar{x} \pm SD$ ).

Our preliminary results indicate that the EUROFIT test battery is a good measure of basic motor abilities in 16-18 years old schoolchildren.

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# FRAME SIZE AND BODY COMPOSITION OF FEMALE UNIVERSITY STUDENTS AND THEIR TRAIT ANXIETY

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## Introduction

Anxiety is an unpleasant emotion with a feeling of impending danger but no identifiable threat. It can be a personality tendency, an emotional state or a syndrome. Work factors are important in producing anxiety especially when they interact with home, marital or leisure problems [Lader, 1977]. There is a genuine similarity between anxiety and depression. Both share many characteristics including dysphoric mood, agitation, sleep and appetite disturbances, poor concentration, sexual dysfunction as well as other psychic and somatic signs of anxiety. It is found that up to 65 % of anxiety patients have secondary depression [Wetzler, 1986].

Anxiety affects all individuals from time to time. A little anxiety facilitates optimal performance, only both too much and too little anxiety are associated with impaired performance. State anxiety is anxiety felt at a particular instance, e.g. before a surgical operation. Trait anxiety refers to a habitual predisposition to be anxious [Spielberger et al., 1968]. Persons with high trait anxiety have low threshold for feeling anxious, they may break down under stress. High trait anxiety is closely related to incidence of neurosis. Signs of high anxiety often include increased smoking and reliance on alcohol. Elevated heart rate and blood pressure, and elevated serum cholesterol and unesterified fatty acids are described to be the physical signs and biochemical reactions to state anxiety [Lader, 1977]. Persons of high trait/state anxiety are believed to be more predisposed to coronary atherosclerosis [Siegrist et al., 1988]. At the same time some researchers [Schocken et al., 1987] have not found relationships between state or trait anxiety scores and coronary artery disease.

Correlations are found between body weight or body mass index and some serum risk factors for atherosclerosis [Connor et al., 1982; Leclerc et al., 1983]. Thus, both anxiety and overweight are

known as risk factors for atherosclerosis. At the same time, little is known about the relations between trait anxiety and body build. The effects of frame size and body composition on physiological and psychological aspects of trait anxiety were investigated in present study.

## Subjects and methods

The sample consisted of 150 practically healthy female students of Tartu University, aged 18 to 35. Their height, weight, waist and hip circumferences were measured and waist/hip ratio was calculated. Their body composition was assessed by the bioelectrical impedance method (Bodystat-500, England). For measuring neuropsychic, sociopsychic and somatic aspects of trait anxiety of the students the Taylor Manifest Anxiety Scale was used [Taylor, 1953]. The results of the test were estimated as follows: 33.3 % — low anxiety, 33.3–50.0 % — moderate anxiety, and over 50.0 % — high anxiety.

## Results

Table 1 shows the mean indices of age, height, weight, waist/hip ratio, body composition and anxiety of the subjects. Body fat among the subjects ranged from 9.5 % to 37.1 %. The normal range for young women should be between 20 and 26 % according to the impedance method. The percentage of body fat was lower than the acceptable range in 40.0 % of the subjects, at which in 10 persons (6.7 % of all subjects) this percentage was extremely low — less than 14.7 %. Only eighteen persons (12.0 %) were overweight.

By results of data analysis of the anthropometrical measurements and body composition the students were divided into 3 frame size groups: small, medium, and large. Only 10 % of the subjects belonged to the group of large frame size.

The mean indices of trait anxiety were not high. Nevertheless, the mean index of sociopsychic anxiety was the highest and ranged between 6.3–81.3 %. The indices of sociopsychic anxiety were low in 54.9 %, moderate in 21.4 % and high in 23.7 % of the subjects. The indices of neuropsychic anxiety were low, moderate and high in 71.8 %, 16.0 % and 12.2 % of the subjects, respectively. The indices of somatic anxiety were the lowest and were moderately increased in 12.2 % of the subjects and showed high indices in 6.9 % of the subjects.

Fig. 1. demonstrates the significant linear correlations between



Tabel 1

## Mean indices of the female university students

Index	$\bar{x} \pm SD$
Age, yrs	21.1 $\pm$ 4.4
Height, cm	167.0 $\pm$ 6.3
Weight, kg	60.6 $\pm$ 8.3
Waist/hip ratio	0.74 $\pm$ 0.07
Body fat, %	21.0 $\pm$ 4.6
Neuropsychic anxiety, %	28.5 $\pm$ 14.8
Sociopsychic anxiety, %	33.6 $\pm$ 18.4
Somatic anxiety, %	24.5 $\pm$ 15.9

somatic anxiety, age, some body composition indices and waist/hip ratio of the students. As expected, there were close negative relationships between body fat content and lean weight, lean percent and lean/fat ratio. Somatic anxiety was negatively correlated with lean weight and frame size but not with lean per cent or body fat indices. It means that the students with low lean body mass and small frame size have more often a personality tendency to feel bodily discomfort, i.e. somatic anxiety, than the students with medium or high lean body mass and frame size. Age of the students was significantly correlated with body fat as well as the waist/hip ratio. Correlations between the waist/hip ratio and indices of body composition show that the waist/hip ratio is quite a trustworthy index of growing stout.

### Discussion

Our results show that there are significant negative correlations only between somatic anxiety and frame size, and between somatic anxiety and lean weight. The wide interindividual variance of other psychological, physiological and social support peculiarities exert influence upon trait anxiety of individuals as well. Nevertheless, the students of small frame size and low lean weight are prone to have a higher trait anxiety than their not so small schoolmates. It could be explained with neuroendocrine peculiarities of small frame size and low lean body mass and, perhaps, with learned pattern of passive defence in stress situations due to small frame size and low strength. Hyypä et al. [1987], Berger et al. [1987] have shown that the secretory responses of hypothalamo-pituitary and adrenal cortex hormones vary according to one's coping abilities. The role of cer-



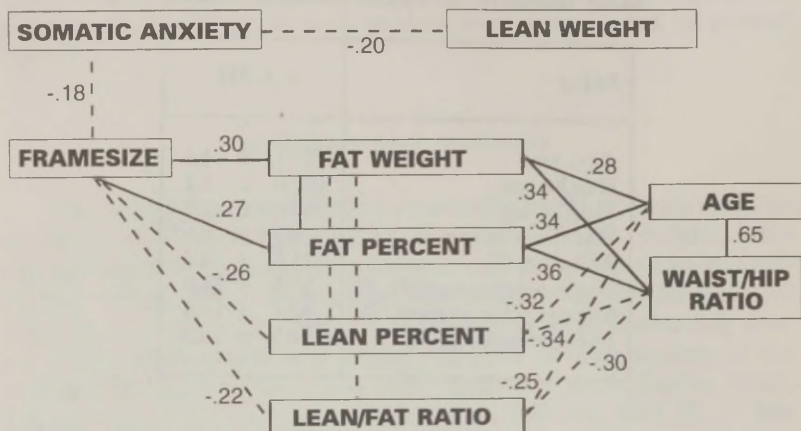


Figure 1. Some significant correlations between anxiety, age, indices of body compositions and waist/hip ratio ( $p = 0.05$  at the coefficient 0.17)

tain brain regions in arousal, emotions and behaviour are disclosed [Valenstein, 1973]. Researchers have also found correlations between certain behavioural pattern or psychic state and alterations of some brain peptide hormones, their receptors and neurotransmitters. For example Sherif et al. [1991] have detected the elevated monoamine oxidase activity in the hypothalami of depressed suicide subjects. In addition to other positive effects, physical training increases lean mass and affects metabolism on the cellular level. Results of our previous investigations have already shown that studentsportsmen have a lower rate of psychic disorders and have higher coping resources than their physically passive schoolmates [Kaasik and Karu, 1990; Kaasik and Jürimäe, 1990].

## Conclusion

The results of the study revealed no significant relations between neuropsychic and sociopsychic aspects of trait anxiety and body composition as well as frame size in this series of female university students. Only somatic anxiety was related negatively to lean weight and to frame size of the subjects. Further investigation is necessary to show whether trait anxiety levels can be influenced by increasing the lean weight of the subjects without significant frame size changes.

i.e. by regular physical training.

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# TWITCH POTENTIATION AFTER MAXIMAL VOLUNTARY CONTRACTIONS OF HUMAN PLANTARFLEXOR MUSCLES

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## Abstract

Twitch potentiation and summation to unfused tetani of plantarflexor (PF) muscles was studied in 12 male volunteers of 20–25 years of age after maximal voluntary contractions (MVC) of varying duration. Isometric twitch responses were elicited by supramaximal electric shocks applied over the tibial nerve in popliteal fossa. Twitch summation was investigated by a short burst (1 s) of supramaximal shocks delivered at 7 Hz.

The results show that after the first MVC lasting 5 s the relative potentiation of the twitch peak torque was  $142.0 \pm 7.0$  % ( $P < 0.001$ ). The relative shortening of the twitch contraction time after the fifth MVC was greater than after the first MVC, twitch summation in unfused tetani and “unfusion” increased and half-relaxation time of unfused tetani shortened after the fifth MVC remarkably. During a 60 s MVC, voluntary force decreased by 30–40 % ( $P < 0.01$ ). No evidence for neuromuscular block (decrease in the amplitude of M-waves) was found.

After the prolonged MVC twitch force potentiation was relatively large ( $143.0 \pm 8.5$  %,  $P < 0.01$ ), but twitch duration was prolonged mainly as a result of slowing in relaxation rate. Twitch summation, “fusion” and relaxation time of tetanus increased.

**Key words:** electrical stimulation, twitch, twitch and post-activity potentiation, fatigue, human plantarflexor muscle.

## Introduction

Post-activity (or post-tetanic) potentiation of skeletal muscle contraction seems to be a general phenomenon of the neuromuscular system. An increase in twitch peak torque after tetanic electrical stimulation has been demonstrated in a wide range preparations,



i.e. single muscle fibers [Colomo and Rocchi 1965], motor units [Olson and Swett 1971, Burke et al. 1976], whole muscle [Standaert 1964, Connolly et al. 1971] and in many different animal species: frog [Colomo and Rocchi 1965], rat [Rankin and Enoka 1988], cat [Gruber 1922] including the human adductor pollicis [Botchlo and Cander 1953].

There is interest, however, in determining to what extent potentiation might occur under natural conditions: i.e. after voluntary contractions. In a partial answer to these questions, the ability of human calf muscles to increase twitch tension after voluntary contractions has been described [Sale et al. 1982, Belanger et al. 1983, Vandervoort et al. 1983, Vandervoort and McComas 1986, Alway et al. 1987].

Some investigators [Vandervoort et al. 1983] observed that fatigue following a sustained voluntary contraction was responsible for the smallest twitch potentiation, but Rankin et al. [1988] demonstrated that twitch force after the fatigue test was potentiated in fast-contracting muscles.

The purpose of the present study was to examine the effects of twitch potentiation and summation to unfused tetani after maximal voluntary contractions of varying duration and to determine whether fatigue is a factor which directly alters the extent of twitch potentiation of human PF muscles.

## Material and methods

**Subjects.** The experiments were conducted on 12 male volunteers, 20 to 25 years old. All subjects had medical histories free of neuromuscular disorders. The physical characteristics of the subjects are presented in Table 1.

Table 1

Means ( $\pm$  SE) of physical characteristics of the subjects ( $n = 12$ )

Age (years)	Height (cm)	Weight (kg)
21.3 $\pm$ 1.2	180.4 $\pm$ 1.5	71.3 $\pm$ 2.0

**Force recording.** The subjects sat in a specially designed dynamometer chair with the right leg placed in full extension, the knee joint supported by a padded cushion and the foot attached to a foot-plate with the centre of rotation passing thorough the ankle joint.

Strain gauges mounted on the footplate enabled PF muscles force to be measured under isometric conditions. The ankle was dorsiflexed to  $10^\circ$  to correspond to the greatest twitch response in most subjects [Sale et al. 1982].

The output from the strain gauge was amplified and recorded on oscillograph paper.

**Electromyographic (EMG) recording.** The evoked compound action potential (M-wave) was recorded from soleus muscle belly using bipolar surface electrodes (silver/silver chloride,  $10\text{ mm}^2$  contact area, 20 mm inter-electrode distance). Before the electrodes were attached, the skin area was dry shaved and rubbed with alcohol and ether (4:1). A large metal electrode was used as ground and placed over the gastrocnemius muscle between the stimulating and recording electrodes as close as possible to the stimulating electrode.

Action potentials of soleus muscle were amplified by Medico MG-42 preamplifiers and were recorded on oscillograf paper simultaneously with the force signal.

**Electrical stimulation.** To determine the contractile properties of the PF muscles the posterior tibial nerve was stimulated percutaneously thorough a pair of surface carbon rubber electrodes. The cathode ( $4 \times 6\text{ cm}$ ) was placed over the tibial nerve in the popliteal fossa and the anode ( $10 \times 15\text{ cm}$ ) under the posterior-medial side of the thigh. Supramaximal square wave pulses of 0.5 ms duration were delivered from an isolated voltage stimulator (Medico MG-42).

The maximal amplitude of soleus muscle was used as a criterion for determining the supramaximal stimulus intensity (50 % higher than maximal M-wave).

Twitch summation in unfused tetani was investigated by a short burst (1 s) of supramaximal shocks delivered at 7 Hz.

**Calculations.** Isometric twitch (see Fig. 1a) was measured as: (1) peak torque ( $P_t$ , kG); (2) contraction time ( $CT_t$ , ms) = time to peak twitch tension; (3) half-relaxation time ( $\frac{1}{2}RT_t$ , ms) = time of half of the decay in twitch torque; (4) maximal amplitude of the M-wave (mV).

Twitch summation (see Fig. 1b) was measured as: (1) maximal force generated ( $P_7$ , kG); (2) twitch-tetanus ratio ( $P_t/P_7$ ) and (3) half-relaxation time of tetanus ( $\frac{1}{2}RT_7$ , ms).

**Experiment protocol.** All twitch and unfused tetani variables were registered before the exercise (initial values), immediately after the first and fifth MVC of 5 s duration (time interval between each MVC was 15 s) and after MVC sustained for 60 s.

**Statistics.** Standard statistical methods were used for calculation of the mean ( $\bar{x}$ ), and standard error of the mean (SE). Differences between the mean values were tested for significance using Student's t-test.

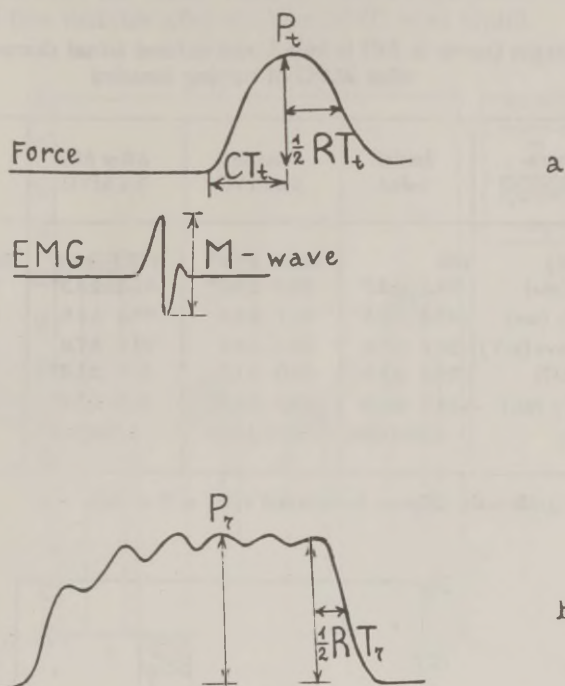


Figure 1. Schematic presentation of the records obtained in twitch (a) and unfused (7 Hz) tetani (b) measurements.  $P_t$  = twitch peak torque;  $CT_t$  = twitch contraction time;  $\frac{1}{2}RT_t$  - twitch half-relaxation time; M-wave = maximal amplitude of evoked compound action potential;  $P_7$  = maximal force of tetani;  $\frac{1}{2}RT_7$  = half-relaxation time of tetani.

The probability level accepted for statistical significance was  $P < 0.05$ .

## Results

Changes (mean  $\pm$  SE) in twitch and unfused tetani characteristics after MVC of varying duration are shown in Table 2.

**Twitch peak torque** (see Fig. 2) was potentiated by an average of  $142 \pm 7.0$  % after the first 5 s MVC and  $175.3 \pm 8.1$  % after the fifth 5 s MVC. After the 60 s MVC twitch peak torque potentiation was relatively large (an average  $143 \pm 8.5$  %).

**Twitch contraction time** (see Fig. 3) was significantly shortened



Table 2

Changes (mean  $\pm$  SE) in twitch and unfused tetani characteristics after MVC of varying duration

Characteristics	Initial value	After first 5 s MVC	After fifth 5 s MVC	After 60 s MVC
$P_t$ (%)	100	142.0 $\pm$ 7.0*	175.3 $\pm$ 8.1*	143.0 $\pm$ 8.5*
$CT_t$ (ms)	98.1 $\pm$ 3.7	83.8 $\pm$ 3.7*	82.5 $\pm$ 3.3*	94.3 $\pm$ 3.2
$\frac{1}{2}RT_t$ (ms)	61.8 $\pm$ 3.5	65.7 $\pm$ 2.8	67.8 $\pm$ 3.6	89.8 $\pm$ 7.1*
M-wave (mV)	20.0 $\pm$ 6.5	20.6 $\pm$ 7.1	20.6 $\pm$ 7.0	19.9 $\pm$ 7.3
$P_7$ (kG)	19.2 $\pm$ 1.0	20.0 $\pm$ 1.3	26.4 $\pm$ 1.3*	29.8 $\pm$ 1.5*
$\frac{1}{2}RT_7$ (ms)	54.7 $\pm$ 2.3	45.8 $\pm$ 1.9*	45.3 $\pm$ 2.8*	86.5 $\pm$ 5.0*
$P_t/P_7$	0.58 $\pm$ 0.04	0.77 $\pm$ 0.05*	0.73 $\pm$ 0.06*	0.53 $\pm$ 0.07*

\* — significantly different from initial value at  $P < 0.05$ .

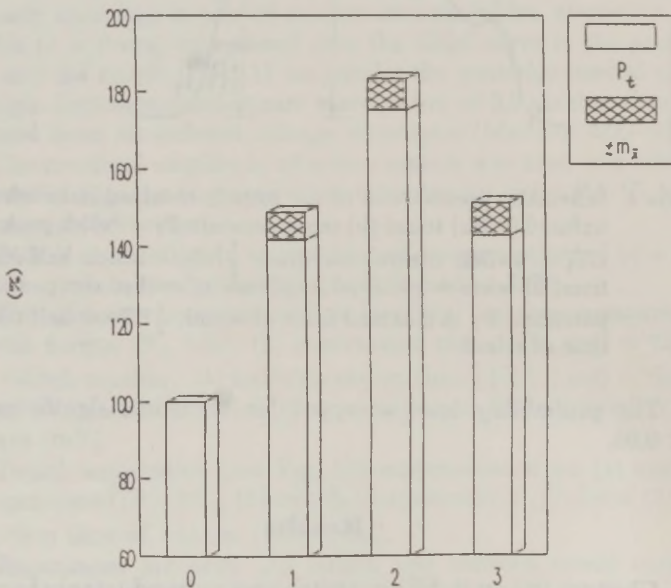


Figure 2. Changes in  $P_t$  (% of initial value equalized with 100 %) after the first (1) and the fifth (2) MVC lasting 5 s and after sustained MVC lasting 60 s (3), in comparison with initial value (0).

after the first 5 s MVC and the fifth 5 s MVC ( $P < 0.001$ ). No

differences between the initial value of twitch contraction time and the value of this variable after the 60 s MVC were found.

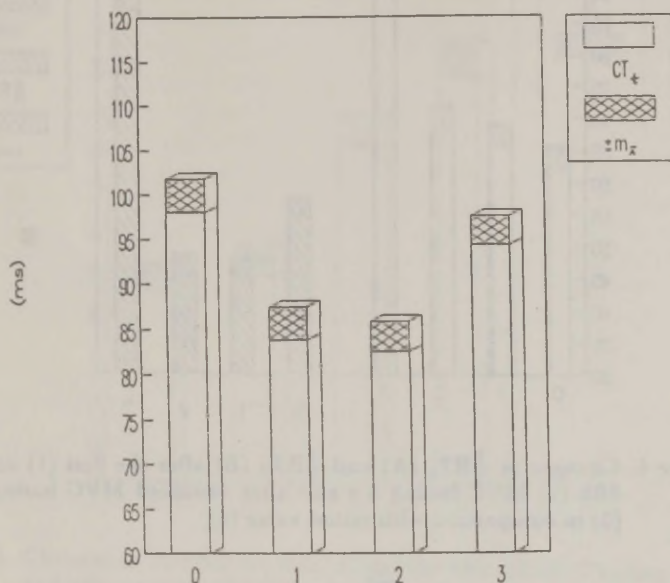


Figure 3. Changes in  $CT_t$  after the first (1) and the fifth (2) MVC lasting 5 s and after sustained MVC lasting 60 s (3) in comparison with initial value (0).

Twitch half-relaxation time (see Fig. 4) did not significantly changed after the first and the fifth 5 s MVC, but after the 60 s MVC this variable was significantly prolonged ( $P < 0.01$ ).

M-wave amplitude of twitch did not change significantly after the MVC of varying duration.

Maximal force of unfused tetani (see Fig. 5) was sharply potentiated after the fifth 5 s MVC ( $P < 0.001$ ) and 60 s MVC ( $P < 0.001$ ).

Half-relaxation time of unfused tetani (see Fig. 4) was significantly shortened after the first 5 s MVC ( $P < 0.01$ ) and fifth 5 s MVC ( $P < 0.05$ ). After the 60 s MVC this variable was significantly ( $P < 0.001$ ) prolonged.

Twitch-tetanus ratio was significantly increased after the first and the fifth 5 s MVC. No changes of this variable were found after the 60 s MVC.

MVC after 60 s maximal effort decreased approximately by 30–40 % in various subjects.

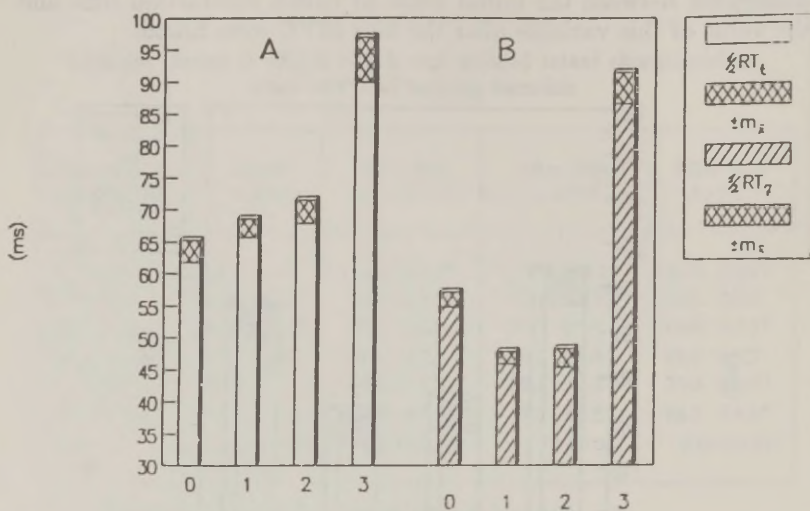


Figure 4. Changes in  $\frac{1}{2}RT_t$  (A) and  $\frac{1}{2}RT_7$  (B) after the first (1) and the fifth (2) MVC lasting 5 s and after sustained MVC lasting 60 s (3) in comparison with initial value (0).

## Discussion

As a result of the present study there emerged the post-activity potentiation of twitch and unfused tetani of PF muscles following a single maximal voluntary static contraction as well as repetitive maximal static contractions. This was expressed by both the increase of twitch peak torque and maximal force of unfused tetani torque as well as the shortening of twitch contraction time after maximal voluntary static contractions. Analogous results have been obtained by other researchers [Belanger et al. 1983; Vandervoort et al. 1983; Vandervoort, McComas 1986; Alway et al. 1987]. It's important to note here that in the conditions of repetitive short-time maximal static contractions the twitch peak torque increased in comparison with the single maximal static contraction. This has been observed by us also in earlier research [Pääsuke 1989; Pääsuke, Viira 1992].

The physiological mechanism of post-tetanic or post-activity potentiation is today not yet clear. Some authors connect this phenomenon with changes in neuromuscular transmission level [Nussinovitch, Rahamimoff 1988]. However, the corresponding research where neuromuscular synaptic block was applied in the condition of direct repetitive stimulation of the single muscle power fiber showed that twitch potentiation can exist without any change in neuro-



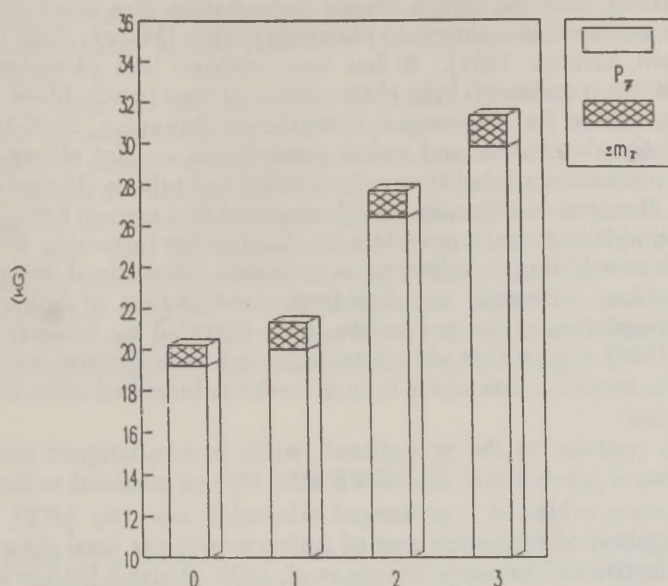


Figure 5. Changes in  $P_7$  after the first (1) and the fifth (2) MVC lasting 5 s and after sustained MVC lasting 60 s (3) as compared with initial value (0).

in neuromuscular transmission or membrane excitability [Close, Hoh 1968]. Similarly it has been shown that in twitch potentiation conditions the amplitude of muscle M-wave does not change [Takamori et al. 1971; Pääsuke 1989]. For this reason post-activity potentiation of skeletal muscle is connected with the physiological processes sites beyond the neuromuscular junction, not with the changes in synaptic transmission or sarcolemma excitation.

Recent evidence concerning the mechanisms associated with twitch potentiation supports alterations in calcium kinetics and/or the degree of myosin light-chain phosphorylation as likely candidates. Although considerable controversy still surrounds the issue [e.g. Rep. Ochi 1984], augmented calcium release from sarcoplasmic reticulum has been recently shown to accompany the potentiation underlying the nonlinear summation of contractions [Duchateau, Hainaut 1986]. It's maintained that increased  $\text{Ca}^{2+}$  release from the sarcoplasmic reticulum and increased sensitivity of contractile proteins to  $\text{Ca}^{2+}$  can be important factors of twitch potentiation [Belanger et al. 1983; Vandervoort et al. 1983; Alway et al. 1987].

Twitch potentiation has also been shown to be correlated to myosin light-chain phosphorylation. In both human and rat post-

contracting muscles, twitch torque potentiation was accompanied by an increased in light-chain phosphorylation [Moore, Stull 1984; Houston, Grange 1991]. It has been claimed that phosphorylation of the regulatory light-chain ( $LC_2$ ) of fast-twitch fibers may be responsible for post-tetanic potentiation [Manning, Stull 1979]. Since phosphorylation and twitch potentiation are not observed in slow muscles from rats [Moore, Stull 1984] and rabbits [Moore et al. 1985]. Houston and Grange [1991] suggested that myosin light-chain phosphorylation could provide a mechanism for increasing human muscle twitch torque following a fatiguing submaximal isometric contraction. Although the physiological mechanism of light-chain phosphorylation is not yet known, data provided by Sweeney and Stull [1986] suggest that phosphorylation enhances calcium sensitivity of the myofilaments which in turn results in increased cross-bridge formation.

In contrast to the potentiated twitch in non-fatigued muscle, our data suggested that the twitch after 60 s of maximal voluntary contraction exhibited a prolonged relaxation time (by  $\frac{1}{2}$  RT). The prolongation of relaxation rate of active muscle has been shown to be indicative of fatigue [Edwards et al. 1975; Bigland-Ritchie et al. 1983]. In our research appeared a considerable prolongation of  $\frac{1}{2}$  RT both in conditions twitch and unfused tetani (7 Hz).

It is well known that prolongation of the relaxation time of muscle is connected with the failure of  $Ca^{2+}$  pumping mechanism of muscle fibers resulting in slow-down reuptake of  $Ca^{2+}$  by sarcoplasmic reticulum. Decrease in the muscle relaxation rate after sustained voluntary static contractions has been shown by other authors [Bigland-Ritchie et al. 1978, 1983] and in our earlier research [Pääsuke 1989].

As appears from the given study, post-activity potentiation is combined in complicated connections with fatigue. Our observations on the coexistence of twitch potentiation and muscle fatigue are consistent with other reports in the literature [Vandervoort et al. 1983; Mac Intosh, Gardiner 1986; Moussavi et al. 1986; Alway et al. 1987; Houston, Grange 1991].

Thus on maximal voluntary static contractions is observed the mobilisation of muscle fiber contraction ability, expressed by increase in force production. At the same time in the condition of sustained contraction the relaxation ability is disturbed, being the symptom of developing fatigue.

## Conclusions

1. Maximal voluntary contraction of plantarflexor muscles lasting 5 s produced a marked potentiation of the twitch force and

reduction of the twitch contraction time. After the fifth maximal voluntary contraction lasting 5 s the potentiation of the twitch force was remarkably greater than after the first maximal voluntary contraction.

2. After the prolonged (60 s) maximal voluntary contraction twitch force potentiation was relatively large, but twitch duration prolonged mainly as a result of slowing in relaxation rate. Twitch summation in unfused tetani increased. Thus no evidence for neuromuscular block (decrease in the amplitude of M-waves) was found.

3. Our data demonstrated that the process of twitch force potentiation and fatigue can coexist. Furthermore, fatigue and twitch potentiation after the sustained maximal voluntary contraction is likely to occur at different sites in the excitation-contraction coupling and contractile apparatus of the muscle fibers.

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# EVALUATION OF THE RATE OF PROTEIN SYNTHESIS IN MUSCLE AFTER EXERCISE: SIGNIFICANCE OF THE SPECIFIC ACTIVITY OF LABELLED AMINO ACID

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## Abstract

The purpose of this paper is to compare the estimation of the rate of protein synthesis after exercise with or without taking into consideration the specific activity of labelled amino acid. The data for this comparison was provided by two previous studies [29, 37]. The results of both mentioned studies indicate that muscular exercises induce substantial changes in the specific activity of administered  $^3\text{H}$ -tyrosine. Due to this change a significant error is resulted in when protein synthesis rate is characterized by labelled amino acid incorporation into muscle proteins without considering the specific activity of the labelled amino acid. In most cases this approach causes an underestimation of the actual changes up to 20–50 %. Errors appeared also in qualitative evaluation of the change.

**Key words:** exercise, intracellular compartment, protein synthesis rate, specific activity, tyrosine

## Introduction

Since the first studies on exercise-induced alterations in protein synthesis rate, changes in the radioactivity of the intracellular precursor pool were taken into account [44]. From this time up to the present some papers have appeared where the assessment of protein synthesis rate was based only on the estimation of incorporation rate of the administered labelled amino acids into muscle protein [e.g. 26, 41]. This approach provides a possibility to characterize the process but not to quantify the rate of protein synthesis. The administered labelled amino acid will dilute in body fluids and, therefore, the degree of dilution determines the supply of muscle fibers by the labelled



amino acid. Moreover, the amino acid transport into cells may be influenced by hormones [23, 42]. In the cell (muscle fiber) the rate of labelled amino acid incorporation into proteins depends on the ratio between the concentrations of labelled and unlabelled amino acid. If the study is performed in conditions of steady state in regard to (1) fluid balance between various compartments of the body, (2) activity of endocrine glands, and (3) metabolism of the administered amino acid, the methodological error may be insignificant. However, in muscular activity the error has to increase significantly due to shifts in fluid balances [32], pronounced alternation in the endocrine function [35], and changes in amino acid metabolism [9, 13, 31, 36]. When labelled tyrosine is administered, one must take into account its release as a result of degradation of cellular proteins. In exercise the increased concentration of free tyrosine in muscle tissue [8, 10, 29, 33] and in blood plasma [12, 18, 29] is confirmed. When labelled leucine is administered, the situation becomes more complicated due to oxidation of branched-chain amino acids [9, 24, 31]. In this case, it is necessary to estimate also the labelled metabolites of leucine (including  $\text{CO}_2$  when leucine was labelled by  $^{14}\text{C}$ ). As examples of this kind of correct methodological approach in exercise studies, some papers have to be referred to [4, 5].

The purpose of this study is to estimate the extent of the error caused by ignoring of the specific activity of administered  $^3\text{H}$ -tyrosine in assessment of protein synthesis during and after exercise.

## Material and methods

Data for calculation of error in protein synthesis rate due to ignoring of the specific activity of  $^3\text{H}$ -tyrosine, was provided by results of previous studies [29, 37].

The material consists of two experimental sets directed to assessment of protein metabolism during a training microcycle and after a single exercise bout. Male Wistar rats were used in both cases. The training microcycle consisted in daily repetition of 90 min swimming in water of  $32 \pm 1^\circ\text{C}$ . Before each exercise bout as well as at various time points after exercise (see Tables 1-4) a subgroup of 3-6 rats was sacrificed. The studied acute exercise bout consisted in 30-min treadmill running at a velocity of  $35 \text{ m}\cdot\text{min}^{-1}$ . Before running as well as 1.5, 12, 24 and 48 h after exercise subgroups of 4 animals were sacrificed.

The rate of protein synthesis was measured [7].  $^3\text{H}$ -tyrosine (specific activity of  $19.5 \text{ Ci}\cdot\text{mmol}^{-1}$ ) was administered in doses of  $80\text{--}100 \mu\text{Ci}\cdot 100 \text{ g}^{-1}$  of body weight. The labelled amino acid was injected in four equal doses intraperitoneally after every 30 min,

Table 1

Comparison of changes in radioactivity of myofibrillar proteins of white part of quadriceps muscle (2 h exposure) after administration of  $^3\text{H}$ -tyrosine, and protein synthesis rate calculated by division of total protein radioactivity by specific radioactivity of  $^3\text{H}$ -tyrosine at various time points during a training microcycle (daily exercise was swimming for 90 min)

Time point	Radioactivity proteins		$^3\text{H}$ -tyrosine specific activity in muscle	Protein synthesis rate		Difference between changes in protein synthesis rate and protein radioactivity
	cpm·mg <sup>-1</sup>	Change		nMol Tyr. mg <sup>-1</sup> of protein 2h	Change	
Sedentary controls	157±11		803±17	0.195±0.090		
1st exercise, immediately after	125±15	-20 %	1178±114*	0.103±0.012*	-47 %	+27 %
8h after	147±12	-6 %	632±69	0.234±0.019	+20 %	+26 %
24h after	144±8	-8 %	1073±83*	0.136±0.006*	-30 %	+22 %
2nd exercise, immediately after	102±12*	-35 %	931±40*	0.110±0.010*	-44 %	+9 %
8h after	108±18	-31 %	1630±130*	0.112±0.011*	-43 %	+12 %
24h after	151±15	-4 %	1153±113*	0.136±0.011*	-30 %	+26 %
4th exercise, 24h after	98±7*	-38 %	1191±66*	0.082±0.007*	-58 %	+20 %
5th exercise, immediately after	61±7	-61 %	1132±101*	0.054±0.006*	-73 %	+12 %
8h after	129±15	-18 %	1557±97*	0.082±0.005*	-58 %	+40 %
24h after	133±14	-15 %	2026±209*	0.087±0.008*	-66 %	+51 %
32h after	102±9*	-35 %	1027±37*	0.099±0.008*	-49 %	+14 %
48h after	87±16*	-45 %	1674±129*	0.052±0.009*	-73 %	+28 %

\* denotes statistically significant difference ( $P < 0.05$ ) from values of sedentary control rats

Table 2

Comparison of changes in radioactivity of myofibrillar and sarcoplasmic proteins of red part of quadriceps muscle (2 h exposure) after administration of  $^3\text{H}$ -tyrosine, and protein synthesis rate calculated by division of total protein radioactivity by specific radioactivity of  $^3\text{H}$ -tyrosine at various time points during a training microcycle (daily exercise was swimming for 90 min)

Time point	Radioactivity proteins		<sup>3</sup> H-tyrosine specific activity in muscle	Protein synthesis rate		Difference between changes in protein synthesis rate and protein radioactivity
	cpm·mg <sup>-1</sup>	Change		nMol Tyr. mg <sup>-1</sup> of protein 2h	Change	
Myofibrillar proteins						
Sedentary controls	285		905±85	0.315		
4th exercise 24h after	148	-48 %	1003±67	0.148	-53 %	+5 %
5th exercise, immediately after	109	-62 %	1189±125	0.092	-71 %	+9 %
8h after	201	-29 %	1350±137*	0.149	-53 %	+24 %
24h after	122	-57 %	1867±176*	0.065	-80 %	+23 %
32h after	148	-48 %	1302±80*	0.114	-64 %	+16 %
48h after	131	-54 %	1757±160*	0.084	-73 %	+19 %
Sacroplasmic proteins						
Sedentary controls	712		905±85	0.787		
4th exercise, 24h after	321	-55 %	1003±67	0.320	-59 %	+4 %
5th exercise, immediately after	502	-29 %	1189±125	0.422	-46 %	+17 %
8h after	486	-32 %	1350±137*	0.360	-54 %	+22 %
24h after	598	-16 %	1867±176*	0.320	-59 %	+43 %
32h after	387	-46 %	1302±80*	0.297	-62 %	+16 %
48h after	495	-30 %	1757±160*	0.428	-46 %	+16 %



Table 3

Comparison of changes in radioactivity of myofibrillar and sarcoplasmic proteins of solens muscle (2 h exposure) after administration of  $^3\text{H}$ -tyrosine, and protein synthesis rate calculated by division of total protein radioactivity by specific radioactivity of  $^3\text{H}$ -tyrosine at various time points during a training microcycle (daily exercise was swimming for 90 min)

Time point	Radioactivity proteins		$^3\text{H}$ -tyrosine specific activity in muscle	Protein synthesis rate		Difference between changes in protein synthesis rate and protein radioactivity
	cpm·mg $^{-1}$	Change		nMol Tyr. mg $^{-1}$ of protein 2h	Change	
Myofibrillar proteins						
Sedentary controls	291		848±106	0.343		
4th exercise						
24h after	183	-47 %	1158±63	0.132	-62 %	+15 %
5th exercise, immediately after	125	-57 %	1090±109	0.115	-66 %	+11 %
8h after	178	-39 %	1405±137*	0.127	-63 %	+24 %
24h after	149	-49 %	1414±189	0.105	-69 %	+20 %
32h after	122	-58 %	1384±131*	0.088	-74 %	+16 %
48h after	132	-55 %	1569±139*	0.084	-76 %	+21 %
Sacroplasmic proteins						
Sedentary controls	808		848±106	0.953		
4th exercise, 24h after	574	-39 %	1158±63	0.496	-49 %	+10 %
5th exercise, immediately after	552	-42 %	1090±109	0.506	-47 %	+5 %
8h after	705	-13 %	1405±137*	0.502	-47 %	+34 %
24h after	706	-13 %	1414±189	0.499	-48 %	+35 %
32h after	483	-40 %	1384±131*	0.349	-63 %	+23 %
48h after	672	-17 %	1569±139	0.428	-55 %	+28 %

Table 4

Comparison of changes in radioactivity of myofibrillar and sarcoplasmic proteins of gastrocnemius muscle (2 h exposure) after administration of  $^3\text{H}$ -tyrosine, and protein synthesis rate calculated by division of total protein radioactivity by specific radioactivity of  $^3\text{H}$ -tyrosine at various time points during a training microcycle (daily exercise was swimming for 90 min)

Time point	Radioactivity proteins		<sup>3</sup> H-tyrosine specific activity in muscle	Protein synthesis rate		Difference between changes in protein synthesis rate and protein radioactivity
	cpm·mg <sup>-1</sup>	Change		nMol Tyr. mg <sup>-1</sup> of protein 2h	Change	
Myofibrillar proteins						
Sedentary controls	217±10		896±92	0.245±0.012		
1st exercise, immediately after	141±15*	-35 %	841±65	0.168±0.018*	-31 %	-4 %
8h after	171±11*	-21 %	690±40	0.249±0.016	+2 %	
24h after	238±12	+10 %	1202±86	0.198±0.013	-19 %	
2nd exercise, immediately after	119±16*	-45 %	1031±113	0.115±0.007*	-53 %	+8 %
8h after	196±20	-10 %	1561±135*	0.125±0.015*	-49 %	+39 %
24h after	204±16	-6 %	1213±50*	0.169±0.013*	-31 %	+25 %
4th exercise, 24h after	133±12*	-39 %	1062±149	0.125±0.007*	-49 %	+10 %
5th exercise, immediately after	124±13*	-43 %	1219±235	0.105±0.009*	-57 %	+14 %
8h after	171±10*	-21 %	1429±123*	0.119±0.012*	-51 %	+30 %
24h after	175±8	-19 %	1881±181*	0.094±0.008*	-62 %	+43 %
32h after	147±22*	-32 %	1421±154*	0.104±0.009*	-58 %	+26 %
48h after	118±11*	-46 %	1648±110*	0.070±0.084*	-71 %	+25 %

Continued Table 4

Time point	Radioactivity proteins		<sup>3</sup> H-tyrosine specific activity in muscle	Protein synthesis rate		Difference between changes in protein synthesis rate and protein radioactivity
	cpm·mg <sup>-1</sup>	Change		nMol Tyr. mg <sup>-1</sup> of protein 2h	Change	
Sacroplasmic proteins						
Sedentary controls	436±32			0.488±0.028		
1st exercise immediately after	363±26	-17 %		0.435±0.030	-11 %	+6 %
8h after	418±29	-4 %		0.608±0.046	+25 %	
24h after	454±24	+4 %		0.377±0.017*	-23 %	
2nd exercise, immediately after	331±14*	-24 %		0.326±0.026*	-34 %	+10 %
8h after	463±18	+6 %		0.301±0.022*	-38 %	
24h after	404±24	-7 %		0.333±0.016*	-32 %	+25 %
4th exercise, 24h after	358±17	-19 %		0.338±0.025*	-31 %	+24 %
5th exercise, immediately after	340±13*	-22 %		0.296±0.042*	-39 %	+17 %
8h after	434±24	-19 %		0.306±0.026*	-37 %	+36 %
24h after	455±22	+4 %		0.245±0.019*	-50 %	
32h after	363±17	-17 %		0.257±0.023*	-47 %	+30 %
48h after	424±26	-3 %		0.253±0.018*	-42 %	+39 %



starting 2 h before decapitation of the animal. It was estimated that this regimen warranted a stable specific activity of labelled free tyrosine within 1–2 h after the first injection (Fig. 1).

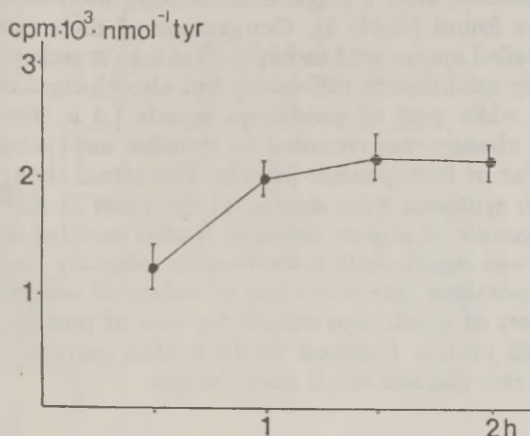


Figure 1. Specific activity of free tyrosine in the gastrocnemius muscle after intraperitoneal administration of  $^{14}\text{C}$ -tyrosine in 4 portions after every 30 min (time of injections is indicated by arrows). Mean  $\pm$  SEM of 4 determinations are indicated.

Muscle samples were prepared and homogenized at a room temperature of  $4^{\circ}\text{C}$ . Radioactivity was estimated with the aid of LKB Wallac Mini-beta counter. Protein content [17] and free tyrosine content [38] were determined in the same samples of muscle tissue.

Protein synthesis rate was calculated by division of the radioactivity of muscle proteins (cpm/mg) to the specific activity of  $^3\text{H}$ -tyrosine (cpm/nmol). The specific activity of  $^3\text{H}$ -tyrosine was expressed as a ratio between the radioactivity (cpm) and total content of free tyrosine (nmol) in deproteinized homogenate of muscle sample.

## Results

**Training microcycle experiment.** In Tables 1 to 4 the actual rate of protein synthesis is compared to changes in labelled tyrosine incorporation rate into muscle proteins. Plotting the percent changes it was found that tyrosine incorporation rates gave an underestimation of the actual alterations in the rate of protein synthesis due to the

increase in the specific activity of tyrosine. The differences were up to 51 %, in most cases from 20 to 40 %.

**Single exercise-bout experiment.** While in training microcycle experiment the most frequent changes in the rate of protein synthesis were decreases, after a single exercise bout alterations in both directions were found (Table 5). Comparison of these results with the rate of labelled amino acid incorporation into muscle protein revealed not only quantitative differences but also changes in various directions. In white part of quadriceps muscle 1.5 h after exercise no significant change was recorded in tyrosine incorporation rate into myofibrillar or sarcoplasmic protein. The actual changes in the rate of protein synthesis were significant decreases at this point of time. In this sample of muscle tissue 48 h after exercise the protein synthesis rate was significantly lower than in sedentary controls, but tyrosine incorporation rate was close to values of sedentary controls. In red part of quadriceps muscle the rate of protein synthesis increased in all protein fractions 24–48 h after exercise. Tyrosine incorporation rate did not reveal such change.

## Discussion

Identification of the specific activity of precursors immediately before their incorporation into proteins is a commonly accepted principle in estimation of the rate of protein synthesis [11, 15, 16, 43]. An ideal solution is determination of the specific activity of aminacyl-tRNA. However, the use of this approach is methodologically complicated due to the small concentrations of tRNA in tissues as well as due to the very short half-life of aminacyl-tRNA [14, 43]. In most studies on estimation of the rate of protein synthesis it has been considered possible to substitute the determination of the specific activity of aminacyl-tRNA by assessment of the specific activity of intracellular pool of free amino acids [3, 22, 25, 30].

However, it was demonstrated that amino acids may incorporate into cellular proteins directly from extracellular pool [1, 19, 27]. This makes it necessary to determine both extra- and intracellular precursor pools [12, 20, 39] or total pool of free amino acid in tissue [14]. The specific activity of aminacyl-tRNA occurred to be a medium value between the corresponding free amino acids specific activity in extra- and intracellular compartments [28, 34].

Calculation of the rate of muscle protein synthesis accounting the specific activity of the total pool of free amino acid is shown to be valid in conditions of muscular activity [6, 7, 21, 40]. However, instead of this approved methodologic approach a simplified way is still used: protein synthesis rate is calculated by the rate of a

Table 5

Comparison of changes in radioactivity of proteins of various muscles (2 h exposure) after administration of  $^3\text{H}$ -tyrosine and protein synthesis rate calculated by division of total protein radioactivity by specific radioactivity of  $^3\text{H}$ -tyrosine after 30 min running

	Specific activity of <sup>3</sup> H-tyrosine	Myofibrillar proteins					Saroplasmic proteins					Mitochondrial proteins				
		<sup>3</sup> H-tyrosine incorporation		Protein synthesis		Difference in changes	<sup>3</sup> H-tyrosine incorporation		Protein synthesis		Differences in changes	<sup>3</sup> H-tyrosine incorporation		Protein synthesis		Differences in changes
		cpm-mg <sup>-1</sup>	Changes	nMol Typ mg protein <sup>-1</sup>	Changes		cpm-mg <sup>-1</sup>	Changes	nMol Typ mg protein <sup>-1</sup>	Changes		cpm-mg <sup>-1</sup>	Changes	nMol Typ mg protein <sup>-1</sup>	Changes	
White part of quadriceps muscle																
Sedentary controls	1110±222	219±16		0.197±0.035			481±33		0.433±0.075			348±69		0.314±0.079		
1.5h after running	2172±115*	207±10	-5 %	0.095±0.006*	-52 %	+47 %	428±6	-11 %	0.198±0.009*	-54 %	+43 %	211±7	-39 %	0.057±0.005*	-69 %	+30 %
12h after	1034±90	219±34	0	0.212±0.036	+7 %	+7 %	408±46	-15 %	0.395±0.058	-9 %	-6 %	268±29	-23 %	0.259±0.037	-18 %	-5 %
24h after	1217±119	233±45	+6 %	0.191±0.034	-3 %	+9 %	392±77	-19 %	0.322±0.058	-26 %	+7 %	291±57	-16 %	0.239±0.044	-24 %	+8 %
48h after	2108±265*	193±17	-12 %	0.092±0.015*	-53 %	+41 %	457±17	-5 %	0.217±0.028*	-30 %	+45 %	348±47	0	0.164±0.030	-48 %	+48 %
Red part of quadriceps muscle																
Sedentary controls	1487±91	399±38		0.298			614±42		0.444			386±29		0.279		
1.5h after running	888±72*	279±14*	-30 %	0.214	-28 %	-2 %	558±26	-9 %	0.428	-4 %	-5 %	257±7*	-33 %	0.197	-29 %	-4 %
12h after	1400±37	335±52	-11 %	0.321	+7 %	-18 %	556±41	-9 %	0.534	+20 %	-29 %	356±53	-8 %	0.342	+26 %	-34 %
24h after	1285±89	369	-8 %	0.455	+53 %	-63 %	671±163	+9 %	0.827	+86 %	+77 %	504±186	+30 %	0.621	+122 %	+91 %
48h after	1452±132	390±34	-2 %	0.340	+14 %	-16 %	768±55	+25 %	0.669	+51 %	+26 %	376±13	-3 %	0.328	+187 %	-21 %
Gastrocnemius muscle																
Sedentary controls	1200±90	350±37		0.266±0.050			513±45		0.390±0.059			352±24		0.268±0.037		
1.5h after running	1759±139*	263±22	-25 %	0.159±0.027	-40 %	+15 %	498±25	-3 %	0.301±0.041	-20 %	+25 %	297±13	-16 %	0.179±0.021	-33 %	+17 %
12h after	1084±81	283±29	-19 %	0.298±0.082	+12 %	-31 %	391±44	-24 %	0.411±0.116	+5 %	-29 %	328±33	-7 %	0.370±0.085	+38 %	-45 %
24h after	1013±86	306±56	-13 %	0.259±0.068	-3 %	-10 %	312±15*	-39 %	0.264±0.032	-32 %	-7 %	361±45	+3 %	0.364±0.065	+35 %	+32 %
48h after	909±147	324±32	-7 %	0.194±0.027	-27 %	-20 %	563±36	+10 %	0.337±0.045	-14 %	+24 %	351±28	0 %	0.210±0.032	-22 %	+22 %

\* Difference in changes was calculated by subtraction of the protein synthesis rate change (%) from the change (%) in  $^3\text{H}$ -tyrosine incorporation



labelled amino acid incorporation ignoring the significance of its specific activity in muscle tissue. The results presented in this paper demonstrate that the simplified calculation may induce meaningful errors. During and after muscular work the specific activity of the administered labelled amino acid may alter significantly. Thereby ignoring of the importance of changes in the specific activity of the amino acid resulted in values differing by up to 50 % from the actual rate of muscle protein synthesis.

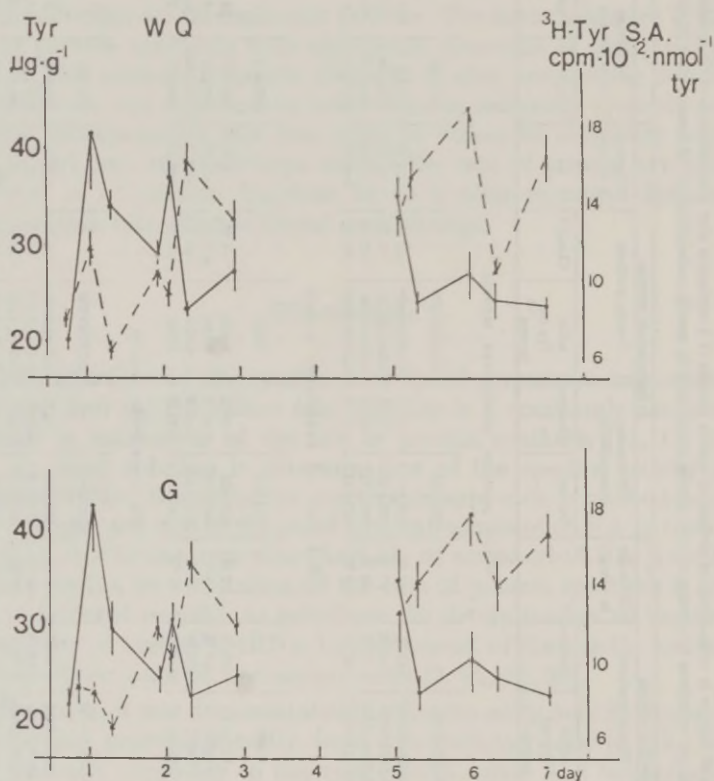


Figure 2. Dynamics of free tyrosine content (Tyr, solid lines) and  $^3\text{H}$ -tyrosine specific activities ( $^3\text{H}\text{-tyr S.A.}$ , interrupted lines) in the white part of quadriceps muscle (WQ) and gastrocnemius muscle (G) during a training microcycle. The time of exercises (90-min swimming) is indicated by small vertical lines on the abscissa.

The single exercise-bout experiment revealed that in addition to quantitative differences in evaluation of alterations in the rate of



protein synthesis, ignoring of the amino acid specific activity may cause also qualitatively different conclusions.

As it is shown in Fig. 3, in most cases the trends in  $^3\text{H}$ -tyrosine specific activity and free tyrosine content in various muscles were opposite, indicating the significance of exercise-induced release of free tyrosine. However, the negative correlation between the two indices was not evident in all cases. Obviously, the changes of  $^3\text{H}$ -tyrosine specific activity were only partly determined by the changes in tissue protein degradation.

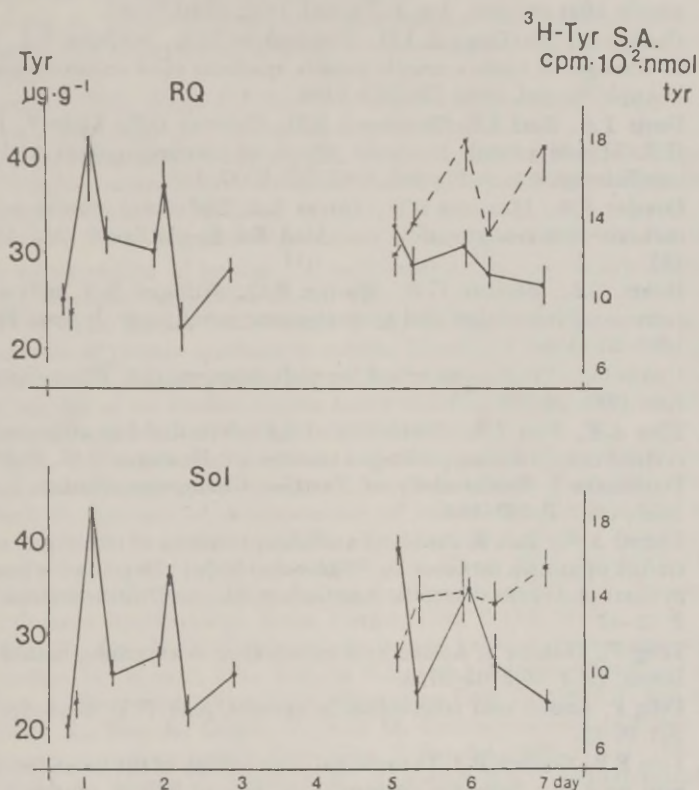


Figure 3. Dynamics of free tyrosine content (Tyr, solid lines) and  $^3\text{H}$ -tyrosine specific activities ( $^3\text{H}$ -Tyr S.A., interrupted lines) in the red part of quadriceps muscle (RQ) and soleus muscle (Sol) during a training microcycle. The time of exercises (90-min swimming) is indicated by small vertical lines on the abscissa.

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# EXERCISE-INDUCED ACTIVATION OF THYROID FUNCTION IN HYPOTHYROID RATS

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## Abstract

It was previously found that in euthyroid rats a 30-min running at  $35 \text{ m} \cdot \text{min}^{-1}$  caused an activation of thyroid function persisting for 48 h. At the end of this period rates of protein synthesis exceeded control levels in fast twitch oxidative-glycolytic and slow twitch oxidative muscle fibres. These responses were not found in hypothyroid rats. The results of the present study indicate that a highly intensive exercise (10-min swimming with an additional load of 10 % body weight) significantly increased blood levels of thyroxine and triiodothyronine. By autoradiography it was demonstrated that for 12 to 48 h after exercise, elevated hormone levels in blood associated with accumulation of labelled amino acids in muscle fibers of various types was above the levels in sedentary hypothyroid rats. Thus the exercise-stimulated thyroid function coincided with change in protein metabolism dependent on thyroid hormones.

## Introduction

During and immediately after exercise inconsistent responses of blood levels of thyrotropin, thyroxine, and triiodothyronine were found with a prevalence of cases of increased levels (for review see [2, 9]). Recently an increased activity of the pituitary-thyroid system was found during a prolonged period (up to 48 h) after a 30-min running in rats. The elevated thyroid activity associated with an increase in incorporation of labelled tyrosine into protein structures of fast twitch oxidative-glycolytic and slow twitch oxidative muscle fibers. In hypothyroid rats exercise failed to produce this change [3]. However, it was found that a 3-week period of training significantly increased thyroxine concentration in blood in rats made hypothyroid by administration of KJ [7]. A question arises, do some variants

of acute exercise also stimulate the thyroid function in hypothyroid organism? The question was tested in rats made hypothyroid by injections of mercasolil, using 10-min highly intensive exercise (swimming with an additional load of 10 % body weight). The adaptive significance of thyroid hormones was assayed with the aid of evaluation of changes in muscle protein synthesis.

## Material and methods

**Animals and procedure.** Experiments were conducted on male 17–18 weeks old Wistar rats. The rats were kept in standard conditions of vivarium and diet. The rats were made hypothyroid by daily subcutaneous injections of 10 mg per 100 g body weight of mercasolil during 2 weeks. The hypothyreosis was confirmed by low levels of thyroid hormones in blood: in hypothyroid rats the thyroxine concentration was  $3.5 \pm 1.0$  (mean  $\pm$  SEM) and triiodothyronine concentration  $0.1 \pm 0.02$  nMol·l<sup>-1</sup> instead of  $36.0 \pm 2.0$  and  $1.00 \pm 0.06$  nMol·l<sup>-1</sup> respectively in normal rats. The thyrotropin concentration was doubled in hypothyroid rats ( $0.2 \pm 0.08$   $\mu$ U·l<sup>-1</sup> instead of  $0.09 \pm 0.01$   $\mu$ U·l<sup>-1</sup>).

The exercise consisted in 10-min swimming in water of  $32 \pm 1^\circ\text{C}$ . The intensity of swimming was stimulated by an additional weight (10 % body weight) attached to the tail. The exercise was performed at 10 o'clock a.m.

Groups of 5 rats were sacrificed either 1.5 h, 12 h, 24 h or 48 h after the end of exercise. 5 sedentary control rats were sacrificed at the time of the end of exercise. Immediately after decapitation the quadriceps muscle and the soleus muscle were excised in temperature of  $4^\circ\text{C}$ . The quadriceps muscle was divided into white, intermediate and red portion. Blood was collected and immediately centrifuged for separation of plasma. The latter was stored at  $-20^\circ\text{C}$  for determination of thyroid hormones.

For comparison the results of experiments on euthyroid and hypothyroid rats were used [3]. The rats were treated in the same way and the same procedure was used. Only instead of 10-min swimming a less intensive exercise (30-min running at  $35 \text{ m}\cdot\text{min}^{-1}$ ) was used.

**Hormone determination.** Thyrotropin, thyroxine and triiodothyronine concentrations were estimated in blood plasma with the aid of radioimmunomethods, using the commercial kits TSH IRMA /<sup>125</sup>I/ RIA-T<sub>4</sub>-<sup>125</sup>I and RIA-T<sub>3</sub>PG respectively.

**Autoradiography.** The rats were injected intraperitoneally with L-(2,3,5,6-<sup>3</sup>H)-tyrosine two hours before cervical dislocation in four equal portions after every 30 min. The specific activity of <sup>3</sup>H-

tyrosine was  $105 \mu\text{Ci}\cdot\text{mmol}^{-1}$  and the total dose  $95 \mu\text{Ci}$  per 100 g body weight. An additional experiment proved that the used routine of isotope administration warranted a steady level of the specific activity of  $^3\text{H}$ -tyrosine within 90 min from the first injection.

Samples of various parts of the quadriceps muscle and a sample of the soleus muscle were broken up and fixed for 48 h in 2.5 % glutaraldehyde in 0.1 M phosphate buffer (pH 7.4) containing 0.1 m EDTA. After washing with phosphate buffer, samples were additionally fixed for 2 h in 1 %  $\text{OsO}_4$  (pH 7.4), washed again; dehydrated in graded alcohol and embedded in epoxy resins. Semithin blocks ( $1 \mu\text{m}$ ) were cut and stained with freshly prepared 0.1 % chrezytle violet (Merck) in caccodylate buffer (pH 7.4). Slices were covered with photoemulsion type-M (CIS, Moscow). The autoradiographs were studied with the aid of a light microscope (Leitz-Laborlux) and photographed on film Micrat-300 (CIS). Accumulation of the labelled amino acid in muscle fiber was quantified by the density of silver grains on the photos and test circles in the area of  $530 \mu\text{m}^2$ . In every sample 100 muscle fibers were studied and the mean number of silver grains was computed.

**Statistical analysis.** Differences between groups were assessed using the Student-Fisher t-test. The differences were considered statistically significant if the probability, assessed with the aid of the t-test, was higher than 95 % ( $P < 0.05$ ).

## Results

A significant increase in the concentrations of thyroxine and triiodothyronine was established 12 h after intensive swimming in hypothyroid rats (Fig. 1). The levels increased during the following 12 h and then they remained on the obtained level at least up to the end of the 48-h postexercise period. Compared to the response of euthyroid rats after 30-min running, hypothyroid rats exhibited more slowly developed changes (Fig. 1). Despite the fact that the obtained highest levels of thyroxine and triiodothyronine were more than twice higher in euthyroid rats, the hypothyroid rats revealed also a postexercise increase in accumulation of labelled tyrosine in muscle fibers. While in euthyroid rats the increased label accumulation took place in fast twitch oxidative-glycolytic and slow twitch oxidative fibers but not in fast twitch glycolytic and intermediate fibers, in hypothyroid rats increases were found in all types of fibers. The greatest response was in fibers of high oxidative potential (Fig. 2).

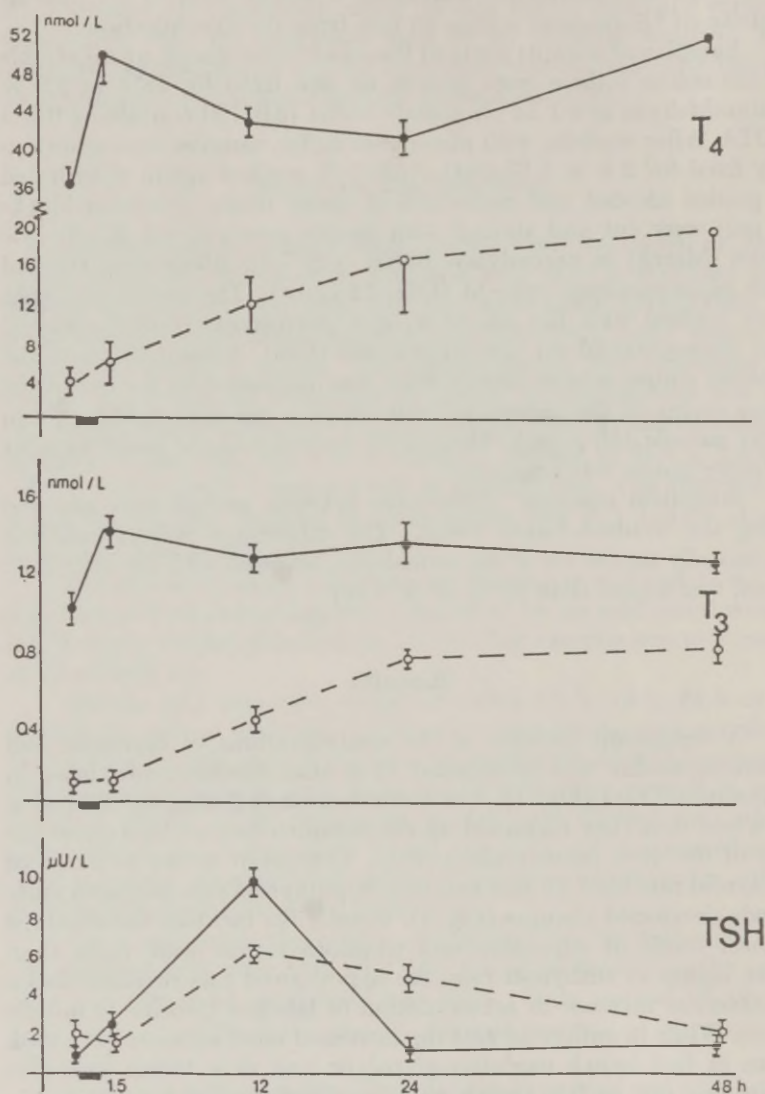


Figure 1 Postexercise dynamics of thyroxine ( $T_4$ ), triiodothyronine ( $T_3$ ) and thyrotropin (TSH) in euthyroid rats after 30-min running  $35 \text{ m} \cdot \text{min}^{-1}$  (solid lines) and in hypothyroid rats after 10-min swimming with an additional load (10 % b.w.).



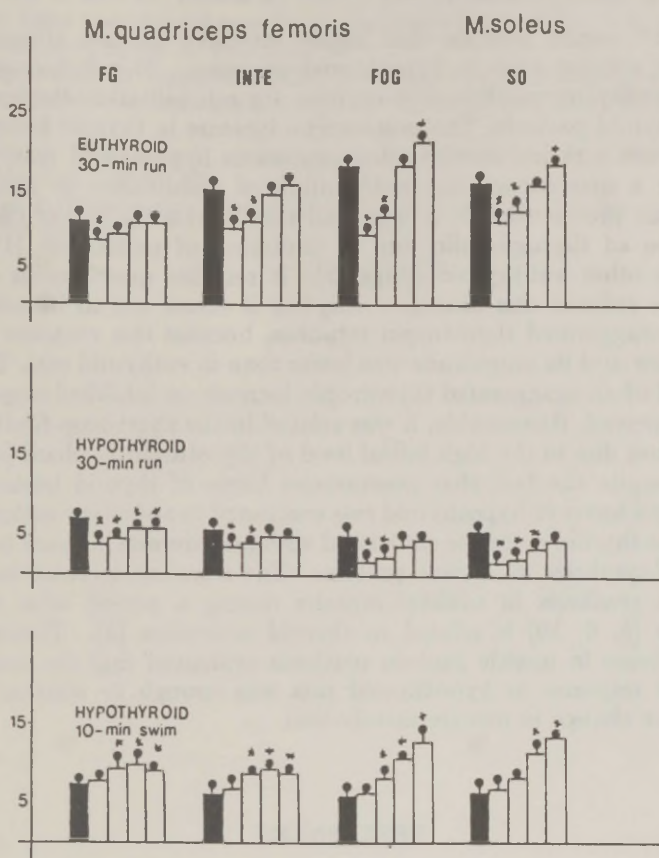


Figure 2. The incorporation of labelled tyrosine into muscle fibers (number of spots on  $530 \mu\text{m}^2$ , mean values  $\pm$  SEM). Black column — sedentary control rats, white columns — 1.5, 12, 24 and 48 h after exercise. Asterisks denote statistically significant differences ( $P < 0.05$ ). FG — fast glycolytic fibers, INTE — intermediate fibers, FOG — fast oxidative glycolytic fibers of quadriceps muscle, SO — Slow oxidative fibers of soleus muscle.

## Discussion

The results indicate that highly intensive exercise stimulates thyroid activity even in hypothyroid organism. This fact suggests a possibility to use intensive exercise for rehabilitation therapy in hypothyroid patients. The postexercise increase in thyroid hormone levels was a rather slowly going process in hypothyroid rats, suggesting a time-consuming mobilization of possibilities to increase hormone production. It is indicated that mercasolil blocks the iodination of thyroglobulin due to inhibition of peroxidase [1], as well as other antithyroid drugs [8]. It remains questionable how exercise reduces this disorder. Anyway it seems not to be related to an exaggerated thyrotropin response, because this response was also slow and its magnitude was lower than in euthyroid rats. Thus, instead of an exaggerated thyrotropin increase an inhibited response was observed. Reasonably, it was related to the short-loop feedback inhibition due to the high initial level of thyrotropin in blood [4].

Despite the fact that postexercise levels of thyroid hormones remained lower in hypothyroid rats compared to sedentary euthyroid rats, the thyroid response associated with postexercise increase in the rate of synthesis of muscle proteins. The transient increase in the protein synthesis in skeletal muscles during a period after their activity [5, 6, 10] is related to thyroid activation [3]. Therefore, the increase in muscle protein synthesis evidenced that the modest thyroid response in hypothyroid rats was enough to warrant the adaptive change in protein metabolism.

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# **ESTIMATION OF THE FUNCTIONAL STATE OF SKELETAL MUSCLE ACCORDING TO ITS NEW MODEL**

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## **Abstract**

It is nearly impossible to overestimate the importance of the functional state of skeletal muscle for the general state of the organism as a whole. One of the most important criterions in estimation of the state of skeletal muscle is its tone. The definition of skeletal muscle tone has caused much discussion and only in the late years some success has been achieved. Complications arise from the fact that every skeletal muscle with its strictly determined motoric function has a different tone value, which further depends on age, sex and the morphological structure of the skeletal muscle [Vain 1990, 1993]. The latter is on the whole determined genetically and by the functional state of the connective tissue structures of the muscle. The tone measurements are also of complicated nature, because the measurement procedure must not influence the biomechanical properties of the skeletal muscle. The procedure must be of short duration, to make it impossible for the patient to affect voluntarily the results of the measurements.

The criteria worked out by us in accordance with the new biomechanical model of the skeletal muscle make it possible to improve the diagnostic methods dealing with the functional state of skeletal muscle and give us valuable additional information concerning the other parameters of classical diagnostics.

**Key words:** Skeletal muscle, diagnostics, biomechanical properties.

## **Introduction**

Movability is one of the most important properties of living organisms. It gives them not only a possibility to communicate with environment but is also inevitable for their ontogenesis, satisfaction of essential needs, development and maintenance of health and workability.



Motion is a mechanical action, which demands a certain amount of mechanical energy for its realization. In the motion of living organisms this energy is produced by contraction of skeletal muscles. The latter phenomenon has not been given a sufficiently thorough scientific explanation yet and is still under discussion among scientists. It is clear that in the process of motion, mechanical energy is created in skeletal muscle itself and transmitted to bones via structures of the connective tissue: the endo-, peri- and epimyseum of the collagen fibre network [Vain 1990, 1993].

According to the above-given, the skeletal muscle has to be mechanically strong, elastic and adaptable to external mechanical stimulation.

These properties greatly depend on the morphological structure of the muscle and the biomechanical properties of the muscle as a whole (i.e. on the mechanical response of the muscle to mechanical stimulation).

Biomechanical diagnostics makes it possible to establish the level of biomechanical properties of the support motor system tissues [Vain 1992]. The methods of biomechanical diagnostics of the functional state of the muscle are based on measuring the parameters expressing the biomechanical properties of the muscle and their analysis. The value of a parameter characterizing biomechanical properties of the muscle describes the momentary state of the muscle. Its time dependence helps to mark out the processes taking place in functioning muscles, which are essential in the diagnostics of workability and functional state of the muscle. The other important problem to be investigated deals with differences in the characteristics of the same muscles, placed symmetrically in the body of the patients. The differences in these characteristics may have their origin in physical activities of the patient, pathological processes or deviations in the development of the motor system.

It is known from previous publications that skeletal muscle must be considered not only a generator of mechanical energy, but, according to the biomechanical properties of the tissue, the recuperator and dissipator of it too [Margaria 1982, Schreiner 1985, Vain 1985-93]. Without the last two notions it is impossible to estimate the physical working capacity of the muscle, the mechanisms of direction and coordination of movements.

Up to now, in estimation of the state of the nervous-muscular apparatus the notions of contractility and muscular tone played the central part, but in late days beside these two, which in essence characterize the statical work of the muscle, the notion of dampedness has been introduced. It is very useful in diagnostics of dynamical working capacity and functional state of the muscle.

## **Anatomy of Skeletal Muscle and the Functions of Morphological Structures According to the New Model of Skeletal Muscle**

In the following paragraphs we describe the relations of the above-mentioned biomechanical characteristics of skeletal muscles with the structure of the muscle.

Skeletal muscles provide movability for living organisms. Depending on their functions, every single muscle has evolutionally developed its own individual structure. For the histological unit of the skeletal muscle the muscle fibre should be considered. The combining of skeletal muscle fibres into muscles is inevitable to transmit the force created in the process of their contraction to the system of levers — the skeleton. Skeletal muscle fibers are bound into a whole muscle by different varieties of the connective tissue: endomyseum, surrounding every single muscle fibre; perimyseum — porous connective tissue, in which arteria and nerves are situated, and which envelops the bunches of muscle fibres; epimyseum — thick connective tissue, enveloping the whole muscle. These structures of the connective tissue also determine the mechanical resistance of the muscle to stretching.

A single muscle fibre could be characterized as a gigantic cell. Its dimensions depend on the concrete type of skeletal muscle to which the fibre belongs. The perimeter of muscle fibres of newborns is about  $7.5\text{ }\mu\text{m}$ , of grown-ups —  $30\text{--}80\text{ }\mu\text{m}$ .

All myofibrils in their turn consist of actin, titin and myosin filaments [Nave 1990]. The sequential complex of bright and dark stripes of a muscle fibre is called the sarcomere. It is separated by Z-lines. One end of actin and titin filaments is fastened to the Z-disk. The other one is left unattached. The free end of a titin filament terminates in a head-shaped formation. The length of titin filaments changes in the process of muscle contraction and stretching. This is the specific feature of titin filaments. The length of actin filaments remains constant in the process of dynamical work of the muscle, the myosin filaments may even shorten [Pollack 1990].

So the basic contractible unit is the sarcomere, where after a nervous impulse reaching it, the radial movement of myofilament heads (cross-bridges) takes place. This movement causes the thickening of sarcomere, muscle fibres, bunches of muscle fibres and the muscle as a whole.

The membrane, enveloping the muscle fibre, is called the sarcolemma. The latter consists of two layers: the inner cellular membrane, the thickness of which is about  $75\text{ }\text{\AA}$ , and the outer basal membrane, the thickness of which overreaches the thickness of the inner membrane more than tenfold. The network of collagen fibres

enables the sarcolemma to conform with changes in the shape of the muscle fibres: the meshes of the filament net are in a relaxed fibre more or less regularly tetragonal, their planes form an angle of  $55^\circ$  with the longitudinal axis of the muscle fibre. In the stretched fibre they turn elongated in the direction of the fibre axis, forming an angle of less than  $20^\circ$  with it. In the contracted fibre the meshes of the net are elongated perpendicularly to the fibre, the angle between their planes and the longitudinal axis not exceeding  $80^\circ$  [Purslow 1989].

Reticular fibres of the endomyseum in the muscles of a newborn are thin and their orientation irregular. In the muscles of a full-grown mammal, reticular fibres of regular orientation prevail, the perimeter of the fibres has increased noticeably. In the process of ontogenesis the thickness of the endomyseum increases about four times on the average.

The perimyseum contains much more collagen fibres than the endomyseum, the mass ratio ranging from 2.8:1 to 64:1 [Light et al. 1985]. The portion of elastin is less than that of collagen in the perimyseum. From the morphological aspect the structures of epimyseum and perimyseum do not differ significantly. In conformity with the new model of skeletal muscle [Vain 1990] the force transmission in muscle is mainly effected via peri- and epimyseum to tendons.

## Biomechanics of Skeletal Muscle

From the biomechanical aspect, skeletal muscle as an organ has three functions: force generation, dissipation and recuperation of mechanical energy. These functions are realized by the skeletal muscle in the following way: in the force generation process after the beginning of the myosin filament cross-bridges radial withdrawal, started by a nervous impulse, the inner pressure and consequently the perimeter of the muscle fibre will increase. As every muscle fibre, bunch of fibres and muscle as a whole is covered by structures of connective tissue, which include collagen and elastin fibre network, the perimeter increase causes the shortening of the muscle as an organ. This can be concluded from the fact that the collagen and elastin fibre network ensures the constancy of the muscle volume, as the myofibrils, tissue fluids and plasma are practically not compressible. As it was mentioned above, the collagen and elastin filaments pass directly over into tendons, so the radial force created by radial sliding of cross-bridges is transmitted into contractional force of the muscle by the collagen and elastin network situated in the connective tissue casing of the muscle. So we can deduce that in the process of



transformation of the muscle inner pressure into contracting force the angle between the collagen filaments and the longitudinal axis of the muscle fibre is of vital importance.

The radial component  $F_p$  of the force, which causes the myofibril cross-bridges to move away,  $F_r$ , obtains significant values only in case the angle  $\beta$  is small. So in the process of muscle perimeter increase the contraction force apparent at the ends of the muscle will not remain constant, but will decrease even in case of the efferent impulsation remaining constant (see Fig. 1).

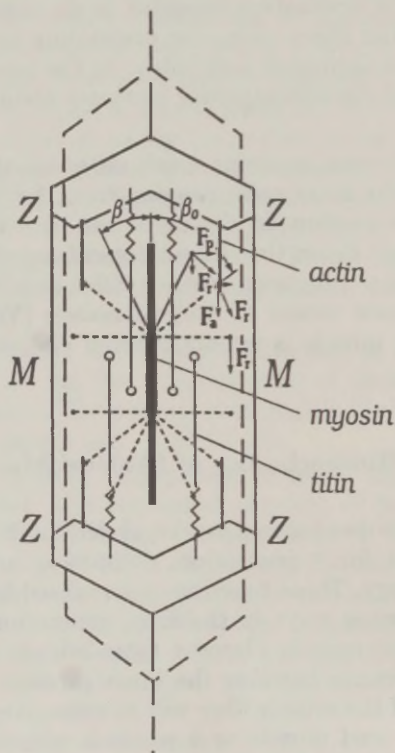


Figure 1. Dependence of the myosin cross-bridges turning radial force  $F_p$  on the angle  $\beta$ , in case  $F_r$  is constant.

The magnitude of mechanical strain depends on the activity of efferent innervation, the amount of energy-saturated proteins and their transportation intensity in the muscle.

The ability of skeletal muscle to be the dissipator of mechanical energy is very important in the movement coordination process. In the human motor apparatus in the process of every elementary



movement (bending, stretching, turning around the joint axis) the synergetical muscles when shortening always strain the antagonists situated symmetrically on the other side of the joint axis. As all the muscles have damping function, stretching of antagonists causes the mechanical energy dissipation  $A$ , which can be characterized by the following equation:

$$A = F \star S,$$

where  $S$  — the stretch range of the antagonists.

$$F = \frac{\theta \star v \star \nu}{2 \star m},$$

where  $\theta$  — oscillation decrement of the antagonist muscle,

$v$  — stretch rate

$\nu$  — oscillation frequency of the antagonist,

$m$  — mass of the antagonist.

As we see, the losses in the dissipation process depend on the dempferity, tone and stretch rate of the strained muscle.

Mechanical energy recuperation in skeletal muscle takes place via deformation of tendons titin and collagen fibres of the muscle. The storage of mechanical elasticity energy via elastic deformation of muscle titin and collagen fibres and tendons depends on the stiffness  $C$  of these tissue structures and tendons as well as on the size of the deformation  $\Delta l$ :

$$A = (C \star \Delta l^2)/2,$$

where  $C = 4 \star \pi^2 \star m^2 \star \nu^2 + \theta/(4 \star m)$ .

The muscle belly and the tendonous parts of the skeletal muscle function as a whole and so for the mechanical energy recuperation time is of great importance. If the time interval between the storage and use of the mechanical energy is short, the relaxability and creepage of the muscle body do not influence the mechanical energy recuperation. In case of longer time intervals the muscle belly relaxation lessens the stiffness of the connective tissue structures, the creepage — the plastic deformation, and so the amount of energy to be recuperated diminishes significantly.

In conclusion it should be pointed out that the functional state of skeletal muscle can be characterized on the basis of its biomechanical model by its two biomechanical parameters: the stiffness and the dempferity. The former can be described by the oscillation frequency of skeletal muscle, the latter by the logarithmic decrement. The values of these parameters are measured and stored using the methods and equipment developed by us [Humal, Vain 1993]. The essence of the method lies in the analysis of the oscillation, induced

by mechanical impact from outside, of the muscle as a whole. The resulting oscillation curve reflects the mechanical properties of the epi-, peri- and endomyseum of the muscle as well as the rheologic characteristics of the muscle fluids and blood.

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# RELATIONSHIPS BETWEEN OXYGEN UPTAKE AND CARDIAC OUTPUT DURING GRADUATED LOADS IN UNTRAINED PUBERTAL BOYS

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## Abstract

Twenty-three 15-16 years-old untrained boys were tested on the bicycle ergometer to characterize the relationships between the oxygen uptake ( $\dot{V}O_2$ ), stroke volume (SV) and cardiac output ( $\dot{Q}$ ) during graduated loads up to the maximum. For the determination of  $\dot{Q}$  the  $CO_2$  rebreathing method was used. The mean maximal values for  $\dot{V}O_2$   $2.092 \pm 0.084$  l/min and  $45.9 \pm 0.9$  ml/min·kg<sup>-1</sup> and for  $\dot{Q}$   $23.2 \pm 0.4$  l/min are similar with the data reported by several authors for adult men. The maximal SV was found during submaximal loads of 40-45 %  $\dot{V}O_{2,max}$ . The aerobic power of young boys is significantly connected with  $\dot{Q}_{max}$  ( $r = 0.72$ ) and with SV during exercise ( $r = 0.68$ ). For the prediction of  $\dot{Q}$  during submaximal and maximal loads in boys the following equation can be used:

$$\dot{Q} \text{ (l/min)} = 5.64 \cdot \dot{V}O_2 \text{ (l/min)} + 6.85.$$

**Key words:** Aerobic power, cardiac output, stroke volume, oxygen uptake, exercise, puberty.

## Introduction

The maximal oxygen uptake ( $\dot{V}O_{2,max}$ ) has traditionally been used as a criterion of cardiorespiratory fitness [1, 15, 16, 18] and as a predictor of endurance performance of sportsmen [2, 10, 16]. It is a well-known fact that there exists a high correlational relationship between oxygen uptake ( $\dot{V}O_2$ ) and cardiac output ( $\dot{Q}$ ) during work in adult subjects. Much less attention has been devoted to characterize analogous relationships during physical exercises in adolescents.



The purpose of this study was to examine the dynamics of oxygen uptake, stroke volume and cardiac output during graduated loads up to the maximum and to characterize the relationships between  $\dot{V}_{O_2}$  and  $\dot{Q}$  in untrained 15-16 year-old schoolboys.

## Methods

23 untrained schoolboys ( $\bar{x}$  age =  $15.7 \pm 0.1$  yrs,  $\bar{x}$  height =  $174.7 \pm 1.6$  cm,  $\bar{x}$  weight =  $63.5 \pm 1.9$  kg) participated.

The subjects performed three submaximal loads on the bicycle ergometer (1.0 W/kg, 1.5 W/kg, 2.0 W/kg, 60 rpm, 6 min). After submaximal loads the work load was increased after one min by 30 W up to the individual maximum [18].

Lung ventilation ( $\dot{V}$ ) and indices of gaseous metabolism ( $\dot{V}_{O_2}$ ,  $\dot{V}_{CO_2}$ ) were determined during the last 30-sec work periods with the Douglas bag technique. For determination of %  $O_2$  and %  $CO_2$  in expired air the Zeiss interferometer was used.

The cardiac output was determined at rest and during submaximal and maximal loads by using the  $CO_2$  rebreathing method [5, 6, 13]. For calculation of cardiac output according to the Fick principle,  $pCO_2$  of arterial blood was determined from alveolar air, the mixed venous  $pCO_2$  was measured by the rebreathing method using  $CO_2$  and  $O_2$  mixtures [6, 12].

## Results

The mean values and standard deviation from the means of  $\dot{V}_{O_2}$ , HR,  $\dot{Q}$ , SV and a-v  $CO_2$  difference are presented in Table 1. The mean  $\dot{V}_{O_2}$  max in the present study was  $2.092 \pm 0.084$  l/min and  $45.9 \pm 0.9$  ml/min·kg<sup>-1</sup>.

It followed that oxygen uptake, heart rate and arteriovenous carbon dioxide difference during submaximal and maximal exercises increased with raising the loads. At the same time alterations in a-v  $CO_2$  difference during graduated loads are insignificant.

## Discussion

The measured maximal oxygen uptake in the present study was similar to the data previously published on untrained young as well as adult subjects [4, 11, 15, 16].

The mean maximal cardiac output of 23.2 l/min in our exa-



Table 1

Oxygen uptake, cardiac output and related functions at rest  
and during work ( $\bar{x} \pm SD$ )

	$\dot{V}O_2$ l/min	HR bts/min	A-v diff ml/l	SV ml	$\dot{Q}$ l/min
Rest	$0.387 \pm 0.010$	$92.8 \pm 3.0$	$45.8 \pm 2.0$	$93.0 \pm 6.0$	$8.8 \pm 0.3$
1. Submax. load	$1.220 \pm 0.020$	$124 \pm 3.0$	$90.1 \pm 2.1$	$106.1 \pm 6.1$	$13.7 \pm 0.4$
2. Submax. load	$1.529 \pm 0.032$	$143.3 \pm 2.8$	$99.4 \pm 1.7$	$104.1 \pm 5.8$	$15.5 \pm 0.4$
3. Submax. load	$1.919 \pm 0.050$	$164.5 \pm 3.0$	$106.0 \pm 2.0$	$105.6 \pm 5.8$	$18.4 \pm 0.4$
Maximal load	$2.902 \pm 0.084$	$202.6 \pm 1.7$	$125.6 \pm 2.3$	$109.6 \pm 6.0$	$23.2 \pm 0.4$

mination was significantly greater than the data reported for 13–14 year-old children [5, 8], at same time our results did not differ from the corresponding data for untrained adult men [14, 17]. It followed that the highest stroke volume was measured during the exercise at 40–45 per cent of  $\dot{V}O_{2\max}$  (heart rate 110–125 beats/min), almost the same relationship exists in adult subjects [7, 14, 17].

The results of the present study indicate that between the values of aerobic power and maximal cardiac output a significant correlation exists ( $r = 0.72$ ). During the exercise a high correlation was found between  $\dot{V}O_{2\max}$  and SV too ( $r = 0.68$ ). It appears that for the good aerobic work capacity in pubertal boys a high maximal cardiac output and large heart volume play an important role. The important role of the maximal  $\dot{Q}$  for guaranteeing a high aerobic power in adult subjects has been previously demonstrated by several authors [2, 9, 17].

Figure 1 shows that a linear relationship exists between  $\dot{Q}$  and  $\dot{V}O_2$  during graduated loads. The regression equation indicates that during physical work the oxygen uptake is an accurate predictor of  $\dot{Q}$ :

$$\dot{Q} \text{ (l/min)} = 5.64 \dot{V}O_2 \text{ (l/min)} + 6.85$$

Almost the same equation for adult men was found by Ekelund [7]:

$$\dot{Q} \text{ (l/min)} = 5.75 \dot{V}O_2 \text{ (l/min)} + 7.19$$

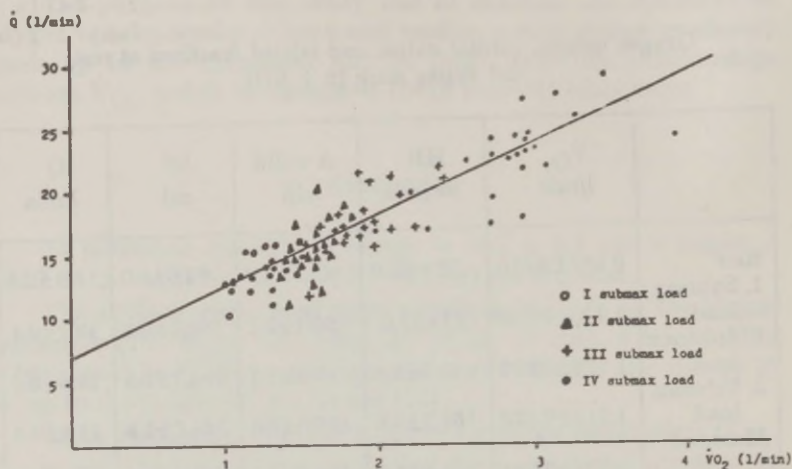


Figure 1. Relationship between cardiac output ( $\dot{Q}$ ) and oxygen uptake ( $\dot{V}O_2$ ).

But our results differ significantly from the formulae found by Åstrand et al. [3] and Saltin et al. [17].

In conclusion: the present study indicate the  $\dot{V}O_2$  to be a valid predictor of  $\dot{Q}$  during graduated loads in 15-16 year-old untrained boys. In this ageperiod the maximal cardiac output and high stroke volume during exercises play an important role for the high aerobic power.

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# GENERAL FITNESS TRAINING WITH THE AID OF AEROBIC GYMNASTICS

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## Abstract

The study was performed in order to check the possibility for using aerobic gymnastics as a means of general fitness training. The study consisted of two pedagogical experiments performed in three groups of women. The training was directed to endurance, dynamic strength, and flexibility improvement respectively to three groups. The duration of the first experiment was 4 months and that of the second — 6 months. The efficiency of training was evaluated with the aid of a battery of fitness tests, including the Harvard step-test, three tests of dynamic strength performed on the highest number of repetitions within 30 s, a test for static endurance of a large group of muscles, and four flexibility tests. The obtained changes were variable, but in all groups the positive effect of aerobic gymnastics on general fitness was established.

**Key words:** aerobic gymnastics, dynamic strength, flexibility, functional capacity of the cardiovascular system, general fitness, training

## Introduction

A good mood [1, 7, 8] and improved aerobic capacity [2, 4, 8, 9] are considered to be the main benefits of systematic aerobic dance or aerobic gymnastics. Results are also obtained indicating a positive effect of aerobic gymnastics on blood lipoprotein content [2, 6]. In addition to these frequently confirmed results, it was found that in female students engaged in aerobic gymnastics the tests of dynamic strength showed a higher strength level than in age-matched physically inactive students [5]. Obviously, aerobic gymnastics may be used not only for aerobic training but also for general fitness training of women. This possibility was suggested by T.S. Lissitskaya [3]. This study was performed in order to check this hypothesis.

## Material and methods

The study consists of two pedagogical experiments, performed on three groups of female aerobic gymnasts (Table 1). All groups exercised thrice weekly for 45 min. In the first group the training was directed to improved endurance. At least during 80 % of the time of session the exercise intensity was maintained at heart rate 140–160 beats per min. In the second group the main direction of training was improved dynamic strength. In every session 50 % of the exercises chosen required surmounting of a resistance. In the third group the training direction was improved flexibility. In every session 30 % of exercises had great movement amplitude or were stretching exercises.

Table 1

Contingent of study persons in experimental group  
(mean  $\pm$  SD)

Group and experiment	n	Age	Height	Weight	Number of persons who had previous training experience
1st group					
1st experiment	11	17 $\pm$ 1.4	165 $\pm$ 4	63.3 $\pm$ 7.8	2
2nd experiment	16	17 $\pm$ 1.2	167 $\pm$ 5	63.2 $\pm$ 8.1	4
2nd group					
1st experiment	15	33 $\pm$ 4.2	166 $\pm$ 5	66.8 $\pm$ 9.6	1
2nd experiment	17	44 $\pm$ 5.4	165 $\pm$ 5	64.5 $\pm$ 9.0	2
3rd group					
1st experiment	12	28 $\pm$ 6.2	164 $\pm$ 5	61.8 $\pm$ 8.9	2
2nd experiment	12	29 $\pm$ 4.4	164 $\pm$ 4	63.5 $\pm$ 7.2	4

The first pedagogical experiment began in January, 1991 and ended in May, 1991. The second pedagogical experiment lasted from October, 1991 to April, 1992.

The following battery of fitness tests were performed before and after every experimental period:

- 1) Harvard step-test,
- 2) push-ups during 30 s on the highest number of repetitions,
- 3) squats during 30 s on the highest numbers of repetitions,

4) sit-ups from a lying position during 30 s on the highest number of repetitions,

5) in a prone lying position holding the chest up for the longest possible time,

6) side splits (criterion: distance from the floor in cm),

7) bridge position (criterion: distance between hands and feet in cm),

8) bending to the front in order to reach a level lower than the support level of feet (criterion: difference in cm).

The training effects were evaluated with the aid of the paired t-test.

## Results

Mean values and individual change of the Harvad step-test index are presented in Table 2. There were pronounced intraindividual as well as intragroup differences in the Harvard index. An analysis of changes with the aid of the paired t-test showed significant improvement of functional capacity of the cardiovascular system in the first group during the second experiment and in the second group in both experiments. No significant change was found in the third group.

Table 2

Harvard step-test index before and after experimental periods  
(mean  $\pm$  SD)

Group	First experiment			Second experiment		
	Jan. 1991	May 1991	Change	Oct. 1991	April 1992	Change
First	91 $\pm$ 25	96 $\pm$ 35	+5.8 $\pm$ 2.5*	86 $\pm$ 32	104 $\pm$ 22	+5.4 $\pm$ 1.6*
Second	45 $\pm$ 28	53 $\pm$ 29	+8.3 $\pm$ 1.9*	54 $\pm$ 27	64 $\pm$ 24	+5.9 $\pm$ 1.3*
Third	55 $\pm$ 31	49 $\pm$ 33	+2.3 $\pm$ 4.1	56 $\pm$ 25	61 $\pm$ 27	+4.5 $\pm$ 3.0

\* Asterisk denotes statistically significant change during the experimental period on the basis of paired t-tests ( $p < 0.05$ )

The paired t-test allowed to establish a significant improvement in the second group in 3 tests of dynamic strength in the first experiment and in all 4 tests in the second experiment (Table 3). In the first group the improvement was revealed only in squats after the first experimental period, but in three tests after the second

Table 3

Individual changes in tests of dynamic strength  
and static endurance analysed with the aid of paired t-test

Groups, Tests	First experiment		Second experiment	
	Change (mean $\pm$ m)	P	Change (mean $\pm$ m)	P
Arm flexions in support lying (number per 30s)				
1st group	+0.54 $\pm$ 1.02	> 0.05	+1.5 $\pm$ 0.83	> 0.05
2nd group	+1.50 $\pm$ 0.57	> 0.05	+2.2 $\pm$ 0.71	< 0.05
3rd group	+0.94 $\pm$ 0.63	> 0.05	+2.5 $\pm$ 0.71	< 0.02
Squats (number per 30s)				
1st group	+1.42 $\pm$ 0.83	> 0.05	+0.40 $\pm$ 0.75	< 0.05
2nd group	+1.49 $\pm$ 0.85	> 0.05	+0.75 $\pm$ 1.33	< 0.05
3rd group	+1.82 $\pm$ 0.92	> 0.05	+2.47 $\pm$ 0.80	< 0.05
Sit ups (number per 30s)				
1st group	+0.77 $\pm$ 0.77	> 0.05	+1.80 $\pm$ 1.06	> 0.05
2nd group	+2.60 $\pm$ 0.77	< 0.02	+2.30 $\pm$ 1.27	< 0.05
3rd group	+2.90 $\pm$ 0.69	< 0.01	+2.95 $\pm$ 0.96	< 0.01
Holding of the chest up in prone lying position (s)				
1st group	+0.43 $\pm$ 7.44	> 0.05	+1.60 $\pm$ 0.93	> 0.05
2nd group	+1.07 $\pm$ 3.68	> 0.05	+2.94 $\pm$ 0.53	< 0.01
3rd group	+1.53 $\pm$ 2.67	> 0.05	+2.83 $\pm$ 0.42	< 0.01

experimental period. In the third group the results improved in most tests.

The tests of flexibility were performed only in the first experiment. In all groups significant improvement was found in side split with the right leg in front and in bending to the front; but not in side split with the left leg in front and in bridge position (Table 4).

## Discussion

Aerobic gymnastics caused improvements in results of various fitness tests. The increased functional capacity of the cardiovascular system is in accordance with the results indicating a positive effect of aerobic dance or aerobic gymnastics on aerobic working capacity [2.



Table 4

**Individual changes in tests of flexibility analysed  
with the aid of paired t-test**

Tests	1st group	2nd group	3rd group
Side splits with the right leg in front (cm)	-1.9±0.67*	-1.31±0.51*	-1.2±0.37*
Side splits with the left leg in front (cm)	-1.1±0.59	-0.8 ±0.49	-0.9±0.45
Bridge position (cm)	-0.6±0.61	-0.3 ±0.36	-0.5±0.31
Bending to the front (cm)	-2.0±0.53*	-1.6 ±0.45*	-1.2±0.25*

Asterisks denote statistically significant change ( $P < 0.05$ )

4, 8, 9]. However, by results obtained in this study, the positive effect may not appear if a special accent is made in improved flexibility, using stretching exercises. The obtained results show also that the positive effect of aerobic gymnastics on the cardiovascular system depends on the initial level of functional capacity as well as on the duration of training period. In the first group possessing a rather high initial level of Harvard index the change was insignificant during the first experiment lasting 4 months, but significant during the second experiment lasting 6 months.

Dynamic strength tests performed on the highest number of repetitions during 30 s, indicated also the dependence of improvement on the duration of training. After the second 6-month training period positive changes were obtained in groups having the accent on strength or stretching exercises by the results of all tests. The same situation was revealed by results of a test for static endurance of a large muscle group. In groups performing intense exercises (the first group) an improvement was found only in the number of squats during 30 s. The positive action of aerobic gymnastics on muscular functions agrees with the results of M. Ivelev [1] and I. Neissaar [5] and the suggestions of T. Lissitskaya [3].

In agreement with the data of Ivelev [1], aerobic gymnastics proved effective for the improvement of flexibility. However, this appeared in the results of side splits with the right leg in front and bending to the front, but not in side splits with the left leg in front or bridge position. These differences are, plausibly, related to the

specific effects of the used exercises on flexibility. Obviously, exercises stimulating an improvement in the flexibility necessary to perform slide splits with the left leg in front or bridge position were not used in a sufficient amount.

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# TRAINABILITY OF THE CARDIOVASCULAR SYSTEM IN PRESCHOOL CHILDREN

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## Abstract

The purpose of the study was to check the influence of organized physical education lessons on the cardiovascular system in kindergarten children. The exercise program consisted in intense exercises of major body activities (running, jumping, gymnastics, active games) three times weekly per 30 min. In 100 3-6-year-old children the training effect was evaluated by heart rate level during two step-tests (15 or 30 steps per min during 3 min). After a 6 months period no reduction of exercise heart rate was found in either exercised or control children. In 65 children of the same age the effect of a 9 months training period was assessed with the aid of the ratio between the sum of recovery pulses to step-test intensity (depending on body weight and stair height). The ratio decreased but a similar change was found also in 53 children of age-matched control groups. In 4-6 years old children a 6-month period of exercise training did not change the anaerobic threshold estimated during an incremental treadmill exercise. The results are in accordance with the conclusion that in preschool children exercise training does not stimulate the development of cardiovascular functions or aerobic working capacity.

**Key words:** aerobic working capacity, anaerobic threshold, cardiovascular functions, exercise training, heart rate, preschool children.

## Introduction

By a general consensus  $\dot{V}O_{2\max}$  increases with training in schoolchildren [6, 12, 15]. However, in regard to children of 7-10 years the results of training studies have been less strict: an improvement was found in endurance running time but not in  $\dot{V}O_{2\max}$  per kg weight [1, 4, 9, 14]. In two studies interval runs [11] or



games in combination with longdistance runs [8] improved  $\dot{V}_{O_2 \text{ max}}$  (by 6.8–8.2 %) and running times in children 8–12 years old. In 5-year-old children either 5 times or 1 time weekly training (runs for 750 to 1000 m) resulted in a significant improvement of running velocity during a 450 m run, decreased heart rate during submaximal exercise, but no increase in  $\dot{V}_{O_2 \text{ max}}$  [18]. On the other hand, when 26 6-year-old children were divided into two groups by the results of 1500 m, 4000 m and 8850 m runs, the fast group had a  $\dot{V}_{O_2 \text{ max}}$  significantly higher than the slow group [19]. By O. Bar-Or [2] "the final verdict recording the relative aerobic trainability of different maturation groups is still pending". The purpose of this study is to check the influence of organized physical education lessons on the cardiovascular system in kindergarten children. The study was performed in two sets. In the first of them, cardiovascular functions were assessed with the aid of a step-test. In the second experimental set anaerobic threshold was estimated.

## Material and methods

All experiments were performed on kindergarten children. They were under systematical medical examination. Children included into experimental or control groups had neither chronic diseases nor had they suffered from any major acute disease. An informed consent was obtained from parents of the children.

The preliminary training experiment was carried out on 100 children of 3 to 6 years. 65 of them constituted experimental groups. 35 children were included into control groups (Table 1). The training influence on the cardiovascular system was evaluated with the aid of a step-test, performed before the experimental period as well as after 4 and 6 months of training. Differently from the first set of the main experiment, two step-tests were used: 15 steps per min or 30 steps per min. Both test exercises lasted 3 min. Heart rate was measured at the end of 3 min stepping.

In the main experimental sets the first protocol was used in 118 children of 3–6 years of age. 65 children were included into experimental groups and 53 into control groups (Table 2). The duration of the experimental period was 9 months. The step-test performed before and after the experimental period consisted of 30 steps per min during 3 min exercise. The stair height was adjusted to require a 90° angle in knee joint for the step. Heart rate was recorded at the end of stepping as well as during the first 3 min after exercise. The total number of pulses during 3 postexercise minutes, called sum of recovery pulses, was divided by the power output during stepping. The power output was calculated taken into



Table 1

Changes in heart rate at the end of 3-min step-test before the experiment, after 4 and 6 months period of systematic exercise performance in the preliminary experiment (mean  $\pm$  SD)

Age	Sex	Group	N	Mean of heart rate in stepping and its std.deviation. 15 steps/minute			Mean of heart rate in stepping and its std.deviation. 30 steps/minute		
				Before the experiment	After 4 months	After 6 months	Before the experiment	After 4 months	After 6 months
3...4	Male	Exper.	7	125 $\pm$ 13.8	131 $\pm$ 15.4	130 $\pm$ 15.2	149 $\pm$ 19.3	140 $\pm$ 16.4	142 $\pm$ 16.6
3...4	Male	Contr.	5	126 $\pm$ 13.9	130 $\pm$ 15.2	132 $\pm$ 15.3	145 $\pm$ 17.0	148 $\pm$ 17.4	148 $\pm$ 17.3
3...4	Female	Exper.	14	123 $\pm$ 14.2	129 $\pm$ 11.0	129 $\pm$ 14.1	152 $\pm$ 17.0	145 $\pm$ 11.7	146 $\pm$ 12.1
3...4	Female	Contr.	5	125 $\pm$ 16.2	131 $\pm$ 14.2	132 $\pm$ 16.6	136 $\pm$ 19.0	140 $\pm$ 18.7	141 $\pm$ 19.1
5...6	Male	Exper.	20	115 $\pm$ 10.3	122 $\pm$ 11.9*	122 $\pm$ 11.8*	139 $\pm$ 17.4	141 $\pm$ 11.0	146 $\pm$ 14.0*
5...6	Male	Contr.	13	110 $\pm$ 10.5	117 $\pm$ 14.0	117 $\pm$ 13.8	135 $\pm$ 15.8	137 $\pm$ 10.5	138 $\pm$ 11.3
5...6	Female	Exper.	24	116 $\pm$ 14.7	125 $\pm$ 11.5	124 $\pm$ 10.2*	141 $\pm$ 16.7	151 $\pm$ 12.6*	150 $\pm$ 12.8*
5...6	Female	Contr.	12	118 $\pm$ 12.5	125 $\pm$ 8.2	125 $\pm$ 8.1	146 $\pm$ 16.3	155 $\pm$ 12.9	151 $\pm$ 12.4

\* Asterisk denotes statistically significant difference ( $P < 0.05$ ) from values obtained in the same group before the experimental period

account the actual height of the stair and the body weight of the child.

Table 2

Influence of a training period on the ratio between the sum of recovery pulses and power output ( $\text{kgm}\cdot\text{min}^{-1}$ ) in step-test in 3-6-year-old children by the paired t-test

Age, sex	Experimental group			Control group		
	n	$d \pm m_d$	t	n	$d \pm m_d$	t
3-4 years						
girls	19	$-0.11 \pm 0.03$	<u>3.67</u>	9	$-0.10 \pm 0.05$	2.00
boys	10	$-0.16 \pm 0.06$	<u>2.67</u>	17	$-0.10 \pm 0.03$	<u>3.33</u>
5-6 years						
girls	17	$-0.07 \pm 0.02$	<u>3.50</u>	15	$-0.07 \pm 0.03$	<u>2.30</u>
boys	19	$-0.06 \pm 0.02$	<u>2.60</u>	12	$-0.02 \pm 0.04$	0.50

d — mean of individual differences

$m_d$  — SEM of individual differences

t — values corresponding to  $P < 0.05$  are underlined

When during the experimental period the legs of a child grew longer, the height of the stair was increased. At the same time the work output for each stair increased also due to a gain in weight. A control experiment was performed to check the significance of the increased work output on the heart rate response. A 3-min step-test was monitored in 66 children of each sex aged 4-6 years on two levels of work output. When exercise intensity was increased by  $26 \pm 6 \text{ kg}\cdot\text{min}^{-1}$  due to the altered stair height, heart rate was elevated by  $10 \pm 3$  beats per min at the end of exercise. During the first 3 postexercise minutes the total number of heartbeats increased by  $14 \pm 6$  beats per min (mean  $\pm$  SEM). However, the ratio of the sum of recovery pulses to power output decreased insignificantly. Therefore, children adjusted adequately to the increased exercise intensity within this limit. Consequently, at the second testing the increase in exercise intensity was not a factor resulting in an elimination of the training effect by an increase in the ratio of the sum of recovery pulses to the power output.

The second protocol of the main experimental sets predicted an estimation of anaerobic threshold in 26 children (21 girls and 5 boys)

before and after a 6-month period of exercise training. The children were tested with the aid of an incremental treadmill exercise. Tape velocity was raised by  $0.5 \text{ km}\cdot\text{h}^{-1}$  after every 100 m, starting from  $5 \text{ km}\cdot\text{h}^{-1}$  until refusal by the child to continue the exercise. The tape incline was  $9^\circ$ . Heart rate was recorded with sporttester "Polar Electro". Anaerobic threshold was found indirectly by the deflection point in heart rate increase. The deflection point was estimated with a computer program and also visually by two investigators.

**Exercise program.** The children of experimental groups performed an exercise program (three times weekly per 30 min). The program consisted of intense exercises of major body activities (running, jumping, gymnastics, active games). A check of intensity of the exercise sessions with the aid of a sporttester showed that each session included a 10-min part when jumping and running exercises increased the heart rate up to 160...170 beats per min.

The habitual motor activity in children of both experimental and control groups were evaluated with the aid of questionnaires, answered by parents as well as by kindergarten teacher. There were no systematic differences besides the organized exercise sessions in children of experimental and control groups.

**Statistical analyses.** The training effects were evaluated with the aid of the Student-Fisher t-test and paired t-test comparing the values obtained in the same group before and after the experimental period.

## Results

The results of the preliminary experiment are presented in Table 1. During the 6-month study period a trend to an increase in exercise heart rate was revealed. However, this change was statistically significant ( $P < 0.05$ ) only in 5-6-year-old children of experimental groups. Anyway, the results showed a great variability and high lability of heart rates in preschool children. Obviously in the studied children the exercise heart rate depends on a number of other factors besides the cardiovascular functional capacity. Therefore a doubt arose on the usefulness of measuring heart rate in moderate exercise for evaluation of the effects of systematic exercise performance. In the main experimental sets other approaches were used for evaluation of the training effect.

The first protocol of the main experiment included evaluation of the functional capacity of the cardiovascular system by the ratio between heart rate postexercise recovery (evaluated by the sum of recovery pulses) and step-test intensity. During the experimental period a significant reduction of the ratio was evidenced in all



experimental groups (Table 2). However, similar changes were found also in control groups (reductions of the ratio were significant in 3-4-year-old girls and 5-6-year-old boys).

The second protocol envisaged the determination of AT. 6-month exercising did not change this measure of the aerobic potential. During incremental treadmill exercise at heart rate deflection point the mean running velocity was  $5.37 \pm 1.17 \text{ km}\cdot\text{h}^{-1}$  and  $5.28 \pm 1.02 \text{ km}\cdot\text{h}^{-1}$  (mean  $\pm$  SD), the heart rates at the deflection point were  $165 \pm 20$  and  $171 \pm 13$ , respective to testing before and after the training period. The paired t-test did not prove significant differences between results obtained before and after training.

## Discussion

In preschool children the exercise training action on the cardiovascular system was evaluated by four criteria: (1) heart rate during exercise, (2) ratio of heart rate recovery to exercise intensity, and (3) anaerobic threshold assessed by heart rate deflection point.

During submaximal exercise, decreased heart rate is a usual result of training. This response was found also in preschool children when they exercised five times, but one, once weekly [18]. By our results, exercising three times weekly was ineffective. Therefore, if there was any positive effect of training on the cardiovascular system, heart rate during submaximal exercise was not sensitive enough to demonstrate it.

In the 1940s the use of the "sum of recovery pulses" (Erholungspulssumme) was proposed for evaluation of cardiovascular functional capacity [5, 10]. The Harvard step-test index consists in the ratio of exercise duration and the sum of heart beats during the second halves of the second, third and fourth postexercise minutes [3]. Later, the ratio of the sum of recovery pulses and exercise intensity was approved to be informative in assessing of functional capacity of the cardiovascular system [16, 17]. However, in preschool children it was impossible to demonstrate the training effect also by this index.

There are no serious doubts that aerobic working capacity as well as training effects on it can be detected by  $\dot{V}_{O_2\text{max}}$  and anaerobic threshold levels [13]. There are complications in assessment of  $\dot{V}_{O_2\text{max}}$  and anaerobic threshold in young children: (1) the actual level of  $\dot{V}_{O_2\text{max}}$  may be not reached due to poorly developed leg muscles, (2) invasive method necessary for proper assessment of anaerobic threshold can be used only in a limited number of children. Anyway, the obtained results show that systematical exercising did not increase the running velocity at anaerobic threshold. Thus, our results are in good accordance with the conclusion of previous stud-



ies [1, 4, 9, 14, 18] that in young children exercise training does not improve their aerobic possibilities. Positive changes in cardiovascular functions were also not established.

According to the results of a number of studies the lack of training effect on aerobic capacity does not exclude the improvement of running time in endurance exercises with training [1, 4, 9, 14, 18]. Obviously, this positive result was related to improved muscle coordination. Mechanical efficiency is rather low in young children [7]. When training improves the use of muscles during exercise, an elevation of mechanical efficiency warrants a possibility to utilize a higher part of  $\dot{V}O_{2\max}$ . Thereby endurance might improve without changes in  $\dot{V}O_{2\max}$  or anaerobic threshold.

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# CONNECTIONS BETWEEN NEUROMUSCULAR PERFORMANCE CHARACTERISTICS AND THE FEATURES OF THEIR MANIFESTATION IN 8-YEAR-OLD CHILDREN

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## Abstract

On the 7th–10th years of age favourable conditions emerge for the effective development of speed and explosive strength (power) production abilities. In the present study were observed 8-year-old schoolchildren who were divided into 2 groups (boys and girls). The indices of speed and explosive strength production ability and maximal muscular strength were recorded. It appeared from the study results that 8-year-old boys the development level of speed, explosive and maximal strength production ability is considerably higher than in girls of the same age.

From correlation analysis results it appeared that more numerous and stronger connections exist between the characteristics of explosive strength production ability and maximal running speed as well as between the characteristics of maximal muscle strength.

The growth of muscle strength on account of muscle hypertrophy and the morphological mechanisms ensuring it have not yet developed in children of this age.

**Key words:** neuromuscular performance, children, speed, maximal and explosive muscular strength

## Introduction

Movement activities of speed and explosive strength (power) character constitute the basic part of motion activity on the younger school age level [Ovsyankin, 1985]. The development of speed and explosive strength abilities has a considerable influence on the development of all motor abilities, possessing a positive impact on both the child's physical development and on the shaping of



movement skills [Filin, 1970; Stemmler, 1965].

Physical exercise developing speed and explosive strength adapt the child's organism for physical abilities in a more comprehensive and effective way than exercises developing only speed or maximal strength. On the basis of the morphological and functional development of the organism the physical activities of explosive strength character can produce a powerful stimulus in the overall development of the young organism and its improvement of functional abilities [Motylyanskaya, 1960].

Explosive strength abilities depend on muscle strength and the ability of neuromuscular system to carry out short-term muscle contractions. Morphological development of the central nervous system structures and muscular system attains by the 7th-8th years of age the level which creates favourable conditions for developing speed and explosive strength abilities.

The factors influencing the manifestation of maximal voluntary muscular strength in 8-14 years old children are first of all the improvement of the nervous regulation of muscle work and age development of muscle mass.

The aim of the present study was to establish the mutual connections of speed, maximal and explosive strength characteristics in 8-year-old children, as well as differences between boys and girls.

## Material and methods

**Subjects.** The subjects of the given study were 41 8-year-old boys (I group,  $n = 21$ ) and girls (II group,  $n = 20$ ) taking part in physical education lessons at school twice per week according to the corresponding curriculum. Data on the body weight and height of the subjects is presented in Table 1.

**Measurements.** The measurements were conducted in two stages. In the first stage the following speed and explosive strength indices were recorded in conditions of school sport facilities including:

- (1) 30 m sprint running;
- (2) standing broad jump;
- (3) pushing of a heavy (1 kg) ball from the breast.

Standard methods were applied in recording these characteristics.

In the course of the second stage (laboratory test) maximal strength of various muscle groups and jumping performance were dynamometrically recorder using a force platform sensitive to the vertical ground reaction force.

Maximal isometric two-leg extension strength (referred to as total legs strength) was measured with a knee angle of 110 degrees and hip angle of 120 degrees on leg dynamometric chair [Pääsuke,

Lemberg, 1989]. The subjects were told to produce on command a maximum force against the force platform placed under their feet.

**Maximal isometric knee extension strength** was measured with the knee and hip angles equal to 90 degrees and 110 degrees, respectively. An experimental knee extensors dynamometric chair was used [Pääsuke, Lemberg, 1989]. The force produced by isometric voluntary contractions of the right knee extensor muscles was measured with a strain gauge. An elastic strap was placed around the distal part of ankle above the malleoli and connected to the strain.

**Maximal isometric ankle plantarflexion strength** was measured using ankle plantarflexors dynamometric chair [Pääsuke, Lemberg, 1989], where the subject sat with the right leg mounted inside a metal frame and the foot strapped to an aluminium plate. The knees were kept at a right angle, while the ankle joint was dorsiflexed by 20 degrees. Maximal strength of plantarflexor muscles was recorded during maximum isometric voluntary contraction by pushing the foot plate.

**Maximal isometric strength of back muscles** was measured using the back dynamometer. The subject stood on the platform with the knees fully extended and the head and trunk erect. The handbar was grasped using a pronated (right hand) and supinated (left hand) grip. The handbar was positioned across the thighs and, without leaning backward, the subject pulled it straight upward using the back muscles.

**Vertical counter-movement jump (CMJ)** from a standing position was performed on a force platform (75 × 75 cm). The hands were kept on the hips throughout the jump. The vertical groundreaction force developed during the jump performance, take-off time and flight-time gave the basis for calculation of the following mechanical parameters:

- (1) height of vertical jump (height of rise of the center of gravity);
- (2) net impulse during take-off;
- (3) power production during take-off;
- (4) rate of maximum force development during take-off.

On recording all the indices the test was first demonstrated, accompanied by oral explanations and trial tests were conducted. Followingly, the subject conducted three tests, the best result (absolute result) was used.

**Statistical analysis.** The means and standard errors (mean ± SE) of the variables and the correlation between them ( $r$ ) were calculated. Differences between the mean values of two groups of subjects were tested for significance by Student's  $t$ -test. A significance of  $P < 0.05$  was accepted.

## Results

The recorded anthropometric, speed, explosive strength and jumping performance parameters are presented in Table 1.

Table 1

Anthropometric, speed and explosive strength characteristics of the studied groups (mean  $\pm$  SE)

Characteristics	Groups		P
	Girls (n = 20)	Boys (n = 21)	
Body height (cm)	134.1 $\pm$ 1.1	135.1 $\pm$ 1.4	> 0.05
Body weight (kg)	28.6 $\pm$ 1.3	31.5 $\pm$ 1.4	< 0.05
30 m sprint (s)	7.13 $\pm$ 0.70	6.92 $\pm$ 0.70	< 0.05
Standing broad jump (cm)	132.2 $\pm$ 2.7	148.3 $\pm$ 3.4	< 0.05
Pushing of heavy ball (cm)	230.7 $\pm$ 7.9	303.1 $\pm$ 15.0	< 0.05
Vertical jumping height (cm)	18.5 $\pm$ 0.5	21.6 $\pm$ 0.8	<0.05
Net impulse during take-off (Nxs)	8888.2 $\pm$ 311.3	14413.0 $\pm$ 4681.9	< 0.05
Power during take-off (W)	191.3 $\pm$ 26.4	189.4 $\pm$ 16.5	> 0.05
Rate of maximum force during take-off (N/s)	3251.8 $\pm$ 397.2	4304.1 $\pm$ 427.1	< 0.05

As can be seen in Table 1, the indices of 8-year-old boys surpass the corresponding indices of same-aged girls. Differences between the groups concerning the recorded characteristics are statistically significant, the only exception being the power during take-off in vertical jump, the mean value of which is not statistically significant.

The recorded maximal voluntary strength characteristics are presented in Table 2.

There is a statistically significant difference between groups concerning all indices of maximum strength. The maximum muscular strength characteristics of 8-year-old boys are considerably higher than the corresponding indices of same-aged girls.

The correlative analysis results of the recorded characteristics are presented in Fig. 1. As can be seen, maximal running speed has



Table 2

**Maximal voluntary strength characteristics of the studied groups  
(mean  $\pm$  SE)**

Characteristics	Groups		P
	Girls	Boys	
Knee extension strength (kG)	18.3 $\pm$ 0.7	22.1 $\pm$ 0.7	< 0.05
Ankle plantarflexion strength (kG)	24.4 $\pm$ 2.2	31.7 $\pm$ 2.2	< 0.05
Two-leg extension strength (kG)	141.6 $\pm$ 6.3	160.7 $\pm$ 4.6	< 0.05
Back muscles strength (kG)	43.2 $\pm$ 3.3	57.3 $\pm$ 4.0	< 0.05

stronger correlative connections ( $p < 0.05$ ) with the following children's explosive strength indices: standing broad jump ( $r = -0.81$ ), height of vertical jump ( $r = -0.53$ ) and heavy ball pushing ( $r = 0.59$ ). The 30 m sprint running result possessed several strong correlative connections also with maximal muscle strength indices: two-leg extension strength ( $r = -0.59$ ) and ankle plantarflexion strength ( $r = -0.66$ ).

Standing broad jump, belonging to the most widespread leg explosive strength characteristics, possesses several statistically significant correlative connections with maximal muscle strength indices: two-leg extension strength ( $r = 0.48$ ), pushing of the heavy ball ( $r = 0.69$ ).

The dynamographic indices of the vertical contra-movement jump make up a separate correlation group that reflect the specific character of these indices. In this way statistically significant correlative connection emerged only in the power during take-off: height of rise of the center of gravity ( $r = 0.64$ ).

## Discussion

As is generally known, the differences between boys and girls in speed, maximal and explosive strength abilities possess certain specific features connected with the peculiarities of the age-gender structures of the developing organism [Stemmler, 1965; Crasselt, Forchel, 1985].

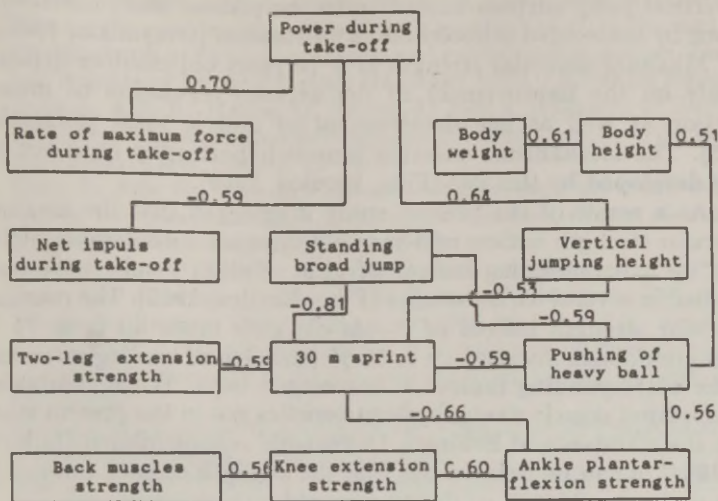


Figure 1. Correlation coefficients between recorded characteristics.

Manifestation of movement speed is connected with the factors of the central nervous system level on the one hand, and of the muscular apparatus level on the other hand. As a result of the given work it emerged that the difference in movement speed between the groups of 8-year-old boys and girls was statistically significant.

Differences in maximal running speed between boys and girls appear already by the 5th-6th years of age [Vrijens, 1978]. At the same time it has also been noted that up to the 13th years of age no differences exist between the maximal running speed of boys and girls [Silla, Teoste, 1989]. The results of 30 m sprint running recorded in the given study correspond to the present standards in both boys and girls [Loko et al., 1984].

Statistically significant differences between the studied groups also emerged in explosive strength indices. The biggest mean value differences appeared in the indices of heavy ball pushing and standing broad jump; the smallest corresponding differences, however, in the indices of vertical jump. When comparing the explosive strength characteristics got in the present study with the standards worked out on measuring Estonian schoolchildren [Loko et al., 1973, 1984], it can be pointed out that the explosive strength characteristics shown by both boys and girls make up 85-95 % of the standard results of 10-year-old children.

The differences are smaller in explosive strength results of heavy ball pushing, bigger in the results of standing broad jump. The results

of vertical jump surpass according to the present study the results shown by same-aged schoolchildren of Russian [Ovsyankin, 1985].

Maximal muscular strength in 8-10 years old children depends mainly on the improvement of the nervous regulation of muscle function as well as age development of muscle mass [Stemmler, 1965]. The mechanisms ensuring muscle hypertrophy have not yet fully developed by this age [Filin, Kurilov, 1969].

As a result of the present study it emerged that the maximal muscular strength indices of 8-year-old boys are considerably higher than the corresponding indices of girls. Similar results have been attained in several earlier studies [Filin, Kurilov, 1969]. The maximal muscular strength indices of 8-year-old girls made up from 75 % (strength of back muscles) up to 88 % (strength of two-leg extension) of the corresponding indices of same-aged boys. When comparing the maximal muscle strength characteristics got in the present study with the standards of Estonian 10-year-old schoolchildren [Loko et al., 1984], it can be pointed out that the strength of back muscles of girls makes up 86.2 % of the 10-year-old girls standard.

When comparing the maximal muscular strength indices of the boys participating in the present study with results got in previous studies [Filin, Kurilov, 1969; Loko et al., 1984], it can be observed that the maximal strength of back muscles makes up 86-94 % of the corresponding index of 10-year-old boys.

The dynamographic characteristics of vertical jump in girls surpass the results of Russian same-aged schoolchildren. In boys, however, the corresponding indices are lower than those shown by Russian schoolchildren [Ovsyankin, 1985]. Only the net impulse during take-off vertical jump surpasses in boys participating in the present study the corresponding index of the above mentioned study by 20-28 %.

In the present study maximal running speed has stronger correlations with the following children's explosive strength indices: standing broad jump, height of vertical jump and heavy ball pushing. Strong correlative connections between maximal running speed and explosive strength indices in all age groups of children are confirmed by other studies on the related topic [Filin, Kurilov, 1969; Filin, 1970; Guzalovsky, 1977].

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# STUDENTS OPINION ABOUT PHYSICAL EDUCATION

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## Abstract

The Estonian Agricultural University's Department of Physical Culture carried out a questioning among students. The object was to clear up their opinion about physical training in the innovated educational system. We tried to investigate what kind of concrete change ought to be realized at physical education classes.

**Key words:** physical education, students.

## Introduction

Research works on physical training in the former USSR usually deal with certain questions: how many students go in for physical culture, in what year, how the leisure time is spent etc. Male and female students are explored separately. The question about social activity and its connectedness with physical culture is not left out. Unfortunately, the reasons why so few students go in for physical education, or why their leisure time is not used for sportive activity, are almost not explained.

Questionings in high schools of Byelorussia show that students have lectures 50–60 hours a week. For leisure time remains 38–45 hours a week. Most of it is used for reading (50 %) and for going to the cinema. Sport is the seventh of nine entertainments. Concerts of classical music are in the last place [9].

According to Reizin [9, 11], at Byelorussian universities students go in for sport 8 hours a week. The recommendable physical activity might be 10–12 hours a week. In pedagogical high schools of Byelorussia the numbers were even smaller: I year students — 4.8 hours a week, IV year students — 2.4 hours a week.

According to Nazarov [5], 2–4 hours a week are spent on physical activity, according to Akimova [1], women — 0.7 hours, men — 0.8 hours a week.

Students go in for sports games (31 %), swimming (11 %), tourism (10 %), gymnastics (9 %), running (9 %), skiing (7 %) and cycling (3 %) [13]. There is no free time to go in for anything else (32 %). A little exactingness towards oneself is troubling (33 %) [4, 9, 11, 16].

The tension of sessional work, specially during examinations, makes higher demands on the organism. The American scientist Prebram expressed his opinion about the direct connection between the strength of emotional reactions and of vegetative reactions. It is observed that after an examination the ability to work falls by 10-15 % and body weight by 2-3 kg [by 9].

Reizin and Istchenko [9] found a mean pulse rate of 109 beats per minute during examination. The highest value was 144 beats per minute. Volkind [19] got the same results in his research. The heart rate of sportsmen during examination was 65 beats per minute, of nonsportsmen — 112 beats per minute.

According to Oplavin [7] the mental ability to work diminished by the end of the first term 40 %, by spring 70 %.

Interesting and useful arrangements were made in GDR during the III reform of higher education [10], which was carried out at the beginning of 1970s. During this the programme of physical training was levelled, an experimental system of personality appraisal of the students was rooted in, the number of examinations was diminished. The norms of physical training were revised and a minimal number of norms were kept. Competitions between different study groups of students were carried out. In some competitions elements of estrade and show were used to raise the emotionality of sportsmen and spectators. Also the systems of competition were complemented.

In all higher educational institutions a commission was brought into being on the level of the Rector's Office, to control the situation of physical training and make perspective plans.

## Methods

We carried out an anonymous questioning. There were 920 answerers, 701 boys and 219 girls, from among first to thirdyear university students. The questionnaire contained 16 questions about the problems of physical education and sports.

The basic problems were:

1. Why do students take part in physical education classes;
2. How to organize sessional work expediently, what is the most suitable time for the classes;
3. What kind should the relations be between theoretical and practical classes;



4. What kind of preparation do the students have before entering the university (in their opinion);

5. What kind of sports ought to be developed at the university;

6. How to carry out competitions and how to prepare the selected teams;

7. Which are the most unpleasant problems in connection with physical education.

Among other things it was asked what the program of physical education should be like. As these students were not specialists, the answers were rather subjective.

## Results

There is good reason to believe that the answers are objective and indicate the actual situation of physical education.

83.8 % of males and 84.7 % of females answered that physical education is necessary. Students said that these lessons were good for developing their physical abilities and health (33.8 % of males, 33.1 % of females).

There is a large number of students who attend physical education classes only in order to pass the end-of-term test (26.8 % of males, 20.8 % of females).

Students prefer to play sports games (50.8 % of males, 33.8 % of females).

The goal is general physical fitness (9.9 % of males, 29.3 % of females).

36.8 % of males and 37.3 % of females would like to practice different sports.

In the students opinion, 90-min classes ought to take place twice a week (46.2 % of males, 54.4 % of females).

17.1 % of males and 8.9 % of females would like to attend classes 3-4 times a week.

To the question in which year of their university studies the physical education classes should take place, 34.2 % of males and 36.2 % of females answered that the classes ought to take place throughout their studies.

26.3 % of males and 17.2 % of females would like to attend the classes in their first and second year.

19.7 % of males and 17.2 % of females would like to train in their first to third year.

Before entering the University, physical preparation was:

very good	— 5.8 % of males, 4.5 % of females
good	— 26.4 % of males, 14.6 % of females
fair	— 52.8 % of males, 65.2 % of females

poor — 15.0 % of males, 15.7 % of females.

81.4 % of males and 85.4 % of females answered that it is necessary to organize competitions and performances. Students prefer athletics, basketball, volleyball, wrestling, skiing, gymnastics.

Let us observe the questions about the program and the disturbing circumstances.

The main factors were:

1. Too big groups (54.6 % of males, 24.4 % of females).
2. Poor sports equipment (21.7 % of males and 29.8 % of females).
3. Poor sports facilities (20.7 % of males, 38.2 % of females).
4. Monotonous classes (3.0 % of males, 3.0 of females).

## Discussion

The research was carried out at the time when in Estonia there was a tendency to abolishing physical training. In some higher schools (Tartu University, The Tallinn Conservatoire) it had taken place. We wanted to know the opinion of students, because it was an agricultural higher school.

The students attitude towards physical training was surprisingly positive. At the same time it is astonishing that students considered their physical preparation, before entering the higher school, quite weak. Researches [11, 13, 14, 17] show that already little regular physical load calls forth rather extensive positive shifts. It seems that there are deficiencies at the elementary stage (from kindergarten until the end of secondary school) of physical training of the youth. As the elementary stages have not been studied complexly, the reasons can not be brought out clearly.

As sessional work makes high demands both on mental life and on the organism as a whole, physical training should be the most obtainable means of strengthening health and mental life for students [3, 6, 15, 16].

Low awareness and economic conditions do not enable the students to use sports facilities for money. The sports interests and hygiene habits acquired in youth, remain the same all throughout life. Especially from this aspect it is difficult to overestimate the importance of physical training.

In arranging sessional work, not enough attention is given to ball-games. In the former Soviet Union students have been interested in ball-games most of all [2, 8, 9, 14, 16, 17, 18].

There are shartages in organizing competitions in higher schools, also some norms should be revised and revaluated [12, 14, 16].

## Conclusions

Analyzing the answers, six essential conclusions, which might be taken into consideration in arranging the studies, can be brought out.

1. There should be obligatory physical education classes in the 1-st to 2-nd year, optional physical education classes in the beginning of the III year.

2. Optional lessons ought to be included in the curriculum, until now they were not.

3. The classes ought to take place twice a week and in the mornings, at 8-10 o'clock, or in the afternoon, beginning at 14 o'clock.

4. Championship competitions should be organized in the future too.

5. Some students would like to develop their mastery. It must be available to them at their University.

6. Greater part of the students are of the opinion that their physical level is fair. There is a point of view that in the case of lacking physical training, the level of physical abilities by the end of the studies falls noticeably.

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# HEALTH EDUCATION IN THE NÕMME CHILDREN'S HOSPITAL

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## Abstract

Positive changes in the attitude to health education and health promotion are being noticed among parents.

At the Nõmme Children's Hospital physical activity groups for children from 1 month to 15 years old were organized: a baby swimming group, a family swimming group, a complex activities group for girls, a special group for overweight children and neurologically ill children.

All parents answered questionnaires about the child's development, parents activity and their own awareness about risk factors of diseases. Children have had health visits and some functional diagnostic tests twice a year.

In the 1991/92 season 2/3 of children suffered from several illnesses. The overweight children had retardation of sexual maturity 10-20 times more often than the children with normal weight. Neurological symptoms were mostly connected with intrauterine reasons.

Health education and health promotion from the early childhood is possible only by team work (psychologist, physical education teacher, paediatrician, parents).

**Key words:** Health education, physical activity, parents knowledge about children's development.

## Introduction

Hypodynamics was found 56.8 % of the 6490 schoolchildren questioned in Estonia.

The prevalence of hypodynamics and risk factors of noncommunicable diseases are high in Estonia and show a tendency of going up.

In addition to the above-given reasons, the newly independent Estonia has some others:

- 1) parents are not oriented to children's physical activity as a guarantee of physical well-being;
- 2) there is a lack of possibilities for large-scale participation in physical activity groups.

In 1987 in the Nõmme Children's Hospital a health education programme for parents and children named "Healthy Estonian Child" was started.

The aim of the programme was:

- 1) to provoke interest in physical activity;
- 2) to rise the skills of physical activity;
- 3) to avoke in children and their parents durable physical activity habits;
- 4) to evaluate the dynamics of well-being and health status in connection with physical training;
- 5) to improve children's health through physical training and decrease some illnesses;
- 6) health education for parents.

The far-reaching aim of the programme was to improve the health of future parents and the birth of a healthier generation.

From the beginning of the programme it was clear that the aims number 1, 2, 4, could be achieved in a shorter time than the aims number 3, 5, 6.

The physical activity groups were as follows:

- 1) 6-11-year-old girls;
- 2) babies;
- 3) infants;
- 4) overweight children;
- 5) children with minimal cerebral dysfunction;
- 6) children with scoliosis;
- 7) parents.

In the 5 years more than 4 000 children took part in the physical activity group. 1/3 of them participated 3 or more years, 65 % of all took part in regular training.

The main aim of this work is

- 1) to give a general review of the health education "teamworks" that takes place at the Nõmme children's hospital;
- 2) summarize the work done in developing the mental life on children with neurological disturbances;
- 3) to give the results of a treadmill test for 4 to 5-year-old girls;
- 4) to give the results of two questionnaires carried out among the parents:

4.1. Awareness of the influence of the environmental condition on the human health;



## 4.2. Parents knowledge about children's development and care.

### 1. General review of the work done in the sphere of health education

The concept of health, sickness and health education have changed and will change even more in connection with the development of sciences and the changes taking place in society. Health is not defined as an absence of sickness anymore, but it is estimated as a condition of physical, psychological and social well-being. At the same time health is valued as an inner ability, instrument or resource.

In the last years we have started to talk about health in a positive way, leading people to take responsibility for their own health. This enables us to create favourable conditions for the growth of health and development of our environment, society and an individual's life.

The aim of the group of scientists work (GSW) in the Nõmme Children's Hospital is to strengthen the child's organism and to develop it through physical exercises.

A purposeful participation of parents in health creation is a precondition for reaching the posed aim. We think that the effect of teaching people a healthy lifestyle depends entirely on the effort of parents, teachers, psychologists and medical workers [2, 10, 12, 14].

In the GSW, children from some months to 15 years of age take part. The main trends of physical education are: the swimming of sucklings, family swimming with a child of 1-6 years, complex activities of girls, groups for overweight children and children with nervous disturbances.

Parents join the group of scientific work voluntarily, paying a symbolic fee. All the parents are asked to fill in questionnaires (questionnaire about the social, demographic and environmental risk factors, questionnaire about the child's development and tutelage). The children pass obligatory health visits for filling in a formalized medical card, the frequency and number of which we have proceeded from the system of health control in the U.S.A.. A health visit to a pediatrician takes place 1 to 2 times a month for children under the age of two, twice a year for children aged from 2 to 6 and once a year for children up to 15 years of age.

Estimation of the results of physical activity in every child takes place at least once a month (according to pulse rate) and is accompanied by a complex functional diagnostics at the beginning and at the end of the cycle of activities.

Generalizing the health conditions of children participating in

the program in 1991/92 we can state that 1/3 of them were healthy and the other 2/3 had health disorders.

Out of the 133 children of the first three years of life, 6 % were premature, 33 % had parturition (delivery) pathologies, 17.2 % had neurological disturbances (hypo- or hypertension syndromes), 39 % had allergic conditions. The number of children often ailing made up 9 %, those with eye-diseases 6 % and with disturbances of the digestive tract 7.5 % of all.

Regardless of the quite high frequency of unhealthy conditions the motoric, manual development and development of speech of children to the DDST (Denver Developmental Screening Test) was constant with age.

In the groups of children of ages from 3 to 7 who attended family swimming, unhealthy conditions were the following: frequent ailing (12 %), neurosis and allergic dermatitis (both 7.7 %), changes following parturition injuries (4.2 %), orthopedic disturbances (9.4 %). After a year of activities, in 40-100 % of children an improvement of health could be noticed.

The children (aged 4-11 years) attending the girls complex activities group were in 1991/92 in addition to the traditional researches taken through an estimation of their physical abilities with tests of physical exercises.

The number of children in a good and healthy condition made up 1/3. In children participating in the health groups for the second or third year (33 %) we could notice a vanishing of orthopedic pathologies in 1/4 of the cases.

The younger the child the less the informative are the instrumental functional diagnostics. This is caused by the imperfection of the apparatus we have in our possession. To estimate the endurance of physical burden of the coronary vessels we used the equivalent metabolic units (EMU-s) to show the results; it was easier and more informative starting from the age of five. Only one adipose boy who attended the group for overweight children had his endurance of coronary vessels of a physical burden constant with his age. We were also convinced that the only possibility to test the physical abilities of preschool children and children of the first grades is to adjust the tests generally used to the corresponding age groups. Testing at the end and at the beginning of the cycle of activities gives us an informative estimation of the dynamics of the level of physical abilities.

Overweight children and children with neurological pathologies have more serious disturbances and need more thorough studies and more intensive teamwork.

The causes of nervous disturbances of children were the maternal conditions and the diseases the child had suffered from. As

a rule the children had orthopedic deviations or they ailed quite often. According to the findings of neurological focals the children had spasticity caused by cerebral paralysis [5], neurosis [8] and retention of mental development [1]. One of the specific features of a neurologist is a strictly individual cooperation with the parents and a close cooperation with the teacher of swimming and gymnastics and protractedness of the results.

Overweight is considered to be a frequent unwholesome condition. Such condition is often connected with a danger of coronary diseases or development of diabetes. Pediatricians have taken less notice of the sexual development of children in cases of overweight.

According to the data found in literature, 53–81 % of overweight grown-ups (adults) have serious disturbances in the sexual sphere.

Among the 78 overweight and adipose children in 52.7 % an acceleration of height over 95 % of the centile line was discovered. The development of mammary glands of the girls was delayed by one year on the average; 19.1 % of the girls had disturbances with their menstrual cycle. The boys had anthropometrical dislocations of genitals 43.3 % and cryptorchism six times more often than the children of normal weight. 9 % of the children had a retention of growth. In comparison to the children of normal weight the overweight girls and boys had disturbances of sexual development 10–20 times more often (accordingly 2.1 %, 19.1 % and 43.3 %), which fact usually is not diagnosed by the pediatrician. The only way of prophylaxis and at the very beginning also the treatment of sexual disturbances is a timely ethiological and pathogenetical treatment of overweight and adiposity in an early childhood, which consists in a diet cure combined with regular physical activity.

According to the data found in literature obese children are less accepted by their peer group, have low self-esteem and poor body image. The social isolation of such children from normal physical activity, lack of involvement and limited success in the movement setting can translate into a vicious cycle of inactivity, greater obesity and continued inactivity [1].

Thanks to the psychologists taking part in the groups of GSW we have got psychological help (especially important to the overweight children and their parents). The methodical materials published have been a great help in the domestic activities of parents.

In 1991/92 we have carried out education days, seminars and individual consultations with the parents. Thanks to the Finnish (Jyväskylä, Helsinki) health educators we have got instructional films, materials and literature for that purpose.

Thus — we have to start with health education and health creation from the early childhood. It is quite possible to carry it out by teamwork even in our present conditions.



## **2. About the work of developing children with neurological disturbances**

Mainly 14 children (2 girls and 12 boys) participated in the work-group of children with neurological troubles. As the main causes of disturbances the children had been given injuries during pregnancy or parturition (10 times), and diseases damaging the nervous system (3 times). There were no hereditary diseases of the nervous system. 6 children had problems with carriage, 2 of them had flat feet, 3 of them had chronic tonsillitis, 4 had frequent catarrhs of the upper respiratory organs (more than 4 times a year) and two children had bronchitis more than 2 times a year). Three children had the 1st level of spasticity caused by the PCI syndrome; 2 children had troubles with coordination and balance; 1 child had a retention of mental development and underdevelopment of speech; 8 children had a neurosis: fits of fright 3, stammer 1, functional ticks 1, enuresis 2 children [4].

The children of this group went in for gymnastics and swimming. According to the data found in literature, physical activity also seems to contribute to the child's neurological maturity and readiness for school [12]. In addition to that, H. Oja occupied himself once a week with the development of the children's mental life.

### **2.1. On development of mental life of children with neurological disturbances**

During two seasons an attempt has been made also to develop the mental abilities and manual skills of children with neurological disturbances in addition to swimming and gymnastics.

In 1990/91 there were 14 children aged 4 to 6 in the training group. In 1991/92 the group consisted of 13 children aged 5 to 7 in both years.

In autumn the level of mental and manual development of the children was fixed. It turned out that the children differed a lot in their abilities. Some children fell behind in manual skill and coordination in the first place, the other children had problems mainly with their volition, behaviour and attention.

As the children were of different level of development, the regular work with them was carried out individually or in pairs. 45 minutes were spent on each child on the average of twice a month.

The main aims of the work as follows:

1) to develop attention, perception, intellectual power, speech and other physical processes as well as manual skill, speed and coordination of the children;

2) to teach the parents different simple exercises they could use at home in order to train their pre-school children.

The children who regularly took part in the work of the training group acquired better steadiness and also developed their wish to strain themselves mentally. Attention, concentration, utterance and comprehension of verbal orders improved as well. We can say that the children have acquired abilities they will need later on for successful studies at school.

There arose some difficulties with the children whose parents did not understand the necessity of purposeful development of their children, who could not find time and had no desire to occupy themselves with their children. Therefore the development of those children remained more conservative than expected.

### **3. Treadmill test results of 4-5-year-old girls attending the complex activities group**

As we have not found any treadmill test results of children under the age of 7 in literature, the aim of the present work was to study the durability of coronary vessels to a physical load of 19 girls of the age of 4 to 5 attending the complex activities group through a treadmill test. The scheme of research envisaged: 1) to measure the pulse rate and blood pressure of the subjects of investigation in a resting condition; 2) to let the child fulfil the 1st load, that is walk on the treadmill for 3 minutes at a quick pace chosen by the child; 3) to let the child fulfil the 2nd load; that is, to run on the treadmill for 3 minutes at a quick pace chosen by the child; 4) during the last 10 seconds of the last and 2nd load to measure the pulse rate of the child with a pulse tester; 5) to estimate the rehabilitation reaction of the child's coronary vessels by measuring blood pressure and pulse rate until a total rehabilitation, that is, until the values of the resting condition are restored (in 5 minutes).

The girls investigated could be divided into two groups according to their participation in complex activities: 1st group — 5 girls, who attended the group of complex activities for the second year, 2nd group — 14 girls who attended the complex activities for the first year. All the girls were on the treadmill for the first time and had no previous experience with it.

Before the beginning of the research the children were all given the same instructions and it was done quite thoroughly. The tasks were explained and then checked if they were understood. After that the experiments on treadmill began. With the 1st load the child had to begin to walk at a slow pace, then according to the child's adjustments, the treadmill was switched to a quicker pace and

the child had to continue the work for 3 minutes. Before starting the 2nd load the child was asked: "Shall we go on running" and "Are you afraid?" When the child agreed to go on running, then the experiment went on at the speed chosen by the child. At the same time there was a previous agreement with the child that when she cannot run any more, she will say so and the treadmill will be stopped.

## Results

To the 1st group belonged 5 girls. All of them could cope well with the task given to them. They did not have any difficulties in changing their speed of moving. Four of the girls chose a speed higher than 4 km/h. They adjusted very well to the changes in the speed of the treadmill. All girls of the 1st group could manage well to run with their chosen speed for 3 minutes. In doing so the maximum pulse rate of 4 girls was more than 160 beats/min and of one girl, 150 beats/min. Rehabilitation took them 1-3 minutes. The type of rehabilitation reaction was hypotonical.

4 children of the 1st group could stand the physical burden of 3-5 EMUs (equivalent metabolic units). This tells us about the small endurability of burden of the coronary vessels. In the given group only one child was able to run on the level of load of 5-7 EMUs, which characterizes the average level of endurability of burden of coronary vessels. We can assume that this child had attended more regular trainings and in comparison to other children, more times a week (the trainer's child). The data given lets us assume that 3 trainings a week used in complex activities are not enough to develop a physical endurability.

The second group investigated was made up on 14 children who attended the trainings for the first season. They has serious difficulties in undergoing the treadmill test. It became apparent that the children had difficulties with social adjustment, they were afraid, especially of running. Only 3 children chose their speed of walking at 4 km/h, the rest started at a more reserved pace (1.6-3.6 km/h). There were especially many difficulties with the transition to running regime. So 6 children only walked on the treadmill; they refused to run as they were afraid of running, simply afraid etc. Only 3 girls of the 2nd group were brave enough to run on the treadmill for 3 minutes (2 of them at 6.7 km/h or 6.4 km/h). The rest of the children started to run but they went on for only 1-1.5 minutes, then they stopped. On doing so we could not observe any clinical symptoms of fatigue. The pulse rate was restored in 1-3 minutes. The rehabilitation reaction was hypotonical or there were no changes



of blood pressure due to the physical load.

During our research we could notice distinct differences in the behaviour and activities of the children of the 1st and 2nd groups. The children of the 1st group were more courageous and sensible. They showed real willingness when fulfilling their tasks, also fulfilled them at once. They did not have any apparent fright, hesitation or excitement. In addition their speed of walking and running was higher than in the 2nd group and they could choose a speed suitable from them.

The children of the 2nd group were not able to make efforts and they had difficulties with physical and social adjustment. They said several times that they are afraid, etc.

We can assume, that the children of the 1st group, who had participated in physical activities longer than the children of the 2nd group, had acquired some experience of physical training and as a result had grown more independent and courageous. They were more disciplined and sure of themselves. The earlier researches have clearly brought out that regular training and physical activities have a positive influence on the independence, activity, creativeness, courage, discipline and responsibility of children [5, 6, 7, 8, 9].

### Conclusions

It is not possible to estimate the endurability of physical burden of coronary vessels of children of 4 to 5 years according to our records when they have not participated in physical training.

In the complex activities of girls aged 4 to 5 they develop their motories, stabilize their central nervous system (the child can make himself do something), that also creates a basis for development of physical endurability and for studying it.

#### 4. The results of questionnaires carried out among parents

##### 4.1. Awareness of the influence of environmental conditions on the human health

The opinions of specialists about the damaging effects of environment on the human organism are of decisive importance when making decisions about the nations health. We have learned a lot of the populations concern about the pollution of environment, the chemicalization of everyday life and the damaging influence of big factories and plants, when carrying out epidemiological researches [11, 15, 16]. The opinion of a population about the damages to the

environment is usually compared to the opinion of a specialist while the latter is considered to the so-called criterion of truth.

At the present time we do not have information about the possible factors damaging to health at a concrete location available to everybody, we also lack an everyday environment-sparing behaviour both of the management of big plants and of housewives. In literature we can find references to under- and overestimations of environment damages coming from big factories, also the sense of danger in connection with the risk of environment among persons of different ages and sexes.

Those circumstances made the group of scientific work of the Nõmme Children's Hospital carry out an interrogation about the known risk factors of the environment and their influence on people's health. To build up the questionnaire we used the materials of J. Tikkanen and others published in literature [15].

200 persons answered the questionnaire, among them the number of women was 131 (65.5 %) and of men 69 (34.5 %). The number of children aged 10–15 among the respondents was 108 (54.0 %), 63 of them were girls and 45 boys; youngsters aged from 16 to 20 were seven (3.5 %), 6 of them girls and one a young man. The number of adults aged from 21 to 50 among the respondents was 70 (35.0 %), 49 of them were women and 21 men. There were 28 persons who were over the age of fifty (14.0 %), 13 of them were women (6.5 %) and 15 men (7.5 %). Most of the people lived in town (93 %), the rest were born in the country (7.0 %).

Analysing the attitudes toward the known risk factors of environment we can say that about 1/3 of respondents considered drinking half a litre of wine, 16 km of cycling and spending a couple of days in a big city to be dangerous on the average. About 3/4 (73.5 %) considered a long-time or life-time living within 8 km of a nuclear reactor to be very dangerous. Cohabitation with a smoker was considered to be dangerous or very dangerous by 79 % of respondents. Analogously with the data given in literature, women realize bigger risks in the situations given above than men (in most cases 1.5–2 times).

Questions about the influences of environment that are damaging to health, concerned the connections between the depletion of ozone, pollution of air and allergies and skin inflammations; the influences of radon that causes cancer, etc. When 59.0 % of the respondents thought that the depletion of ozone can cause skin cancer (32.5 % of women and 20.5 % of men), then 40.5 % could not express their opinion of this problem. Close by were the answers about radon in the air of flats and the causes of skin cancer. The direct connections between the disturbances in the consistence of air, mould and fungi in flats and allergic symptoms and inflammation

processes of children, were known better, as 83 % of the respondents answered affirmatively (56.5 % of women and 26.5 % of men). 64.5 % of the respondents were aware of the fact that formaldehyde in the air can cause burning in the eyes and headache, but the affirmative answer was given 2.3 times more often by women than by men. The role of nickel in causes of allergical reactions of skin was less known — 56.0 % answered affirmatively, 1/3 could not answer this question.

Almost all the respondents were aware of the damaging influences of a high level of noise (90.0 %). It was good to see that most of the respondents were aware of the connection between the parents smoking and the frequency of cancer of their children (80.0 %), here, too, women confirmed this fact two times more often than men. Only 41.5 % of the respondents knew about the vitamin A damaging affect on embryos — fact generally known in foreign literature.

From an interrogation about the attitudes to the environment damaging to our health, we learned that especially troubling was the pollution of air, water and earth (accordingly 97.5 %; 99.0 %; 89.0 %) and the addition of nuclear danger (84.5 %). A little less of danger was seen in the addition of waste and the increase of noise where 79.0 % and 62.5 % of respondents gave an affirmative answer.

Of the chemical and physical factors weakening health that occur in flats, the most often mentioned were noise (72.0 %), dust coming from the outside (78.0 %), pollution of outer air (84.0 %), dryness and dampness (57.0 %), draughts (62.0 %), tobacco smoke (76.5 %), mildew or fungi (66.0 %), darkness (39.9 %), and other (10.5 %). In these questions women also gave an affirmative answer averagely 2 times more often than men.

We tried to learn how people could interfere with their activities into the problems of environment. A discussion about the healthy environment with friends was considered to be useful by 49.0 % of respondents, 11.0 % denied such a need. Getting acquainted with the problems of environment through newspapers was considered to be important by 62.5 % of respondents, through radio and television by 65.5 %. 79.5 % of people demanded bigger attention to destroying waste and 62.5 % had considered joining groups of nature protection. The same number of respondents said yes to a necessity to join the work of a health commission to protect the environment. Seeing a doctor or undergoing a laboratory research in connection with the influences of environment was considered to be useful for health by 51.0 % of respondents. The most often expressed wishes for improving the healthiness of environment were the following: conclusions of new international agreements 73.5 %; passing of laws of environment protection (82.5 %); addition of education of environment protection to the schedules of primary,



secondary and higher schools (78.0 %); education of doctors in the field of environment protection (70.0 %); addition resources to the researches on health and environment (78.5 %).

By way of summarizing we can say that both young and middle-aged people know relatively well the factors of environment that can cause damage to a person's health. Women are more concerned about the damaging influences of the environment. The level of development of a society determines in a way the attitudes to one or another risk factor. People have a somewhat greater belief (confidence) in social institutions than in their own activities.

#### 4.2. Parents' knowledge about children's development and care

The aim of the present research was, on the one hand, an attempt to elevate the knowledge of parents, and on the other hand, a desire to clear up the spheres where the knowledge of parents needs to be increased. To solve this problem we composed a questionnaire of 38 questions. Before every group of questions we brought out some basic statements characterizing the child's development.

The questionnaire was answered by 75 parents, who were all (with a couple of exceptions) mothers.

We were glad to see that to all the question concerning the normal development of the spinal column and its deformation-causing factors in children of different ages, most of the parents gave the right answers (93.3 %). But amazing was the fact that 28 persons were doubtful whether strong muscles can help to avoid the deformation of the spinal column.

42 of parents had trained the muscles of the child more or less enough, 18 parents had given it little notice and 15 had done it only occasionally.

Most of the parents considered sitting up and sitting in a pram with a soft backing too early to be damaging. At the same time we were amazed at some parents' opinion that it is damaging to carry a baby in a special back or abdominal bag (26 out of 75).

Most of the parents were of the opinion that their child gets enough sleep at night (81.3 %) and their sleep is peaceful without waking up (73 %) and that their children get up in the morning alert and agile. The parents were quite well informed that frequent evidences of tiredness can damage the child's nervous system (68.0 %), but 10 persons were sure it will not have any bad influences.

Almost all the parents have quite correctly agreed that the children's food has to be fresh and warm and also chopped up for infants, except 10 of them who were not too sure of it. Quite a lot of parents were of attitude that children ought to eat at a fixed

time, the rest could not say anything about it or just were not quite sure. Only 43 parents suggested that the food should be served appetizingly, the rest did not consider it to be important. Herewith a number of parents have the correct attitude that a child must eat often and in small quantities, not seldom and a big quantity at a time (49), that is 65.5 %; 19 parents were of the opinion that the child should eat as much as he (she) likes and whatever he (she) wants, the main thing being that he (she) eats.

The knowledge of a lot of parents about the foodstuffs rich in minerals was quite reserved. Only 14 gave the right opinion that there are some in vegetables. Correctly was given the existence of minerals in milk, meat, liver. It was really surprising that in 32 cases lemonade, biscuits, sweets, soda water, fanta and mineral water were considered to be the sources of minerals.

The data we got made it quite obvious that there is quite a number of parents who do not have a clear knowledge of factors that can promote and restrain the development of a child. From those results we can draw a conclusion that health education in schools is very shallow, especially were it concerns motherhood. It would be very useful to carry out discussions with parents to inform them; it should also be done by the medical staff of polyclinics and consultation offices.

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# ON THE CONNECTIONS BETWEEN THE EFFICIENCY OF LEGS' WORK VARIANTS IN BREASTSTROKE AND JOINT MOBILITY

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## Abstract

The legs' work in breast stroke is extremely variable, with three distinguishable basic variants — screw, push-off and wedge. As a result of the conducted experiment it emerged that in case of all the three different legs' work variants as well as the individual style, the external rotation from knee joints performs as a favourable factor in legs' work efficiency. The lack of connections with dorsal flexion from ankle joints and simultaneous negative connections of the initial position of plantar flexion with legs' work efficiency indicate the greater informative value of free movement components from ankle joints as compared to the respective general movement components.

**Key words:** flexibility, swimming

## Introduction

In breaststroke the swimmer realizes his abilities to a considerable extent with the help of legs' work which differently from that of crawl swimming is very variable and complicated. Three main variants can be distinguished on the basis of anatomical analysis of legs' work in breaststroke — screw, push-off and wedge variants [Jagomägi, 1975] (Fig. 1). The variant of legs' work that is conditionally labelled "individual" is usually not a pure basic variant but to a higher or lesser degree nearing one of them. The dependence of the efficiency of different variants of breaststroke legs' work on the joint mobility of lower extremities has not been researched extensively. The problems of the breaststroke swimmer's specific flexibility or joint mobility have in practice been dealt with, not considering different technique variants [Counsilman, 1968; Ali Fagmi, 1972].

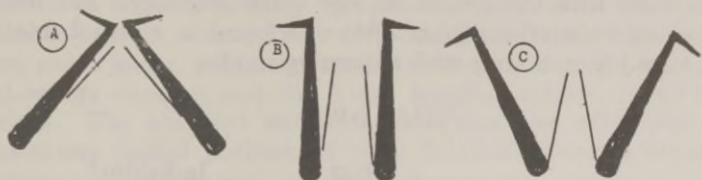


Figure 1. Initial position of breaststroke kick in case of A) screw, B) push-off and C) wedge variants.

The aim and task of the given paper was to study the connection of the joint mobility of lower extremities with breaststroke legs' work efficiency in different variants.

### Subjects and methods

The subject were 26 swimmers, aged 11–15 years: 15 boys and 11 girls. With dividers goniometre external and internal rotation from hip joints, external rotation from knee joints, dorsal flexion and initial position of plantar flexion from ankle joints were measured. The subjects swam 50 m in breaststroke (time recorded) with legs' work in three basic variants — screw, push-off, wedge — and in the individual style. While crossing 50 m the number of kicks on the distance was simultaneously counted. In order to guarantee three different variants of legs' work while swimming, rope was used for fixing certain positions.

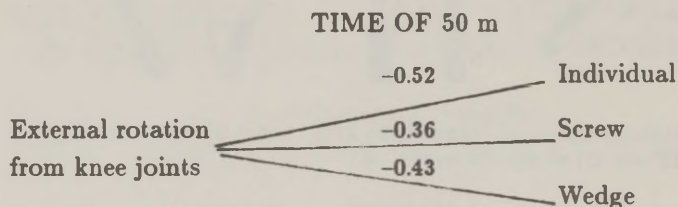
### Results

50 m swimming results and the number of kicks in different legs' work variants proved to be as follows:

Technique variant	50 m results (s)	No. of kicks	Speed (m/s)	Length of step (m)
Individual	57.5	42.8	0.86	1.16
Screw	61.2	43.6	0.81	1.14
Push-off	74.8	54.7	0.91	0.66
Wedge	84.4	47.6	0.59	1.05

For analyzing the connections between the mobility of lower extremities and the efficiency of swimming motions, the correlation

method was applied. Data analysis proved that external rotation from hip joints and dorsal flexion from ankle joints did not have connections with the indices of legs' work efficiency. The largest number of connections ( $p < 0.05$ ) was found in external rotation from knee joints, mainly with swimming results:



The number of kicks had connections only with the push-off variant of legs' work ( $r = -0.38$ ).

The initial position of ankle joint plantar flexion was connected with wedge and push-off results on 50 m distance ( $r = 0.58$  and  $r = 0.38$ , respectively). This index was connected with the number of kicks only in case of the screw variant ( $r = 0.44$ ).

Internal rotation from hip joints was connected only in one case — with the individual legs' work result ( $r = 0.46$ ).

## Discussion

According to correlation analysis the lower extremities joint mobility indices can be interpreted both in positive and negative sense, concerning legs' work efficiency. Positive, i.e. joint mobility that is favourable to legs' work efficiency is external rotation from knee joints. Bigger external rotation connects with increase in swimming speed in the screw, wedge and individual variants. The results of the given study coincide with the conclusions of earlier studies [Ali Fagmi, 1972; Jagomägi, 1975]. The connection between external rotation and number of kicks is also expected — better external rotation enables the swimmer to perform a longer "step" (in the given case, in the push-off variant).

Several authors [Counsilman, 1968; Ali Fagmi, 1972] have considered it essential in breaststroke to have good dorsal flexion from ankle joints, having connected it with legs' work efficiency. Dolenko [1972], however, has not found confirmation to this statement in his experiments and he does not consider dorsal flexion to be an essential factor in breaststroke. In our work also there emerged no connections confirming the importance of dorsal flexion from ankle joints in breaststroke legs' work. Earlier studies have not convincingly established it either, in most cases connection has not been



observed [Jagomägi, 1975].

On the basis of the present study we can state the negative connection of joint mobility component with the efficiency of the swimming result. Namely with the initial position of plantar flexion from ankle joints, swimming results worsen in case of the push-off and wedge variants and the "step" length decreases in the screw variant. The obtained results indicate that free movement joint parameters (initial position of bend or stretch) are in swimming motions more informative than general movement parameters (active bend or active stretch). Anyway, in ankle joint mobility the difference in data is significant, since free movement amplitude makes up only 30 % of the general movement [Jagomägi, 1987]. Probably in swimming, however, the movement from ankle joints is performed mainly in the range of free movement amplitude.

The negative connection of internal rotation from hip joints with legs' work efficiency in the individual variant can probably be explained by the influence of gender factor. Internal rotation from hip joints has always been a dimorph characteristic, i.e. it is considerably bigger in girls than in boys. Since in the given subjects group boys and girls were observed together, the higher internal rotation indices of girls had an influence towards the emergence of negative connection.

On the basis of 50 m swimming results it is not possible to make preferences to one or the other legs' work variant in breaststroke since the technique is a individual phenomenon and has to be adapted by trying different variants and taking into account the anatomical and morphological features of the swimmer. In the course of the experiment it appeared that for two of the subjects the wedge variant of legs' work proved to be the most efficient one, though for the subjects group as a whole it turned out to be the slowest variant of all.

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# **LACTATE DIAGNOSTICS FOR EVALUATION OF AEROBIC AND ANAEROBIC CAPACITIES IN ESTONIAN SPORTSMEN**

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## **Abstract**

Three repetitions of exercises of various intensities were performed in field conditions by 27 Estonian best athletes in running, rowing and Nordic skiing at the beginning, in the middle, and at the end of the preparation period of training. Blood lactate level was determined after each exercise bout. Typical was an increase of the intensities at 4 or 8 mmol/l during the first half of the preparation period, while the second half of the period resulted in reduction in both aerobic and anaerobic capacities.

**Key words:** aerobic capacity, exercise, lactate, training

## **Introduction**

A possibility for evaluation of aerobic and anaerobic capacities on the basis of plotting blood lactate levels against exercise intensity (Fig. 1) is seriously argued [6, 8, 9, 10, 15]. This method allows to assess the training efficiency when the test is repeated after various stages of training. This method provides also information for the individualization of training in various zones of exercise intensity [2, 3, 14]. The method was introduced to the practice of training control in Estonian national teams in 1985. This paper contains the main results obtained by this method in the period from 1985 to 1992 in a number of Estonian athletes. The evaluations were given for sportsmen of cyclic endurance sports.

## **Material and methods**

The test was performed three times in swimmers, 4 times in Nordic skiers and 5 times in runners (Table 1). All the persons



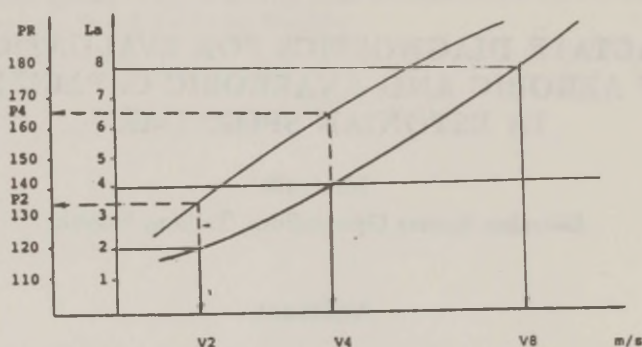


Figure 1. Lactate-speed-heart rate. V4 — velocity at lactate level of 4 mmol/l; V8 — velocity at lactate level of 8 mmol/l; P4 — heart rate corresponding to V4.

were members or candidate for members of Estonian national teams excluding 4 female runners-juniors.

Table 1

Contingent of studied persons (mean  $\pm$  SD)

Sport event	Sex	n	Year of studies	Age	Year of training
Swimming	male	6	1985	15 $\pm$ 0.4	8
Rowers	male	9	1986	21.7 $\pm$ 0.8	14.0
Rowers	female	1	1986	27	
Middle distance runners	male	3	1990	23	7-10
Long distance runners	male	2	1990	21	9-10
Long distance runners	female	1	1990	33	14
Nordic skiers	male	5	1991	21 $\pm$ 2.5	13 $\pm$ 3.4

By the results of systematic sport-medical examinations the athletes were allowed for high load training and competition by their health conditions. The test consisted of three repetitions of an exercise performed at increased intensities: in swimmers 200 m swimming (in the main style), in runners of middle distance — 800 m

running, in long-distance runners and skiers — 2400 m running, in rowers — 5 min cycling exercise on a bicycle ergometer. The interval between the first and second repetition was 1 min, between the second and third repetition 20 min. Just after the end of each exercise bout blood samples were obtained from the finger-tip. Lactate content was determined enzymatically using Boehringer Mannheim's method and spectrophotometer "Spekol 10". Simultaneously heart rate was recorded with the aid of sporttester "Polar Electro PE 3000". Lactate and heart rate values were plotted against exercise intensity (Fig. 1). Exercise intensities corresponding to lactate levels of 4 and 8 mmol/l (V4 and V8) were used as indices characterizing the aerobic and anaerobic capacities of sportsmen, respectively.

## Results

The obtained results are presented in Tables 2–4 and in Fig. 2 as mean values of sport event groups. A comparison of the first and second testing revealed a shift of the curves to the right side. This indicates an increase of exercise intensity V4 and V8. The first testing was at the beginning of the preparatory period and the second testing at the end of the first stage of the period. Obviously, the training was effective in regard to both aerobic and anaerobic working capacities. In testing at the end of the preparation period the curve was shifted to the left side in all groups. The average changes in exercise intensities corresponding to the lactate level of 4 mmol/l are presented in Tables 2 and 4.

During the last testing in rowers the curve (Fig. 2) was even on the left side, compared with the curve at the beginning of the preparatory period. A pronounced shift to the left was found also in female junior runners and swimmers. Less pronounced changes were recorded in male runners and Nordic skiers. In swimmers and 3 middle-distance runners the last testing took place 3 days after return from a middle altitude training camp of 3 weeks. When the exercise intensity at lactate level 4 mmol/l was used for calculation of the time for 100 m swimming or for 1000 m running, it appeared that the swimming time increased by 1.1 to 6.1 s (1.5...6.3 %) and the running time by 17 to 32 s (8.8...15.5 %). Therefore in these sportsmen the shift of the curve to the left was related with the altitude training. It is assumed that in altitude training the improvement of the organism's capacity will be revealed approximately after 2 weeks of reacclimatization. However, in swimmers it was not found in performance level in competitions two weeks after the return. In rowers the pronounced shift of the curve to the left was not related with the altitude training. Obviously, there were other factors influencing

Table 2

Results of testing of swimmers and rowers in various training stages (mean  $\pm$  SD)

Sports event, sex, n	V4, m/s W4, W/kg			V8, m/s W10, W/kg			Changes	Calculated time for 100 m (s) in swimmers and power output in rowers (W/kg) to lactate levels 4 mmol/l	
	I	II	III	I	II	III	From 1st to 2nd	From 2nd to 3rd	from 1st to 3rd
Swimmers, male, 6	Jan. 22 1.22 $\pm$ 0.12	March, 19 1.32 $\pm$ 0.11	May, 7 1.27 $\pm$ 0.12	Jan. 22 1.36 $\pm$ 0.11	March, 19 1.42 $\pm$ 0.13	May, 7 1.39 $\pm$ 0.12	-5.7 (-2.4...-15.7)	+2.7 (+1.1...+6.1)	-3.0 (-14.5...+0.6)
Rowers, male, 9	Jan. 22 1.67 $\pm$ 0.90	Feb. 12 1.96 $\pm$ 0.60	Apr. 17 1.55 $\pm$ 0.40	Jan. 22 3.36 $\pm$ 0.37	Feb 12 3.39 $\pm$ 0.25	Apr. 17 3.19 $\pm$ 0.42	+0.29 (-0.77...+1.74)	-0.41 (-0.26...+0.86)	-0.12 (-0.11...1.12)
Rowers, female, 1	1.50	1.83	1.64	3.24	2.94	3.51			

Due to the small number of subjects in the group and the big variability, all changes are statistically nonsignificant ( $p > 0.05$ )



Table 3

Results of testing of runners and Nordic skiers in various training, stages (mean  $\pm$  SD)

Sports event sex, n	V4, m/s						V8, m/s					
	I Nov. 3	II Dec. 1	III Jan. 3	IV Mar. 1	V Apr. 2	VI May 3	I Nov. 3	II Dec. 1	III Jan. 3	IV Mar. 1	V Apr. 2	VI May 3
Long distance runners, male 2	4.60- 4.62	4.82- 4.97	4.76- 5.10	4.73- 5.11	4.90- 5.14	-	5.00- 5.14	5.28- 5.37	5.35- 5.50	5.42- 5.54	5.38- 5.45	-
Long distance runners, female 1	4.45	4.58	4.79	-	-	-	4.80	4.92	5.00	-	-	-
Middle distance runners, male 3	4.30- 5.42	4.80- 5.20	5.10- 5.40	5.01- 5.56	4.69 5.69	4.81- 5.11	5.35- 6.11	5.70- 5.91	5.90 6.11	5.92- 6.20	5.77- 6.19	5.63 6.03
Nordic skiers, male 5	May 27 4.03 $\pm$ 0.24	Jul. 3 4.48 $\pm$ 0.13	Aug. 27 4.47 $\pm$ 0.11	Oct. 2 4.37 $\pm$ 0.21			May 27 4.68 $\pm$ 0.24	Jul. 3 5.13 $\pm$ 0.28	Aug. 27 5.06 $\pm$ 0.21	Oct. 2 5.00 $\pm$ 0.27		

Due to the small number of subjects in the group and the big variability, all changes are statistically nonsignificant ( $P > 0.05$ )

Table 4

Changes in calculated time of 1000 m(s) running by exercise intensity  
at lactate level of 4 mmol/l

Sport event, sex n	From 1st to 2nd 4 weeks	From 2nd to 3rd 4 weeks	From 3rd to 4th 8 weeks	From 4th to 5th 4 weeks	From 1st to 5th 6 month
Long distance runners, male, 2	-9- -16	-11- +9	-0.4- +1	-0.6- -7	-13- -21
Long distance runners, female, 1	-6	-9	-	-	-
Middle distance runners, male, 3	-1 (-25- +15)	-11 (-6- -15)	+6.7 (-7- +15)	+10.7 (-17- +32)	-0.7 (-37- +23)
	5 weeks	8 weeks	5 weeks		4.5 month
Nordic skiers, male, 5	-26.8 (-17- -34)	-4 (-8- +5)	+3.6 (-4- +14)		-21 (-16- -27)

the dynamics. However, in rowers the V4 increased together with a reduction in V8 and in other rowers V4 was reduced in combination with a slight improvement in V8.

During the whole preparation period a general improvement was found in 9 sportsmen. They constituted 3 variants of improvement (Fig. 3):

- a) an improvement of only aerobic capacity (V4), in a male rower and a female runner,
- b) an improvement of only anaerobic capacity (V8) in a swimmer, a male and a female rower and a runner,
- c) an improvement of both capacities in a swimmer, a male runner and a Nordic skier.

## Discussion

In this study the aerobic capacity was evaluated by exercise intensity at the lactate level of 4 mmol/l. It is justified by an approach to estimate the anaerobic threshold with the aid of exercise intensity at lactate level 4 mmol/l [4, 5, 16]. For evaluation of anaerobic working capacity, exercise intensity at lactate level 8 mmol/l was used.

The link between the improvement of aerobic and anaerobic capacities on the one hand, and volume of related exercises on the other hand, is argued [1, 7]. By our results the training was effective during the first half of the period, but in the second half of the period, only in a limited number of sportsmen. Consequently, a special analysis of the performed training is necessary to find the shortcomings.

A special problem is altitude training. In this case the individual approach is particularly necessary. It is impossible to use the data obtained at sea level for the design of training because in high altitude conditions the perceived exertion is different as well as exercise intensities and heart rates at anaerobic threshold [12]. Therefore during altitude training additional sets of lactate diagnostic are necessary.

Anyway, it is obvious that the training design during the second half of the preparation period in the studied sportsmen need corrections. During the second half of the period a new task arisen had to be completed. Nevertheless, there must be a sufficient amount of correctly chosen exercises for maintaining or even further improving of the aerobic and anaerobic capacities of sportsmen.



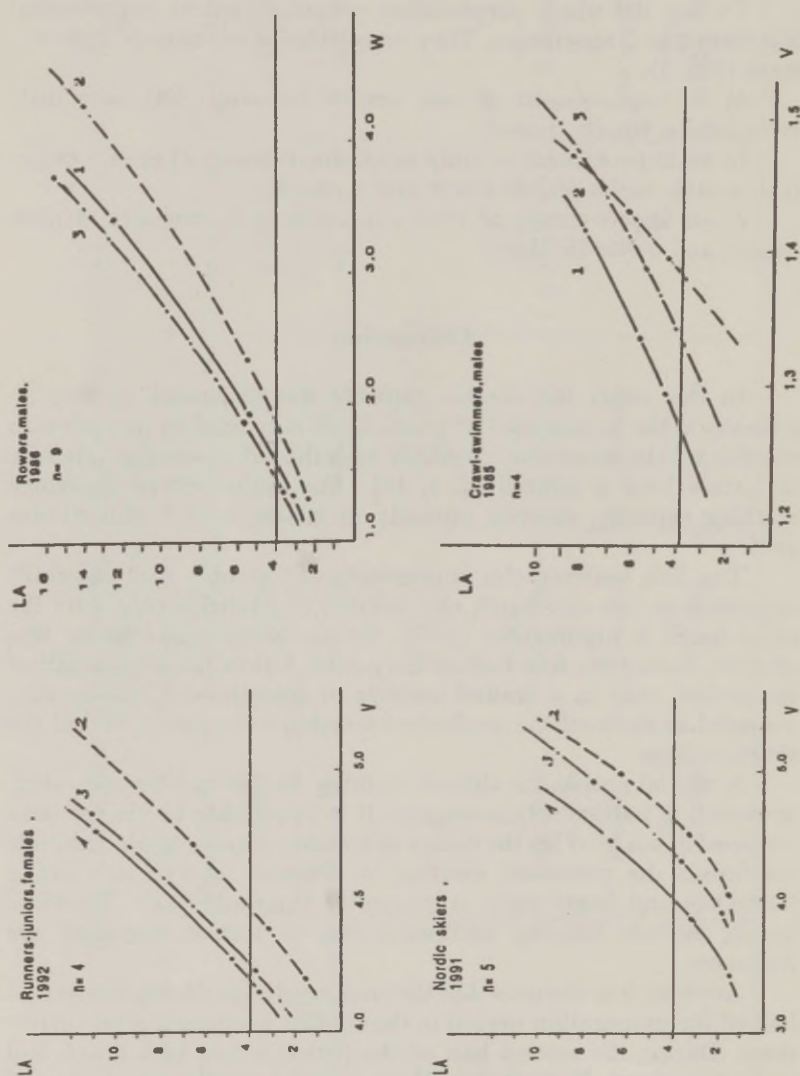


Figure 2. Lactate-velocity curves characterizing the preparation period of Estonian best athletes (groups). Curve 1 (—): test at the beginning of preparation period, curve 2 (---) in the middle and curve 3 (-.-) at the end of it.

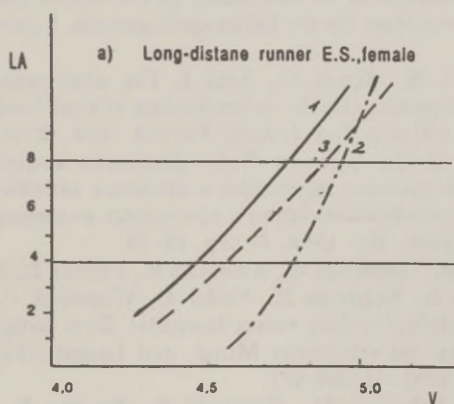
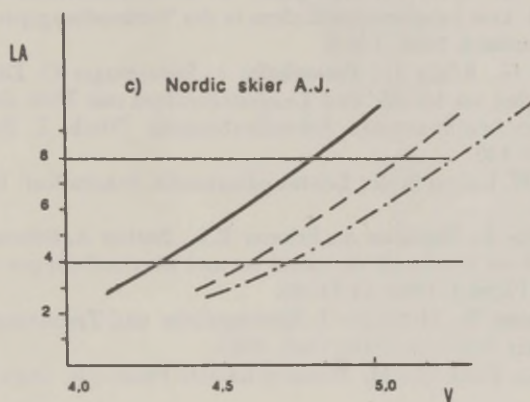
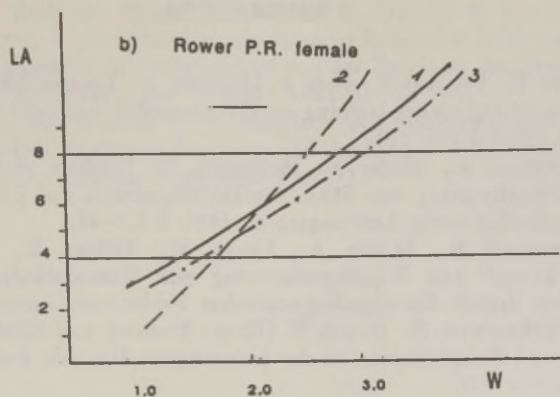


Figure 3. Lactate-velocity curves of sportsmen whose preparation period was successful.

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## REET ANN HOWELL (NURMBERG)

### IN MEMORY

June 10, 1993 was the day when the heart of R. A. Howell stopped beating. The outstanding scientist and pedagogue, the Head of the School of Human Movement Studies, Queensland University of Technology, Brisbane, Australia was only 48 years old.

Assoc. prof. Reet Howell has taught at Colleges and Universities in Canada, the United States of America and Australia, including the Department of Physical Education, Brisbane College of Advanced Education, Mont Gravett Campus, the University of Ottawa, Canada, Scarborough College — University of Toronto, Canada, San Diego State University, California and Palomar College, California. She has published extensively and written several books, mostly in the field of sport history and physical education. She was a corresponding fellow of the American Academy of Physical Education.

Since she was born in the family of Estonian emigrants her scientific interests were concerning problems related to Estonia. Her doctoral dissertation was written on an unique topic at this time (1972), the Estonian sport history (University of California, Berkley). Last years, after Gorbachev's perestroika she had intensive contacts with Estonia with Tartu University in particular. In spring 1991 she delivered lectures at Tartu University with her husband prof. Max Howell. The next longer visit to Tartu was to take place in spring 1993, but the doom decided in another way.

With her help one of our students has an opportunity to study in Brisbane as a Ph D students now.

All those who had the possibility to meet R. A. Howell will maintain a vivid memory of a pedagogue, talented scientist and a nice person forever.

T. Jürimäe