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BIOLOGICAL AND PEDAGOGICAL
PROBLEMS OF PHYSICAL EDUCATION
AND SPORT

II

Töid kehakultuuri alalt

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GLUCOCORTICOID CONTROL OF GLYCOGEN AND ALANINE METABOLISM IN RATS DURING EXERCISE

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ABSTRACT

In male Wistar rats (body weight 190–240 g) adrenalectomy suppressed the rise of lactate concentration in blood and oxidative muscle fibres as well as glycogen utilization in oxidative but not glycolytic fibres during swimming for 3 or 4 h. The aggravated glycogenolysis in oxidative muscle fibres was confirmed by a more pronounced rise of the rate of contracture development in isolated soleus muscle after exercise compared to the rates in normal animals. After exercise low levels of glycogen are associated in adrenalectomized rats with a more pronounced hypoglycemia than in normals. In normal rats glycogen level stabilized after swimming for 4 h in the liver in conjunction with a high level of corticosterone in blood. After swimming for 8 or 12 h a further glycogen decline was insignificant. When the duration of swimming was 16 h, there was a decrease of corticosterone concentration in blood. Then a new drop in liver glycogen occurred. It was suggested that during prolonged exercise glucocorticoids participate in mechanisms of starving of carbohydrate utilization and of gluconeogenesis. When adrenalectomized rats swam until exhaustion, the dexamethasone i.p. administration (0.2 mg per 100 g of body weight) after 3.5 h of exercise increased the swimming duration and reduced the hypoglycemia at the expense of further utilization of liver glycogen. Obviously, during prolonged

exercise glucocorticoids exert an effect on glucose production as well.

Differently from normal rats, adrenal insufficiency excluded the exercise-induced rise in alanine levels of blood plasma, oxidative muscle and liver. While in normal rats elevated alanine contents are associated with increased activity of alanine-aminotransferase in oxidative fibres, in adrenalectomized rats the enzyme activity in muscles did not change and decreased in hepatic tissue during exercise. The dependence of exercise-induced on corticosteroids was confirmed by the increase of the enzyme activity after exercise in adrenalectomized rats treated with 125 μ g of corticosterone. In normal rats training excluded both the rise of blood corticosterone and activation of hepatic alanine-aminotransferase during exercise. Thus the stimulation of glucose-alanine cycle by glucocorticoids promotes the alanine supply and utilization in liver during exercise. In adrenalectomized rats arginase activity decreased during exercise in conjunction with a lack of further elevation of urea levels in blood, liver and skeletal muscles. Consequently, the use of amino groups from alanine and other amino acids for urea formation depends on glucocorticoids.

Key words: Adrenalectomy, alanine, alanine-aminotransferase, arginase, corticosterone, dexamethasone, exercise, hypoglycemia, urea

INTRODUCTION

Sufficiently intensive or prolonged exercise activates the pituitary-adrenocortical system (for review see /48/). In order to stress the adaptive role of this response, usually decreased physical working capacity under adrenocortical insufficiency is mentioned. The analysis of this phenomenon showed that, it is causally related to the disturbances on the level of transmembrane shifts of electrolytes and water due to the glucocorticoid deficiency /49/. These disturbances in turn seem to be connected with disorders in the synthesis of the participating enzymes or other regulatory proteins. Glucocorticoids induce the synthesis of a number of enzymes, including enzymes of gluconeogenesis /9, 53/, protein

catabolism and amino acid metabolism /11, 47/. Adrenalectomy abolished the exercise-induced increase in the activity of hepatic tryptophan oxygenase /50/. The rates of postexercise replenishment of hepatic, white and red skeletal muscles /22/ and myocardium /22, 36/ glycogen were low in adrenalectomized animals. The administration of glucocorticoid to adrenalectomized rats re-established both the high enzyme activity of tryptophan oxygenase /50/ and the rate of glycogen repletion /22, 36/ after exercise. These glucocorticoid effects were not observed if the RNA /50/ or protein synthesis were inhibited by simultaneous administration of actinomycin D or cyclohexamide correspondingly. During exercise the adaptive role of pituitary-adrenocortical response is obviously more widespread than their essential function in the control of transmembrane metabolism of electrolytes and water.

During prolonged exercise the utilization of hepatic glycogen store was exaggerated in adrenalectomized rats in conjunction with hypoglycemia developed instead of persisting euglycemia in normal rats /16, 27, 46/. These changes were probably related to disorders in gluconeogenesis due to the glucocorticoid deficiency. Additionally, the aggravated sparing of glycogen utilization by decreased lipolysis might have significance as well as glucocorticoids increase the ability of lipolytic agents to activate triglyceride lipolysis /10/. In adrenalectomized rats the free fatty acid level in blood remained constant during exercise /27/ or the rise was negligible /46/, as in the case of the elevation of lactate level /27/. The latter fact suggest that there are disorders in muscle glucogenolysis. An increased drop of muscle glycogen was found in adrenalectomized rats during exercise /46/. When exercises were performed by adrenalectomized rats, the glycogen utilization in muscles and liver as well as lipolysis activation were close to normal /14, 27/. Gorski et al. /16/ found that exercise-induced mobilization of glycogen in vastus deepest (composed mostly of the fast-twitch oxidative-glycolytic fibers) and soleus (composed mostly of the slow-twitchoxidative fibres) diminished whereas glycogen utilization in vastus superficial (composed mostly of fast-twitch glycolytic fibres) did not change in adrenalectomized rats as compared to sham-operated controls. Thus the disorders of muscle glucogenolysis seem to depend on the fibre type.

Gluconeogenesis is related to the glucose-alanine cycle which is stimulated by glucocorticoids /8, 12, 20/, as well as to the hepatic urea formation /4, 41/. In order to further assess the effects of glucocorticoids on muscle glycogenolysis and on the glucose-alanine cycle and urea formation during exercise the following experiments were performed. For this purpose the exercise-induced metabolic changes in adrenalectomized and normal rats were compared. Additionally, the changes in blood corticosterone level caused by training or extreme duration of exercise were compared with metabolic indices, related to the above mentioned processes.

METHODS

Procedure

The experiments were carried out on male Wistar rats (10-12 weeks old, body weight 190-240 g). The rats were kept in standardized conditions of vivarium and standard laboratory diet, containing 12-15 % of protein, 26-30 % of carbohydrates, 8-10 % of lipids. The lighting schedule was 12 h light + 12 h dark. 10 days before the experiments bilateral adrenalectomy was performed by the dorsal rout in a group of rats. In control rats of corresponding series the skin and muscles were incised and then sutured like in adrenalectomized rats. The adrenalectomized rats were maintained on the 1 % NaCl in drinking water. To control the adrenocortical insufficiency the corticosterone concentration in blood was assessed in subgroups of adrenalectomized rats with the aid of a fluorometrical procedure 3 days, 1, 2 and 8 weeks after surgery. A minimal level of corticosterone (1 to 4 μg per 100 ml of plasma) was found during the first two weeks. After 8 weeks the corticosterone concentration in blood was $8 \pm 1.8 \mu\text{g} \cdot 100^{-1}$, probably due to the development of accessory tissue capable of producing of corticosteroids.

The exercise consisted in swimming in water of $32 \pm 1^\circ\text{C}$. The mean surface of water was $80 \pm 7 \text{cm}^2$ for each rat in the swimming tank. The limited area forced each rat to swim actively.

The time schedule of experiments was adjusted to finish swimming between 2 and 4 p.m. At the same time the sedentary control animals were sacrificed.

The first series. Both adrenalectomized and sham-operated rats swam for 4 h. 6 normal and 6 adrenalectomized rats were sacrificed by cervical dislocation either immediately or 4 h after exercise. Both soleus and both quadriceps femoris muscles were separated. The quadriceps muscles were divided into red and white part. Only the portion of quadriceps (the lateral part) containing mainly fast twitch glycolytic fibres, was used in the this series. The samples of the right side muscles were immediately frozen in liquid nitrogen and stored for the determination of glycogen and lactate.

The muscles of the left side were used for recording the development of contracture in an isolated muscle. The contracture of isolated muscle is causally related to the dysfunction of Ca-pump due to its insufficient energy attaining. In this situation the part of oxidative phosphorylation is negligible in ATP resynthesis and the main role belongs to anaerobic glycogenolysis. It was found that the rate of development of contracture in isolated muscle depends on possibilities for anaerobic glycogenolysis /51/. On this background the rate of development of contracture of isolated muscle was recorded to obtain an integrated index of possibilities for glycogenolysis. For this aim the apparatus described by Körge and Männik /23/ for the ischemic contracture of myocardium, was adjusted for the study of isolated skeletal muscle. The development of contracture of isolated muscle was recorded in Ringer physiological solution for rats, containing 137 mMol of NaCl, 4 mM of KCl, 1 mMol of MgCl₂, 1 mMol of KH₂PO₄, 12 mMol of NaHCO₃ and 2 mMol of CaCl₂, temperature 37°C.

The second series. Three groups of adrenalectomized rats were used in this series. One group (n=7) consisted of sedentary control rats, the other two subgroups (n=6) performed a test for assessment of the maximal swimming duration. The duration of swimming was measured by the time until the rat submerged under water for 10 s. After 3.5 h of swimming the rats were injected i.p. by 1 ml of physiological saline or 1 ml of solution of dexamethasone, containing 0.2 mg of hormone per 100 g of body weight.

Rats were taken out from the swimming tank alive. Within 2 min under a light ether anesthesia the blood was drawn from the aorta. Quadriceps muscle were divided into portions of white and red quadriceps. Muscle samples and liver were immediately frozen. The same procedures were performed with sedentary control rats at the same time of day. Glucose

was determined in the blood. In samples of muscle and liver tissues the content of glycogen was detected.

The third series. Both adrenalectomized and normal rats performed a 3-h swimming. Immediately after exercise the blood was collected and centrifuged at 4°C, liver and quadriceps muscle were separated and frozen. Lactate, glucose, alanine and urea concentrations were determined in the blood plasma. The glycogen, alanine and urea contents were measured and alanine-aminotransferase activity assessed in liver and muscle tissues. The activity of hepatic arginase was detected as well.

The fourth series. In this series the blood corticosterone response to exercise was compared with changes in hepatic alanine-aminotransferase activity. The corticosterone response was avoided in two ways: (1) by using previously trained rats, (2) with the aid of adrenalectomy. Additionally, the experiments were performed on adrenalectomized rats treated with 125 µg of corticosterone i.p. injection before swimming. The exercises were (a) 1.5-h swimming with an additional load of 6 % of body weight, attached to the tail for comparison of responses in normal trained and untrained rats, (b) 3-h swimming without any additional load for comparison of responses in adrenalectomized and sham-operated rats. The training consisted of 5 swimming sets weekly during two months. The duration of swimming increased gradually from 30 min up to 120 min.

Within 2 min after the end of swimming under a light ether anesthesia the blood was collected by puncture of the aorta and the liver was separated. The corticosterone concentration in blood as well as the alanine-aminotransferase activity and protein content in the homogenate of the liver tissue were determined.

The fifth series. Only intact rats were used in this series. They were divided into 5 groups: one group of sedentary control rats and 4 groups for swimming. The swimming duration was 4, 8, 12 or 16 h. Immediately after the end of swimming under a light ether anesthesia the blood was drawn from the aorta and centrifuged. Corticosterone was determined in heparinized blood plasma. The hepatic tissue and quadriceps muscle were separated and frozen for glycogen determination.

Analyses

Glycogen was determined by the method of Lo et al. (25), lactate by the standard enzymatic procedure after extracting the powdered tissue with perchloric acid, and glucose by 0-tolluidine method. To determine lactate and glucose as well as urea the kits of Lachema (CSFR) were used. Alanine was measured by a paper chromatographic assay /37/. Enzyme activities were assessed in the supernatant obtained by centrifugation of the tissue homogenate at 1,000 x g for 30 min. The alanine-aminotransferase (2.6.1.2) activity was measured by the method of Haschen /18/ using a VEB Arznei Mittelwerk (previous DDR) kit, arginase (3.5.3.1) activity by the method described by Asatiani /1/. The enzyme activities were expressed per 1 mg of protein or per unit of wet weight of tissue. The protein content was determined by the method of Lowry et al. /26/. In blood plasma corticosterone was determined with the aid of a fluorometric procedure after a previous thin-layer chromatography on silica gel /21/.

All analyses were made in duplicate. All analytical procedures were performed at 4°C.

Statistical analysis. The results of subgroups have been expressed on the mean \pm SE. Statistical significance between the subgroups was evaluated by Student-Fischer t-test with the 0.05 probability level designated as significant.

RESULTS

The first series. In normal (sham-operated) rats 4-h swimming caused a pronounced rise in lactate contents of skeletal muscles (Table 1). In adrenalectomized rats the increase of lactate content was approximately the same in fast twitch glycolytic muscle (by $8.57 \pm 1.01 \mu\text{Mol}$ vrs $11.01 \pm 1.75 \mu\text{Mol}$ in normals, $P < 0.05$). In the slow twitch oxidative muscle the lactate content in adrenalectomized rats rose to a lesser degree than in normals (by 5.97 ± 0.71 vrs $9.28 \pm 0.72 \mu\text{Mol}$, $P < 0.01$). After a 4 h postexercise recovery the lactate content in normal rats was a little bit lower than in sedentary control rats (in the fast glycolytic muscle significantly and in the slow oxidative muscle insignificantly). In adrenalectomized rats the lactate elimination was retarded.

4 h after exercise the lactate levels were still significantly over the values of sedentary adrenalectomized rats.

Table 1

Lactate and glycogen changes in glycolytic (white part of quadriceps) and oxidative (soleus) fibres in normal and adrenalectomized rats induced by 4 h swimming (mean±S.E.M.)

	n	Lactate ($\mu\text{Mol.g}^{-1}$ wet tissue)		Glycogen (mg.g^{-1} wet tissue)	
		Glycolytic fibres	Oxidative fibres	Glycolytic fibres	Oxidative fibres
Normal rats					
Sedentary	6	3.74±0.13	3.17±0.23	10.48±0.78	8.12±0.81
Immediately after 4-h swimming	6	14.75±1.75. ⁺	12.45±0.68. ⁺	8.93±0.64	3.57±0.12. ⁺
4 h after 4-h swimming	6	3.20±0.10. ⁺	2.91±0.14	9.80±0.87	10.35±1.27
Adrenalectomized rats					
Sedentary	6	1.08±0.13	3.15±0.23	8.43±0.93	5.89±0.45
Immediately after 4-h swimming	6	10.65±1.01. ⁺	9.12±0.67. ⁺	7.80±0.41	3.96±0.29. ⁺
4 h after 4-h swimming	6	4.92±0.24. ⁺	4.33±0.23. ⁺	8.00±0.55	4.83±0.30. ⁺

Asterisk denotes statistically significant difference ($P < 0.05$) from values of sedentary rats.

Adrenalectomy caused a decrease in glycogen stores of soleus (by 2.23 ± 0.93 , $\mu\text{g.g}^{-1}$ wet tissue, $P < 0.05$). In "white" quadriceps this change was insignificant. The exercise-induced reduction in glycogen stores was statistically significant only in the soleus in normal as well in adrenalectomized rats (Table 1). The decrease of glycogen content was in the soleus of adrenalectomized rats 2.4 fold smaller than in the muscle of normal rats (by 1.93 ± 0.54 vs. 4.55 ± 0.61 $\mu\text{g.g}^{-1}$ wet tissue, $P < 0.01$). 4 h after exercise the glycogen content in soleus exceeded insignificantly the level in normal sedentary rats. In exercised adrenalectomized rats, on the contrary, it was significantly lower than in sedentary adrenalectomized rats.

The rate of development of contracture in sedentary adrenalectomized rats was insignificantly higher than in normal sedentary rats in both studied muscles. However, the rise in the rate observed after exercise, was in adrenalectomized rats 2.3 fold (0.72 ± 0.086 vs. 0.32 ± 0.058 mm.min⁻¹, $P < 0.01$) higher in case of soleus muscle. The rate of contracture development in isolated "white" quadriceps increased equally in adrenalectomized and normal rats. 4 h after exercise the rate was in muscles isolated from normal levels equal to the rate in normal sedentary rats. In adrenalectomized rats both muscles were transferred into maximal contracture with a faster rate than in sedentary state still 4 h after exercise.

The second series. The dexamethasone administrated to adrenalectomized rats after 3.5 h of swimming increased the maximal duration of swimming by 30 %. In these animals the hypoglycemia less pronounced and the glycogen drop in both types of muscles as well as in the liver more pronounced than in saline treated adrenalectomized rats (Table 2).

The third series. In this series of experiments a statistically significant ($P < 0.05$) elevation of blood lactate level in conjunction with a slight hypoglycemia and a decrease in glycogen reserves was found after adrenalectomy (Table 3). When in normal animals an increase of lactate concentration in the blood was detected after 3 h of swimming, it did not happen in adrenalectomized rats. Instead of a mild reduction of blood glucose in normal rats a pronounced hypoglycemia developed in adrenalectomized rats. The liver glycogen content dropped to low values in both groups. The glycogen in exercised muscles was lower in intact animals than in adrenalectomized rats at the end of exercise.

Table 2

Liver and muscle glycogen and blood glucose changes after swimming till exhaustion in adrenalectomized rats treated after 3.5 h of swimming with dexamethasone or physiologic saline (mean \pm SEM)

	n	Duration swimming (h)	Blood glucose (mMol. L ⁻¹)	Glycogen (mg g ⁻¹ wet tissue)		
				Liver	Glycolytic fibres	Oxidative fibres
Sedentary controls	7	-	4.89 \pm 0.21	41.9 \pm 3.73	6.35 \pm 0.39	3.17 \pm 0.36
Treated with saline	6	9.2 \pm 0.75	1.89 \pm 0.12	24.41 \pm 2.91	5.18 \pm 0.47	2.58 \pm 0.20
Treated with dexamethasone	6	12.0 \pm 0.99 ⁺	3.07 \pm 0.23 ⁺	11.2 \pm 0.98 ⁺	1.78 \pm 0.14 ⁺	1.10 \pm 0.13 ⁺

Asterisk denotes statistically significant differences (P<0.05) between dexamethasone treated and saline treated rats.

Table 3

Changes of lactate, glucose and glycogen levels in tissues of rats induced by adrenalectomy and 3-hour swimming (mean±S.E.M.)

	Intact		Adrenalectomized	
	Sedentary n=5	Exercised n=9	Sedentary n=6	Exercised n=7
Lactate in blood plasma (mMol · l ⁻¹)	1.32±0.11	4.06±0.48 ¹	1.72±0.12 ¹	1.82±0.18 ^{1,2}
Glucose in blood plasma (mMol · l ⁻¹)	7.85±0.47	5.68±0.29 ¹	4.88±0.38 ¹	2.95±0.41 ^{1,2,3}
Glycogen in liver (mg · g ⁻¹ of wet tissue)	49.0±3.17	21.5±0.13 ¹	25.1±0.17 ^{1,2}	21.6±0.17 ^{1,3}
Glycogen in quadriceps muscle (mg · g ⁻¹ of wet tissue)	7.19±0.35	2.39±0.04 ¹	4.03±0.18 ^{1,2}	2.43±0.01 ^{1,2,3}

- 1 - statistically significant difference ($P < 0.05$) from values of intact sedentary rats
 2 - statistically significant difference ($P < 0.05$) from values of intact exercised rats
 3 - statistically significant difference ($P < 0.05$) from values of adrenalectomized sedentary rats

In sedentary adrenalectomized rats an hypoalaninemia was observed in association with decreased alanine contents both in "red" and "white" parts of quadriceps muscle as well as in the liver (Table 4). During exercise the alanine levels elevated in blood plasma, red portion of quadriceps muscle and liver together with the activation of alanine aminotransferase in "red" quadriceps. In adrenalectomized rats the alanine levels in blood plasma and muscle tissue persisted on a low level, observed in sedentary adrenalectomized rats. A slightly elevated alanine level was observed in the liver but it remained below the values in normal rats. In adrenalectomized rats the alanine aminotransferase activity did not change significantly in muscles but decreased in the liver during exercise.

Adrenalectomy caused a pronounced rise of urea content in the studied tissues (Table 5). However, the performed exercise decreased rather than increased the urea concentration in blood, quadriceps muscle and liver. In exercised adrenalectomized rats urea concentrations were higher than in normal sedentary rats, but differences from the values of exercised normal and sedentary adrenalectomized rats were not statistically significant ($P > 0.05$). The arginase activity decreased after adrenalectomy but did not change due to the exercise.

The fourth series. In this series the changes in hepatic alanine-aminotransferase activity were compared with the levels of corticosterone in blood plasma. In untrained intact or sham operated rats the swimming caused an increase both in the blood corticosterone concentration and hepatic alanine aminotransferase activity (Table 6). In order to avoid the corticosterone increase without any surgical or pharmacological interferences, previously trained rats were used. After swimming there was no increase in the blood corticosterone level as well as in hepatic alanine-aminotransferase activity. When the exercise-induced rise in the blood corticosterone level was eliminated by the adrenalectomy, the enzyme activity remained on the low level after exercise. However, when 125 μg of corticosterone was injected before exercise then after swimming the corticosterone level was over the values of sedentary sham-operated rats and the alanine aminotransferase activity was doubled in comparison with sedentary untreated adrenalectomized rats.

Table 4

Changes of alanine contents and activity of alanine aminotransferase induced by adrenalectomy and 3-hour swimming (mean±S.E.M.)

	Intact		Adrenalectomized	
	Sedentary n=5	Exercised n=9	Sedentary n=6	Exercised n=7
ALANINE				
in blood plasma (uMol/l)	375±5	595±70 ¹	230±5 ^{1,2}	245±45 ^{1,2}
in white portion quadriceps muscle (uMol/g of wet tissue)	1.22±0.01	1.31±0.10	0.88±0.01 ^{1,2}	0.90±0.01 ^{1,2}
in red portion of quadriceps muscle (uMol/g of wet tissue)	1.31±0.01	1.93±0.09	0.90±0.01 ^{1,2}	0.96±0.01 ^{1,2}
in liver (uMol/g of wet tissue)	1.62±0.01	3.08±0.19	0.85±0.01 ^{1,2}	1.05±0.01 ^{1,2,3}
ACTIVITY OF ALANINE AMINOTRANSFERASE (uMol of pyruvate per 100g of wet tissue in 1h)				
in white portion of quadriceps muscle	117±10	98±7	88±6 ¹	118±18
in red portion of quadriceps muscle	197±18	243±10 ¹	106±12 ²	227±19
in liver	332±8	300±13	300±37	228±23 ^{1,2,3}
in liver (uMol of pyruvate per 1 mg of protein in 1 h)	16.7±1.7	15.0±0.7	13.7±2.2	12.1±1.2 ^{1,3}

1,2,3 - see Table 3

Table 5

Changes of urea levels in blood plasma, quadriceps muscle and liver and of arginase activity in liver induced by adrenalectomy and 3-hour swimming (mean±S.E.M.)

	Intact		Adrenalectomized	
	Sedentary n=5	Exercized n=6	Sedentary n=6	Exercized n=7
UREA CONCENTRATION				
in blood plasma (mMol l ⁻¹)	4.4±0.5	8.3±1.1 ¹	14.7±2.1 ¹	11.5±1.9 ¹
in quadriceps (mMol g ⁻¹ of wet weight)	4.2±0.2	6.9±0.3 ¹	14.0±0.8 ¹	10.2±2.1 ¹
in liver (mMol g ⁻¹ of wet weight)	6.2±0.6	10.7±0.6 ¹	13.8±0.8 ¹	11.8±1.9 ¹
ARGINASE ACTIVITY IN LIVER				
uMol of urea per 1 mg of wet tissue in 1 min	589±33	541±25	331±54 ^{1,2}	299±39 ^{1,2}
uMol of urea per mg of protein in 1 min	30±1.7	28±1.3	20±3.3 ¹	16±2.0 ^{1,2}

^{1,2} - see Table 3

Table 6

Exercise-induced changes in blood corticosterone concentration and hepatic alanine-aminotransferase activity

Exercise	Group	Blood corticosterone (ug per 100 g of plasma)		Hepatic alanine- aminotransferase activity (uMol of pyruvate per 1 mg of protein in 1 h)	
		Sedentary	Exercized	Sedentary	Exercized
1.5 h swimming with an additional load of 6 % of body weight	Untrained rats	14.4±1.0	25.5±2.3 ⁺	14.4±2.4	26.4±3.9 ⁺
	Trained rats	19.0±3.0	18.1±4.8	17.7±2.4	14.4±1.2
3 h swimming without any additional load	Sham operated rats	18.1±2.9	29.0±3.6 ⁺	17.4±0.6	24.0±1.2 ⁺
	Adrenalectomized rats	2.1±0.8	1.4±0.4	9.3±1.2	6.6±1.5
	Adrenalectomized rats, treated with 125 ug of corticosterone	-	24.1±1.5	-	20.4±2.1

Asterisk denotes statistically significant difference ($P < 0.05$) between sedentary and exercised rats. Each group consisted of 6 rats

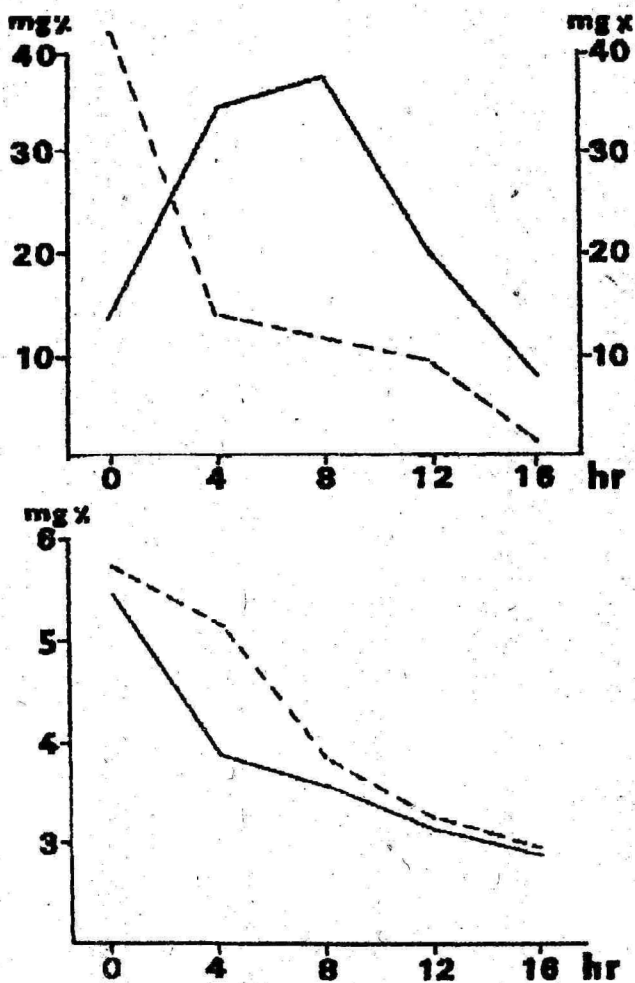


Fig. 1

Blood corticosterone (μg per 100 ml of plasma), liver and skeletal muscle glycogen (mg per g of wet tissue) in normal rats after swimming for 4, 8, 12 and 16 hrs. In the upper part: solid line - blood corticosterone, interrupted line - liver glycogen. In the lower part: solid line - glycogen in "red" quadriceps, interrupted line - glycogen in "white" quadriceps.

The fifth series. Concordant changes were observed between the blood level of corticosterone and the activity of

tryptophan oxygenase in hepatic tissue in normal rats after swimming for various durations (Fig. 1). After 4 h swimming both the concentration of corticosterone in the blood and the activity of the enzyme in the liver increased substantially. At the same time a pronounced drop of hepatic glycogen stores was found. The hepatic glycogen content seemed to be levelled off on a reduced level. The continuation of swimming for up to 12 and 16 h revealed the concordant decrease in the blood corticosterone level and in the hepatic tryptophan oxygenase activity. The low blood corticosterone is associated with a further decline in the hepatic glycogen content.

During the first 4 h of swimming the glycogen content decreased only in the red portion of quadriceps muscle, containing mainly oxidative fibres. Further, a decrease in the white portion of quadriceps was added. In both samples of muscle tissue there was no statistically significant difference in glycogen contents between results obtained after swimming for 12 or 16 h.

DISCUSSION

The results of the study indicate the participation of glucocorticoids in the control of glycogenolysis, gluconeogenesis, glucose-alanine cycle and urea formation during exercise. With regard to glycogenolysis this was demonstrated by a decreased lactate production during exercise and by alterations in utilization of glycogen stores in adrenalectomized rats. The diminished blood lactate response is in a good agreement with the result of a previous study /27/. Our results showed that oxidative fibres were responsible. We also observed a decreased glycogen utilization only in soleus muscle of the adrenalectomized rats. The results of Gorski et al. /16/ also demonstrated that adrenalectomy aggravated glycogen utilization in muscles composed mostly of the oxidative fibres as well as of the oxidative-glycolytic fibres but not in muscles composed mostly of fast-twitch glycolytic fibres. The dependence of the influence of adrenal insufficiency on the type on muscle fibres explains the various results of studies, indicating either exaggerated /46/ or unchanged /27/ glycogen utilization in adrenalectomized rats during exercises.

Taking into consideration the essential role of epinephrine in muscle glycogenolysis during exercise /5,13, 28,38,39,45/, the lack of this hormone aggravates glucogenoly-

sis in oxidative muscle fibres of adrenalectomized rats. Similarly to the effect of adrenalectomy, the β -adrenergic blockade with the aid of propranol administration excluded the decrease in glycogen content both in oxidative-glycolytic and oxidative muscles of the rat during running or swimming. In the glycolytic muscles glycogenolysis was blocked after 30 min running but was almost normal after running to exhaustion /15/. However, the release of norepinephrine from the sympathetic nerve endings may at least partially compensate for the lack of epinephrine. The effect of norepinephrine on the muscle glycogenolysis is demonstrated /34/. The facts that surgical or chemical sympathectomy could not prevent glycogenolysis during exercise /38,43, 54/ do not eliminate the possibility that norepinephrine may compensate for the lack of adrenaline in adrenalectomized rats. The observed increase of glycogen utilization by glucocorticoid administration to adrenalectomized rats during exercise confirms the role of corticosteroids in exercise-induced glycogenolysis.

The increased rate of contracture development in the soleus muscle of adrenalectomized rats after exercise confirmed the aggravation of glycogenolysis due to adrenal insufficiency. The previous results reached at our laboratory indicated that the rate of contracture development in isolated muscles is inversely related to the possibilities for glycogenolysis /51/.

The effect of glucocorticoids on the glycogenolysis in skeletal muscles might be actualized through the permissive effect of glucocorticoids on the catecholamine action /9,17/ as well as through the inhibition of blood glucose utilization /30,33/. The lack of glucocorticoid effect on glucose utilization in adrenalectomized rats, obviously, disturbed the blood glucose homeostasis and became a factor promoting hypoglycemia during prolonged exercise.

Epinephrine is unessential for the stimulation of liver glycogenolysis during exercise /2,6,14,28/. The effects of adrenalectomy on the hepatic glycogenolysis are therefore mainly related to the adrenocortical insufficiency. In previous studies an enhanced drop of liver glycogen was found in adrenalectomized rats after exercise /16,27,46/. This result can be explained by the aggravated sparing of glycogen utilization due to the disorders in lipid mobilization found in exercising adrenalectomized rats /16,27,46/, as well as by the reduced rate of gluconeogenesis. The latter is related: (1) to the

induction or activation of various gluconeogenic enzymes /9,53/ including glycogen synthetase /7,44/ and glycogen synthetase phosphate /31/ by glucocorticoids, (2) to the permissive action of glucocorticoids with regard to various gluconeogenetic agents /9,17/ and (3) to the influence of glucocorticoids on the glucose-alanine cycle /8,12,20/.

The natural results of aggravated sparing of glycogen utilization and reduced gluconeogenesis is a pronounced hypoglycemia. Consequently, there are at least two factors promoting hypoglycemia in exercising adrenalectomized rats. We found approximately equal low glycogen content in the liver of adrenalectomized and normal rats after 3 h swimming but the hypoglycemia was more pronounced in adrenalectomized animals. The latter might be related to the insulin effect. In adrenocortical insufficiency the insulin effects are augmented /3/. When adrenalectomized rats had to swim until exhaustion the dexamethasone administration increased the glycogen drop in the liver together with less pronounced hypoglycemia in comparison to saline-treated adrenalectomized rats. Obviously, glucocorticoids exert also a effect promoting the utilization of hepatic glycogen. In humans it was found that dexamethasone increased total glucose fluxes through glucose-6-phosphatase /52/. The data on the glucocorticoid effect on the hepatic glucose production are conflicting. Glucocorticoids have been reported to decrease /35/, increase /19/, or not affect /32,52/ glucose production. The resulting effect of glucocorticoids obviously depends on the interrelation with other agents, on the first place with insulin /3,52/.

Comparison of swimming effects of various duration in normal rats revealed that after an initial decline in liver glycogen it levelled off in conjunction with the high level of corticosterone in blood (Fig. 1.). This stabilization of glycogen content can be explained by the effective gluconeogenesis, the rate of which was equal to the rate of glucose output. Obviously, such situation is possible on the background of using lipids as the main oxidative substrate in contracting muscles. When the duration of swimming was 16 h there was a decrease of corticosterone concentration in the blood. Then a new drop in liver glycogen occurred. Thus in case of an inadequate level of glucocorticoids the gluconeogenesis is disturbed reminding of the situation in adrenalectomized rats.

The effective gluconeogenesis depends on the hepatic enzyme systems as well as on the supply of the liver by gluco-

neogenic substrates. In adrenalectomized rats the alanine levels were suppressed in blood, skeletal muscles, and liver in resting state, confirming the essential role of corticosteroids in the control of glucose-alanine cycle /8,12,20/. Differently from normal rats, adrenal insufficiency excluded the rise of alanine levels by exercise. When in normal rats elevated alanine contents are associated with increased activity of alanine aminotransferase in oxidative muscle fibres, in adrenalectomized rats the activity of this enzyme did not change in muscles and decreased in hepatic tissue during exercise. Glucocorticoids possess an essential role in the induction of this enzyme /4,40,42/. The dependence of exercise-induced changes in the activity of alanine-aminotransferase on corticosteroids was confirmed by the increase of activity after exercise in adrenalectomized rats treated with corticosterone. In normal rats training excluded the rises in blood corticosterone and the activity of hepatic alanine-aminotransferase.

The glucose-alanine cycle supplies the urea formation by amino groups in the liver, and thus the observed high urea levels in the tissues of adrenalectomized rats were connected with its impaired elimination /24/ rather than its increased production. Obviously, due to the decreased arginase activity during exercise, the further formation of urea was impossible in adrenalectomized animals.

In conclusion, the obtained results indicate that during prolonged exercise glucocorticoids participate in the mechanism of the starving of carbohydrate utilization, as well as of the stimulation of gluconeogenesis, glucose-alanine cycle and urea production. They seem to exert some effects also on hepatic glycogen utilization.

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PROTEIN METABOLISM IN MUSCLES AFTER THEIR ACTIVITY

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ABSTRACT

In Wistar rats 10-h swimming induced increased protein degradation rate in soleus muscle that persisted at least the first 24 hrs of postexercise recovery. Immediately after the exercise the protein synthesis rate was on the level of sedentary controls. During the 12 hrs of recovery period it decreased. The protein synthesis rate returned to the control level 24 h after the exercise and exceeded it 48 hrs after the exercise. In m. rectus femoris the contents of free tyrosine and 3-methylhistidine increased in a period from 2 to 24 hrs after the end of swimming. This was accompanied with the augmented blood level of tyrosine and corticosterone and an elevated glycogen content in the liver and muscle. It was followed by an augmented 3-methylhistidine excretion on the second day of the recovery period. If in the skeletal muscle the 3-methylhistidine level was augmented for a 22-hour period then in the intestinal tissue the 3-methylhistidine level was elevated only during the first two hours after exercise. We may conclude: (1) The recovery period is not characterized only by an augmented anabolism, but also by an increased rate of protein turnover in the muscle. (2) The increased 3-methylhistidine excretion after an exercise must not be considered as an index of the prevalent breakdown of contractile proteins but as a sign of their increased turnover. (3) There is only a minor contribution of 3-methylhistidine derived from intestinal tissue to its increased excretion after exercise.

Key words: Protein metabolism, exercise.

INTRODUCTION

The recovery period after exercise is considered to be related to protein anabolism. This is evidenced by nitrogen retention [2, 4], an elevated rate of amino acid incorporation into various fractions of the skeletal muscle proteins [6,15,20,25,34] and by an increased protein content of exercised muscles [1,36]. An increased protein synthesis rate has been detected in humans during the recovery period [20,26]. The following experiments were performed with the aim to prove the increased protein turnover in muscles during the recovery period.

METHODS

Wistar rats (body weight 170–200 g) were maintained on the standard diet, containing 12% of protein (excluding any meat proteins), 28% of carbohydrates and 9% of fat. Water was allowed ad libitum. 6 rats were used as sedentary controls. The others swam all together in a water tank of 40 cm depth. The relatively small water surface (on the average 100 cm² for each animal) forced them to swim actively. The water temperature was 33±1°C. After the end of swimming the rats were divided into 6 groups of 5–6 animals. 1,2,6,24 and 48 hours after the end of swimming the rats of a group were bled by heart puncture, performed within a 2 min period of light ether anesthesia. The tissue samples of m. rectus femoris, liver and intestine were separated immediately. In m. rectus femoris the contents of protein [17], free tyrosine [32], glycogen [16] and 3-methylhistidine [10], were determined. Protein and 3-methylhistidine contents were determined in the tissue of intestine, too. The free tyrosine [32] and corticosterone in blood plasma [13] the glycogen in liver [16] and the 3-methylhistidine in urine [24] were assessed. The urine collection was performed in 48-hour groups during postexercise recovery period as well as in sedentary control rats. The urine was collected in special individual cages.

To investigate the influence of the exercise bout described above on the protein metabolism in the soleus muscle separate groups of animals (weighing 120–140 g) were used. The rates of protein synthesis and degradation were assessed [8] immediately on the cessation of the exercise and after

6, 12, 24 and 48 h. By this time schedule the groups of 6 rats were sacrificed - 3 for determining the rate of synthesis and 3 to measure the degradation rate.

To determine the rate of protein synthesis the soleus muscle of one leg from each of the 3 rats was preincubated for 30 min at 37°C in a flask containing 3 ml of Krebs-Ringer bicarbonate buffer [30], containing chloroamphenicol 0.3 µg/ml, 10 mM glucose and L- U ¹⁴C -tyrosine (0.1 mM, 0.245 µCi/ml), pH 7.4. After the preincubation the muscle was transferred into a flask containing 3 ml of fresh medium and incubated for 2 hours. During both incubations, the flasks were shaken and mediums aerated with 95% O₂ - 5% CO₂ mixture. The soleus muscle of the opposite legs were used for measuring the inulin space. The muscle was incubated in the presence of inulin -¹⁴C- carboxylic acid (2.7 µM 0.02 mCi/ml). The inulin space did not change substantially during the experiments and at the end of incubation, the ¹⁴C-inulin content per mg of muscle was equal to the ¹⁴C inulin in 0.297±0.022 µl of the medium. This value was used to calculate the specific activity of the intracellular tyrosine, on the basis of which the nanomoles of tyrosine incorporated into protein were calculated [8].

The intensity of the liberation of tyrosine from muscular protein was taken as a measure of the rate of protein degradation. Free tyrosine content was assessed in the muscle tissue and in the medium after 2 hour incubation of the muscle in the presence of cycloheximide (0.5 mM). The incubation conditions were as described above. Since muscle neither synthesises nor degrades tyrosine [3,22] and the protein synthesis was blocked by cycloheximide, the changes of its content in the muscle and incubation medium must mirror the changes in the rate of protein degradation.

The differences between the mean values of the groups were statistically evaluated by Student-Fisher t-criterion.

RESULTS

Immediately after 10-hours swimming the protein degradation rate was increased by 36%, the protein content decreased by 26% and the protein synthesis rate remained approximately at the level of sedentary controls in the soleus muscle (Figure 1). During the postexercise recovery period the protein degradation rate remained on elevated levels. The protein synthesis rate decreased during the first 12 hours of the recovery period. 24 hrs after the end of exercise it increased to the initial level (the difference from the values the control group was not statistically significant, $p > 0.05$). 48 hrs after the end of exercise the protein synthesis rate significantly exceeded the rate obtained in sedentary rats. (Figure 1).

The studies of postexercise metabolism were started 1 h after the end of exercise in m.rectus femoris, as well as in liver, blood and intestinal tissue. 1 h after the exercise the ratio of dry weight to the wet weight was slightly decreased in the muscle tissue, indicating a tendency to hyperhydration. From the 2nd hour of postexercise recovery this ratio was on the level of the control group or slightly above it. In a period from 2 to 24 h after the end of swimming, increased contents of protein (per wet weight of tissue), free tyrosine and 3-methylhistidine (per g of tissue protein) were observed in the muscle. These changes are associated with a significant increase in the blood tyrosine at the same time and with the augmented 3-methylhistidine excretion on the second day of the recovery period (Figure 2).

As the samples of tissues of m.rectus femoris and liver were not taken immediately after the end of swimming the obtained data cannot be used for evaluation of the drop of glycogen reserves during exercise. However, the comparison of the data of exercised and sedentary rats indicated that already 2 hrs after the end of exercise a supercompensation of glycogen stores in the muscle and liver was achieved. Within 2 to 6 hrs after the swimming a postexercise elevation of the blood corticosterone level was detected (Figure 3).

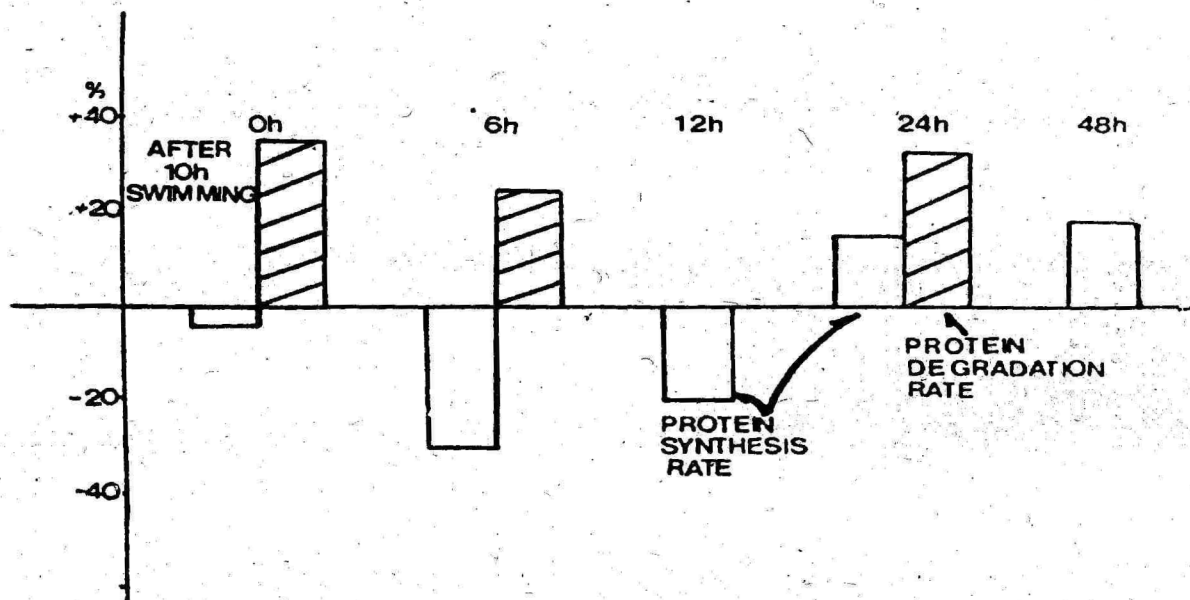


Fig. 1. Changes of protein synthesis (white columns) and degradation (striated columns) rates in soleus muscle during the recovery after 10 h swimming as expressed in per cent. The time is indicated from the end of exercise.

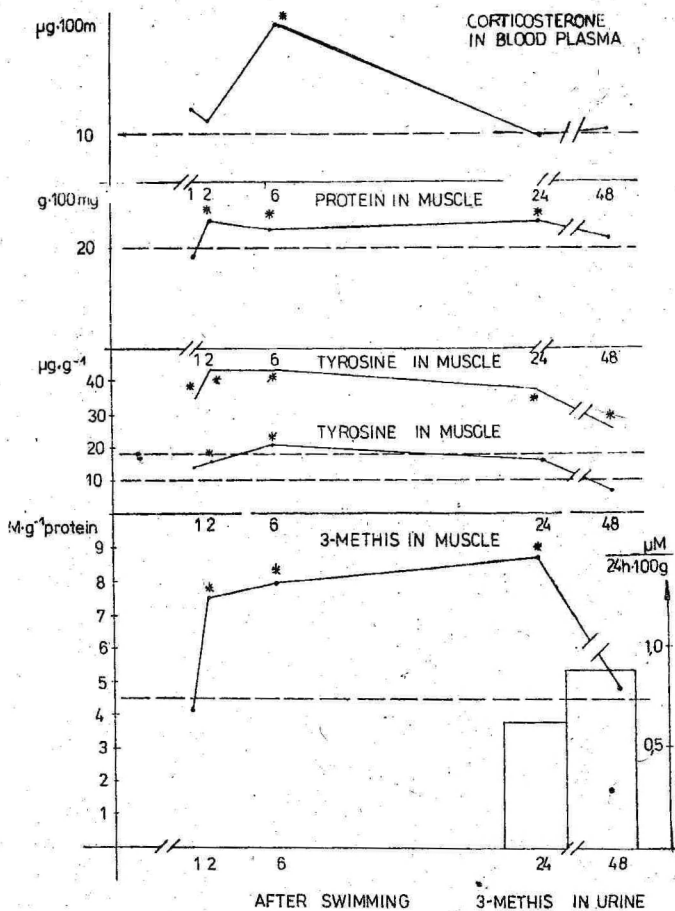


Fig. 2.

Concentration of corticosterone in blood plasma, contents on protein in m. rectus femoris, tyrosine in muscle and 3-methylhistidine in skeletal and intestinal muscle 1,2,6,24 and 48 h after swimming for 10 h in rats. The columns at the bottom of the figure indicate the excretion of 3-methylhistidine. The interrupted horizontal lines denote the levels of control groups. The statistically significant differences ($P < 0.05$) between results and control group level are indicated by asterisk.

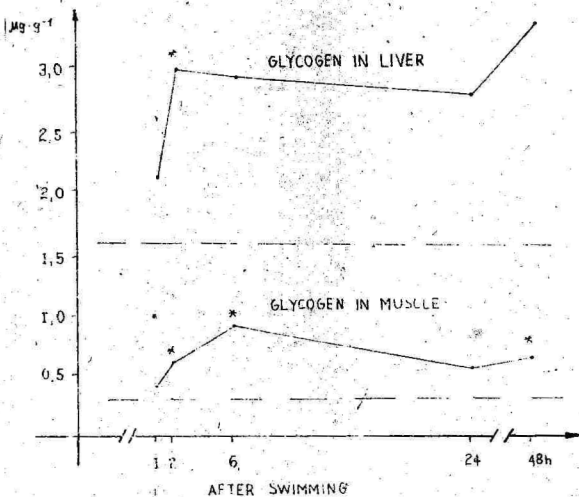


Fig.3

Contents of glycogen in liver and in m.rectus femoris 1,2,6,24 and 48 h after swimming for 10 h in rats.

1 h after the end of exercise the free 3-methylhistidine content in the intestinal tissue was on the level of sedentary control rats. During the 2nd hour of postexercise recovery a rapid increase of 3-methylhistidine concentration was obtained (Fig. 2). It was followed by a return to the normal level. From the 6th postexercise hour the 3-methylhistidine in intestinal tissue content did not differ from the values of the control group.

DISCUSSION

In accordance with the data of various authors (6,15,20,25,26,34), the obtained results confirm the increase of protein synthesis rate in postexercise recovery period. However, in the rat soleus muscle this change was observed only after 48 hours of recovery following 10 hours of swimming. The protein synthesis rate was on the initial level immediately after swimming. Within 6-12 h after the end of exercise it decreased and only then an increase was observed. A similar dynamics of synthesis rate of myosin fractions and of actin was established in a previous study in our laboratory [29]. These results suggest that the intensive protein synthesis in a

working muscle is common only in a delayed stage of the recovery period.

The protein degradation rate tended to increase immediately after the end of exercise. A high intensity of protein degradation persisted at least 24 hrs after the exercise. Obviously, as a result of the intensive protein degradation the protein content in the soleus muscle decreased during exercise. The followed increase of protein synthesis rate is associated with the normalization of the protein content 24 h after the exercise. However, the further intensive protein synthesis did not lead to the increased protein content. It indicates the concomitant maintenance of elevated protein degradation.

The comparison of obtained results reveals a disbalance between the rates of protein synthesis and degradation. In control animals the total amount of free tyrosine in muscle and incubation medium at the end of 2-hour incubation of soleus muscle indicated a degradation rate that preceded the tyrosine incorporation rate about 5 times. It was due to the fact that the amount of the free tyrosine, normally in muscle tissue, was accounted. On the other hand, the protein synthesis rate might be underestimated to some extent. The use of the whole soleus muscles (the weight of which ranged from 39 to 51 mg, average 44.3 mg) possibly brought about an error due to the incomplete diffusion of substrates [5], and oxygen [18] into muscle tissue. However, it was hoped that these disadvantages were minimized by the comparatively long incubation period (2 hours), and also by continuous shaking and aerating the flasks. In addition, errors due to the possible cellular damages, that would be quite real in the case of using muscle strips and absolutely inevitable in the case of minced muscle were avoided by the used procedure. On the basis of a critical analysis of measurement of protein turnover rates in individual tissues J.C. Waterlow concluded that the main value of *in vitro* methods is for determining the mechanisms, not rates [33].

Taking into account the changes, expressed in per cent (Figure 1) the increase of protein degradation rate 24 hrs after the exercise was approximately twice as high as the elevation of protein synthesis rate. Despite the possibility of a further achievement of equilibrium between protein synthesis and degradation, the prevalence of protein degradation during the first stage of recovery explains why the elevation of protein

synthesis was not in the increased protein content of soleus muscle.

In m. rector femoris as well as in soleus muscle the recovery period coincided with signs of increased protein degradation (increased free tyrosine and 3-methylhistidine levels). This was observed in a period from 2 to 24 hrs after the end of exercise and coincided with elevated blood corticosterone level and supercompensations of glycogen reserves in the liver and muscle. Glucocorticoids are known as a catabolic agent [7,9,12,28]. However, their role in the elevated degradation of muscle proteins still remains obscure. A special experiment indicated that the dynamics of increased excretion of 3-methylhistidine was quite similar in adrenalectomized and sham operated rats during the recovery days after exercise days [31].

We did not get convincing evidences about the enhanced protein synthesis in m. rectus femoris after the exercise. The obtained modest increase in protein content might in part be due to a slight dehydration. However, at least the maintenance of the normal protein content in conjunction with the elevated degradation required an increase in the synthesis rate.

All the obtained results together indicate that in postexercise recovery the enhanced protein synthesis proceeds and/or coincides with the increased intensity of protein degradation, constituting an increased protein turnover. This agrees with the results of other studies [20,25,26]. It has been established that training or compensatory work hypertrophy are accompanied by an elevated rate of protein turnover [11,14,23,33,35]. Accordingly, it has been concluded that the rapid growth of the skeletal muscle coincides with the rapid protein breakdown [33]. The increased protein turnover, consequently, contributes to the renewal of the molecular content of the actinomyosine complex and of other muscle proteins to replace the physiologically exhausted structure elements with the aim to ensure the enhanced firmness of the contractile function.

At rest conditions a considerable amount of 3-methylhistidine is released from the smooth muscles of the gastro-intestinal tract [21,27]. However, when in the skeletal muscle the 3-methylhistidine level was augmented during a period from 2 to 24 hrs after exercise, in the intestinal tissue of rats the 3-methylhistidine level was elevated only during the first

hours after exercise (Fig. 2). This obviously does not account for the delayed increase in the excretion of 3-methylhistidine.

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ALL-OUT ANAEROBIC CAPACITY TESTS: CYCLE ERGOMETER, JUMPING AND RUNNING LOADS COMPARED

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ABSTRACT

Three different all-out anaerobic tests were used: 45 s and 2 min bicycle ergometer, jumping (Bosco's test modification) and running on the indoor track. Six male (MR) and five female (FR) long distance runners and six nonsportsmen (NS) volunteers participated. The mean \dot{V}_{O_2} max/kg were 60.3 ± 2.1 ; 43.4 ± 3.6 ; 45.8 ± 2.0 ml.min⁻¹. kg⁻¹, respectively. In all the anaerobic tests venous blood samples were taken 3-5 min before the start, 5 min, 30 min and 40 min of recovery. There were no significant differences in the lactate concentrations after the tests between the groups (except between FR and NS after the 2-min running test). During the 45 s running test the glucose concentration increased significantly in FR ($p < 0.05$). After the 2 min running test the glucose concentration increased significantly in all groups. The insulin and cortisol concentrations did not change significantly during different anaerobic tests and not during the recovery period either (except a significant increase of insulin and glucose concentration after a 2-min running test in the FR group).

KEY WORDS: Anaerobic tests, glucose, lactate, cortisol, insulin, long distance runners, non-sportsmen

INTRODUCTION

During intensive muscular work the need for energy exceeds the supply from aerobic sources and energy must then be produced from anaerobic sources by a breakdown of creatin phosphate (CP) and anaerobic glycolysis. During maximal muscular effort the CP stores are depleted, according to theoretical calculations, in 5-7 s [32,36]. Experimental studies have also shown that the glycolytic metabolism is involved in exercise lasting less than 10 s [22,24,26]. We must assume that the alactic and lactic metabolisms act simultaneously a few seconds after the beginning of an exercise. De Bruyn-Prevost and Sturbois [11] demonstrated that glycolytic power via lactate synthesis increases from the beginning of work to approximately 45 s. Hultman and Sjoholm [23] have also shown that glycolysis reached its maximum between 40-50 s. During a 1 min bicycle ergometer test the correlation was the highest ($r=0.70$; $p<0.01$), between the blood lactate (LA) concentration and average power produced during the third period (30-45 s) becoming non-significant during the last 15 s period [18]. The glycolytic system is primarily involved in the regeneration of ATP with exercises lasting up to 2 min [14,38].

When comparing the endurance type of exercise there are relatively few data about the hormonal adaptation to the short-term exercise. It is well-known that the catecholamines stimulate muscle glycogenolysis which produces lactate. Intensive exercises increase the levels of circulating catecholamines [30]. Adrenalin is a powerful stimulator of hepatic gluconeogenesis [6] and glucogenolysis [16]. On the other hand, adrenaline inhibits insulin secretion but hyperglycemia can stop this inhibition [2]. The insulin concentration in blood increases mostly during short-term exercises [12,20,34]. Little attention has been paid to the study of females.

Relatively short-term intensive exercises activate the pituitary-adrenocortical system, too. The blood cortisol concentration increases [28,29,33,41]. The increase can continue during 10 to 30 min of the recovery period, too [45].

The methods commonly used for the measurement of the anaerobic working capacity consist of various tests of maximal effort such as Wingate test [1], 60-s maximal test on bicycle ergometer [42], 60 s jumping test [39], short-term running tests [28] and others.

The aim of this investigation was to compare the influence of three different anaerobic tests of the same duration but with different power output to the lactate, glucose, insulin and cortisol concentrations in the blood in trained and untrained young males and females.

MATERIAL AND METHODS

Six male long distance runners (MR, 60-100 km running per week), five female long distance runners (FR, 40-60 km running per week) and six male nonsportsmen (NS) volunteered to take part in the study. Characteristics of the subjects are presented in Table 1.

Table 1

Physical variables of the subjects (Mean±SD)

	Male runners (n=6)	Female runners (n=5)	Male control (n=6)	Total (n=17)
Age (years)	22.3±1.8	20.0±2.1	18.8±1.3	20.4±2.3
Height (m)	1.84±0.06	1.69±0.07	1.77±0.06	1.77±0.09
Weight (kg)	73.7±6.8	61.0±6.9	66.2±6.0	67.3±8.3
\dot{V}_{O_2} max/kg (ml·min ⁻¹ ·kg ⁻¹)	60.3±2.1	43.4±3.6	45.8±2.0	50.2±8.0
AT _{LA} (HR)	160.8±10.2	166.5±9.5	168.0±3.7	165.1±8.5
AT _{LA} (W)	264.0±10.8	186.7±8.5	195.0±9.1	215.2±36.8
AT _{HR} (HR)	161.3±8.5	167.0±8.4	169.7±2.9	166.0±7.6
AT _{HR} (W)	264.5±15.1	188.2±8.4	199.5±10.9	217.4±36.3

Determination of maximal oxygen consumption \dot{V}_{O_2} max and anaerobic threshold (AT). In FR and NS the first load on the bicycle ergometer was 50W and it increased every 3 min by 50 W to 200 W, the last load was 225 W and the work terminated in a 1 min sprint (150 W) at maximal speed. In MR all the loads were 50 W higher. During the last 30 s of each load and the 1-min sprint the air samples were collected (a paramagnetic O₂ analyzer and infrared CO₂ analyzer used), at the same time the blood samples from fingertip were taken for LA measurements (Boehringer Mannheim, FRG)

and heart rate (HR) was measured by SPORTTESTER PE-3000 (Finland). Both 4 mmol.l^{-1} blood LA [19,31] and HR [5,9] criterion methods were used to calculate the AT.

Supramaximal tests on bicycle ergometer.

Two tests (45 s and 2 min) on the bicycle ergometer were used. The resistance at the pedals was 5.5 W/kg in MR and 5.0 W/kg in FR and NS. The pedal rate was measured during each 5 s and total power was calculated.

Supramaximal tests on force platform.

A modification of Bosco et al. [3] jumping test was used. The duration of jumping was 45 s and 2 min. The flight time during jumping in the force platform was registered graphically. The power was calculated by Bosco et al. [3] equation.

Supramaximal running tests. The subjects ran on the indoor track at maximal speed during 45 s and 2 min.

Before all the supramaximal tests individual 10-15 min warming-up was used. All short-term tests were performed from 09.00 to 12.00 a.m. Only one test was performed per day.

Blood samples. During all the anaerobic tests approximately 1 hr before the start the vena cava were cannulated by teflon cannula (VENFLON, VIGGO PRODUCTS, SWEDEN). Venous blood samples (5-7 ml) were taken 3-5 min before the start and after 5 min, 30 min and 40 min of recovery.

In the blood plasma the concentration of LA (enzymatic method, Boehringer Mannheim, FRG), glucose (enzymatic method, Lachema kits, CSFR), insulin and cortisol (by specific radioimmunoassay with the help of the kits of the Institute of Bioorganic Chemistry of Byelorussian Academy of Sciences,; based on methods recommended by Jaffe and Behran, [25]) were measured.

Statistical analysis involved the determination of means (\bar{x}), standard deviations (SD) and correlation coefficients (r). Their significance was determined by the Student t-test for paired series with a probability threshold of $p < 0.05$.

RESULTS

Average values and standard deviations in \dot{V}_{O_2} max and AT, calculated by different methods are presented in Table 1. There were no significant differences between the two methods used for calculating the AT values.

Mean power (Table 2) on the 45 s anaerobic bicycle test was not significantly different between groups. The jumping power of MR during the 45 s test was significantly higher than that of FR and NS ($p < 0.05$). A similar situation was noticed during the running test ($p < 0.01$). The mean power in the 2-min bicycle test of NS was significantly higher than that of MR ($p < 0.05$). The mean power of MR was higher than that of FR ($p < 0.05$) and NS in the jumping test ($p < 0.01$). The mean power of the 2-min running test for MR was significantly higher than in the case of FR ($p < 0.01$) and NS ($p < 0.05$). The mean power was the highest during running tests in all groups ($n=17$). The average power developed during the 45 s running test of the total group correlated significantly with the mean power of the ergometer test ($r=0.401$) and jumping test ($r=0.461$), the correlation coefficients were nonsignificant between different 2 min tests. The correlation was significant between the 45 s and 2 min running ($r=0.805$) and jumping ($r=0.592$) tests.

Table 2

Mean power output (W/kg) during different short-term exercises (Mean \pm SD)

		Male runners	Female runners	Male control	Total
Bicycle	45 s	9.47 \pm 1.36	8.33 \pm 0.47	8.43 \pm 0.85	8.77 \pm 1.16
	2 min	5.80 \pm 0.47	5.68 \pm 0.78	6.56 \pm 0.34	6.05 \pm 0.69
Jump	45 s	21.31 \pm 3.56	16.26 \pm 1.96	17.07 \pm 2.28	18.33 \pm 3.52
	2 min	19.08 \pm 3.25	13.90 \pm 2.35	12.17 \pm 2.51	15.12 \pm 4.08
Run	45 s	26.86 \pm 0.89	23.09 \pm 0.80	23.53 \pm 1.80	24.58 \pm 2.18
	2 min	24.01 \pm 1.21	19.79 \pm 0.92	21.07 \pm 2.66	21.73 \pm 2.60

The changes in the LA concentration during different tests are presented in Figure 1. There were no significant differences between groups in the 5th minute of recovery after the 45 s tests. The LA concentration of FR was significantly higher than that of NS ($p < 0.05$) after the 2 min running tests.

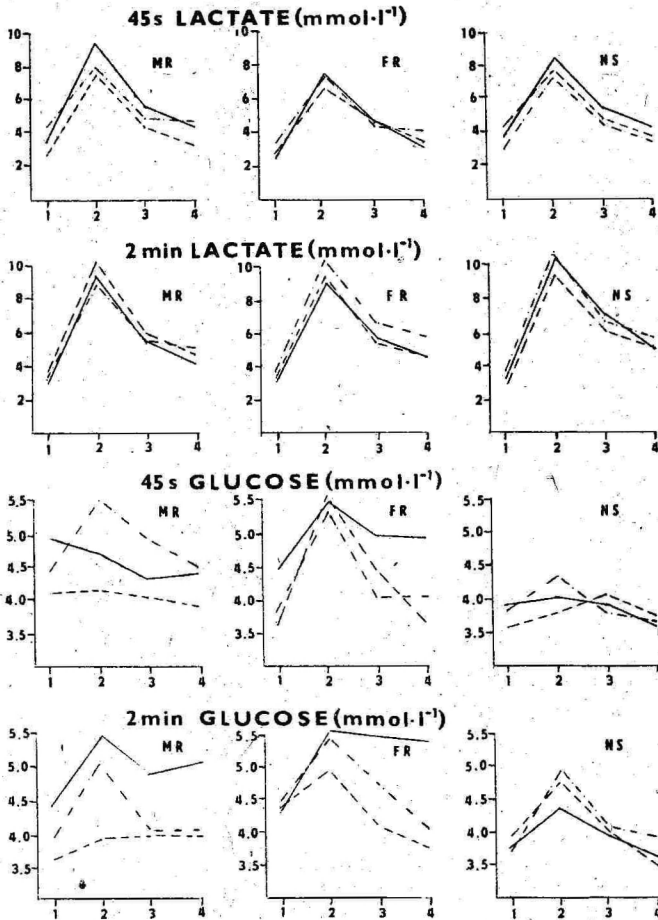


FIGURE 1.

Changes in the lactate and glucose concentrations in blood during different anaerobic tests.

1. before test 2. 5 minute of recovery 3. 30 min of recovery 4. 40 min of recovery

- male runners
- - - female runners
- · - · nonsportsmen

The glucose concentration in the blood did not change during the 45 s bicycle and jumping tests (Figure 1). The FR glucose concentration increased significantly during the 45 s running test ($p < 0.05$). The glucose concentration increased significantly after a 2 min running test in all groups (Figure 1).

The changes in the cortisol and insulin concentrations in the blood during different tests are presented in Table 3. and Table 4. There were no significant changes during different tests and during the recovery period (except a significant increase in the insulin concentration of the FR group after the 2 min running test).

Table 3

Changes on the cortisol (nM.l^{-1}) concentration during different short-term exercises (MEAN \pm SD)

		Male runners	Female runners	Male control	Total	
Bicycle:	45 s before	612.1 \pm 227.5	703.1 \pm 303.3	746.4 \pm 387.4	687.2 \pm 299.6	
	5 min	525.4 \pm 336.1	787.2 \pm 249.1	772.6 \pm 350.0	695.0 \pm 320.6	
	30 min	686.0 \pm 329.2	747.2 \pm 240.9	820.7 \pm 476.3	751.3 \pm 344.8	
	40 min	627.8 \pm 319.5	660.1 \pm 138.7	763.7 \pm 453.7	683.9 \pm 315.8	
	2 min before	557.8 \pm 162.1	592.4 \pm 153.5	759.9 \pm 284.1	636.7 \pm 216.0	
	5 min	692.4 \pm 293.6	619.3 \pm 216.0	787.5 \pm 288.6	700.2 \pm 259.8	
	30 min	663.2 \pm 222.0	787.2 \pm 228.7	779.6 \pm 294.8	743.3 \pm 242.6	
	40 min	688.5 \pm 270.0	844.0 \pm 236.7	901.5 \pm 348.5	809.4 \pm 289.4	
	Jump:	45 s before	519.2 \pm 119.6	563.7 \pm 128.9	628.8 \pm 84.6	570.6 \pm 115.5
		5 min	522.8 \pm 156.3	768.9 \pm 546.8	566.8 \pm 140.6	619.5 \pm 336.3
30 min		413.8 \pm 108.5	555.7 \pm 139.7	563.2 \pm 149.2	510.9 \pm 144.1	
40 min		461.6 \pm 117.0	477.5 \pm 134.6	555.3 \pm 155.4	498.1 \pm 135.0	
2 min before		498.9 \pm 98.6	483.2 \pm 112.5	621.2 \pm 167.2	534.4 \pm 137.2	
5 min		431.8 \pm 129.2	537.3 \pm 127.4	624.9 \pm 82.0	531.4 \pm 135.2	
30 min		398.8 \pm 165.4	542.7 \pm 126.4	621.4 \pm 122.8	521.0 \pm 161.8	
40 min		387.2 \pm 163.3	520.6 \pm 135.7	640.1 \pm 101.4	515.9 \pm 166.1	
Run:		45 s before	563.4 \pm 102.3	626.2 \pm 219.0	496.7 \pm 135.3	558.4 \pm 154.5
		5 min	524.3 \pm 107.2	605.4 \pm 220.7	593.0 \pm 243.4	572.4 \pm 188.8
	30 min	492.9 \pm 157.7	685.2 \pm 187.5	538.1 \pm 149.4	569.9 \pm 188.3	
	40 min	519.5 \pm 181.3	619.9 \pm 180.0	477.3 \pm 160.9	535.1 \pm 172.8	
	2 min before	505.2 \pm 160.0	616.1 \pm 182.3	506.2 \pm 104.4	538.2 \pm 149.7	
	5 min	524.5 \pm 141.8	513.0 \pm 192.3	523.6 \pm 132.6	520.8 \pm 145.1	
	30 min	576.2 \pm 145.3	701.8 \pm 130.9	518.2 \pm 108.8	592.7 \pm 143.1	
	40 min	557.9 \pm 110.0	625.7 \pm 104.6	487.5 \pm 110.0	553.0 \pm 116.5	

Table 4
Changes on the insulin (ml.ml⁻¹) concentration during
different short-term exercises (MEAN±SD)

		Male	Female	Male	Total	
		runners	runners	control		
Bicycle:	45 s before	14.3±16.2	11.1±7.1	16.6±17.8	14.0±13.8	
	5 min	12.0±5.7	16.2±4.8	15.9±12.3	14.8±8.1	
	30 min	9.8±5.2	9.6±8.3	15.2±14.6	11.8±10.2	
	40 min	10.4±9.9	10.6±9.9	19.9±15.5	13.6±12.2	
	2 m before	14.1±4.8	8.2±5.1	18.2±12.0	13.1±8.5	
	5 min	17.4±5.2	22.1±15.6	20.4±11.2	20.1±11.2	
	30 min	7.7±4.5	10.4±6.2	8.9±4.1	8.9±4.7	
	40 min	13.5±16.1	7.1±4.1	17.0±17.4	12.9±14.0	
	Jump:	45 s before	17.4±12.3	20.8±20.6	13.4±10.8	17.4±14.8
		5 min	15.0±11.2	24.4±12.9	15.7±13.8	18.5±12.6
30 min		16.0±13.6	23.3±18.8	18.4±10.9	20.0±14.5	
40 min		12.3±10.0	20.5±16.8	9.9±7.6	20.5±20.7	
2 min before		16.8±7.9	19.9±16.4	16.4±14.4	20.1±16.4	
5 min		21.7±7.3	31.1±11.8	15.7±17.8	23.2±13.4	
30 min		12.6±8.6	13.1±4.7	12.7±7.0	12.8±6.5	
40 min		16.5±10.8	13.5±8.2	15.0±10.6	14.9±9.2	
Run:		45 s before	11.7±6.8	18.0±14.2	19.8±20.6	16.4±13.4
		5 min	16.4±5.5	21.9±6.3	18.6±10.9	18.9±7.6
	30 min	11.0±5.6	7.7±3.0	16.3±15.0	11.7±9.5	
	40 min	13.4±6.6	8.0±7.7	14.0±12.8	13.0±9.8	
	2 min before	20.4±15.6	10.5±8.6	10.9±9.9	14.9±12.5	
	5 min	23.8±11.2	26.3±8.2	18.1±3.5	22.8±8.6	
	30 min	11.3±4.6	11.7±4.7	14.2±12.9	12.3±7.7	
	40 min	10.8±5.5	8.4±6.1	12.4±10.3	15.3±13.8	

*p<0.05

DISCUSSION

The \dot{V}_{O_2} max and AT of our runners measured by two methods before anaerobic tests indicate that they have a relatively high aerobic working capacity [4,13,43].

Several protocols have been presented to measure maximal leg power; cycle ergometer, jumping and running are the most popular. The power depends on the force and velocity. Maximal muscular power is obtained at optimal values between variables. The highest mean power in our study was during the running tests (Table 2). The correlation coefficients between the 45-s and 2-min tests were not so high as presented by Katch et al. [27] for the 40 s and 2-min tests (r=0.95).

The LA concentration after the 45-s and 2-min maximal tests at the 5th minute of recovery were relatively low in our study. Surprisingly, there were no significant differences

between the groups (except between FR and NS after the 2-min running test). On the other hand, in long distance runners the LA concentration is lower than in sprinters, as a rule [37,44]. The relatively low LA concentrations can be attributed to the circumstance that we measured the concentration at the 5th minute of recovery. After short duration tests the peak concentration is achieved after approximately 7.5 minutes of recovery [10,15]. The concentration of LA was relatively high after the warming-up, too (Figure 1).

The glucose concentration increased significantly after the 2 min running test in all groups (Figure 1). A rise in glucose production without unchanged insulin levels (except FR) may be found as a response to the exercise conditions with low initial insulin levels for trained individuals [17].

Insulin concentration in the blood increased significantly only after the 2-min running test in the FR group (Table 3). The glucose concentration increased simultaneously (Figure 1). As a rule, the insulin concentration decreased when the glucose concentration increased during a prolonged exercise [17,40]. When during a brief exercise \dot{V}_{O_2} exceeds approximately 50% of \dot{V}_{O_2} max the insulin concentration in peripheral plasma decreases, the decrease being directly related to working intensity [21]. On the contrary, Christensen and Brandsborg [7] noted that during an exercise of more than mild intensity the insulin secretion is rather insensitive to the change in plasma glucose concentration. Nevertheless, the results of studies are very different. Sometimes after heavy running the insulin and glucose concentrations increase simultaneously [12,34] or the insulin level decrease in proportion to the increased running distances - from 100m to the marathon race [39,46]. The simultaneous increase of insulin and glucose concentrations in our study of the FR group we can explain by Hermansen et al. [20] opinion that the high insulin level during short-term exercises is secondary to the increased blood glucose concentration. The high insulin concentration may be one of the factors that increase muscle glucose utilization and inhibits lipolysis. Secondly glucagon that is also increased during heavy running [35] has a stimulating effect on insulin secretion and the glucagon stimulus is effective despite the presence of normal amounts

of adrenalin [8]. In our study the correlation between the insulin concentration in blood and the work output during the 2-min running test was significant ($r=0.698$) only in the FR group. The correlation with glucose concentration was nonsignificant in all the groups.

The activation of the pituitary-adrenocortical system normally takes place if the intensity of exercise exceeds the level of 60-70 % of \dot{V}_{O_2} max. After a short term exercise the increase in the blood cortisol level continued during 10-30 min of recovery [45]. In our study the cortisol concentration did not change significantly during different anaerobic tests. Significant rises in the plasma cortisol concentration have been found after intense 5 min running [41], after 4.5 minute maximal work [33] or only a 1 min maximal exercise [29].

To conclude, the power putput during the 45-s and 2-min all-out bicycle-ergometer, jumping and running tests was the highest during running. There were no differences between tests in the maximal LA concentrations after exercises. The most powerful test – the 2-min running increased the glucose and insulin concentrations in the blood of the FR group simultaneously.

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CONNECTIONS BETWEEN THE HORMONE LEVEL IN BLOOD AND THE EFFECTIVENESS OF EXERCISE TRAINING

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ABSTRACT

The purpose of this experiment was to study the effect of systematic exercise training on body weight depending on different initial levels of insulin. During 8 weeks 130 female university students, aged 18–27 years, practised aerobic exercises (aerobic dance or jogging) three times 50 minutes per week (HR 140–150 beats.min⁻¹). Joggers (n=50) and dancers (n=80) were divided into groups according to the initial level of insulin: < 10,0 μU/ml; 10.0–20.0 μU/ml; > 20.0 μU/ml. Higher level of insulin was in accordance with bigger body weight but the reduction of body weight as a result of the training was the same.

The obtained data indicate that exercise training normalizes the level of insulin. Higher level of insulin did not reduce the effectiveness of weight-losing exercise training but decreased the improvement of PWC₁₇₀ and reduced the effect on plasma lipoproteins.

Key words: exercise-training, body weight, body fat, fat distribution, plasma insulin

INTRODUCTION

The increase in energy expenditure associated with aerobic exercise training can produce a mobilization of the energy stored in the adipose tissue if such an increase is not compensated by a decrease in other components of energy expenditure. Results from the exercise literature are not, however, unanimous in showing a body fat reducing effect of aerobic exercise-training in experimental conditions where the energy intake of subjects was not controlled. [1,14]

Many studies have shown that the regional distribution of adipose tissue is one important variable to be considered in

association between obesity and insulin secretion. [2,,5,6,7] Peiris et al. [11] suggest that obesity is associated with insulin hypersecretion, whereas upper body fat accumulation is associated with reduced hepatic insulin extraction and diminished insulin clearance. [12]

This experiment was to study the effect of systematic exercise training on body weight depending on different initial levels of insulin.

MATERIAL AND METHODS

Subjects were 130 female Tartu University students. Participants were subjected to a full physical examination by a physician which included medical history. Female students with cardiovascular disease, diabetes, or other endocrine disorders were excluded. Students had plasma glucose values > 140 but < 200 mg/dl 2h after an oral glucose tolerance test (OGTT) and were not diagnosed as having impaired tolerance following the classification of the National Diabetes Data Groups. Measurements were performed while the subjects were in the early follicular phase of their menstrual cycle and in an apparent weightstable period.

Training. The training sessions consisted of 50 minute exercises (aerobic dance or jogging HR 140–150 beats. min^{-1}). Exercises were performed three times a week.

Measurement of total body fat and physical working capacity. Body density was measured by Parizkova [10]. Fat mass was obtained by multiplying the percentage of body fat by body weight. Physical working capacity was assessed by the test of PWC₁₇₀. The test was performed on a bicycle ergometer according to Karpman [4].

Plasma determinations. Venous blood samples were taken before and after the training period (8 weeks) in the morning after 12 hours fasting. The blood sampling was adjusted to days 8–14 of the ovarian–menstrual cycle. Insulin levels were determined radioimmunologically [3], and blood lipids using routine methods.

Statistical analyses. Preexercise and postexercise values were compared using the Student t–test for paired observations. Correlation analyses were performed using the Pearson interglass coefficient.

RESULTS

Higher level of insulin was in accordance with bigger body weight but the reduction of body weight as a results of the training was the same (Table 1 and 2). The training-induced decrease of insulin level was more pronounced in the blood of joggers who had a higher initial level of insulin (Fig. 1). No changes were found in joggers with lower initial level. Dancers who had initial insulin level under 20 $\mu\text{U/ml}$ did not show any change but in most cases with initial level over 20 $\mu\text{U/ml}$ a reduction took place.

Table 1. Changes in anthropometric characteristics depending on the initial insulin level in blood serum in joggers. Results are means \pm S.D.

	Initial insulin level < 10.0	Initial insulin level 10.0-20.0
Age (years)	18.6 \pm 0.16	18.6 \pm 0.19
Height (cm)	167.1 \pm 1.14	166.4 \pm 1.43
Weight (kg) b	65.3 \pm 1.07	72.2 \pm 1.58
a	63.8 \pm 1.11	70.6 \pm 1.66
difference	-1.6 \pm 0.29	-1.6 \pm 0.33
Percent fat b	28.5 \pm 0.69	31.3 \pm 0.75
a	25.4 \pm 0.67	29.2 \pm 0.82
difference	-3.1 \pm 0.42**	-2.1 \pm 0.29
Body fat (kg) b	18.7 \pm 0.66	22.7 \pm 0.92
a	16.3 \pm 0.62	20.8 \pm 0.96
difference	-2.4 \pm 0.2**	-1.9 \pm 0.26
Fat-free b	46.6 \pm 0.65	49.4 \pm 0.91
mass (kg) a	47.5 \pm 0.71	49.8 \pm 0.93
difference	0.8 \pm 0.32	0.3 \pm 0.21
Index Kettle b	23.4 \pm 0.31	26.1 \pm 0.52
a	22.8 \pm 0.32	25.5 \pm 0.53
difference	-0.6 \pm 0.10	-0.6 \pm 0.13

n=50. b=before, a=after training.** indicates significant difference $P < 0.01$.

Table 2. Changes of antropometric characteristics depending on initial insulin level in blood serum in dancers.

Results are means \pm S.D.

		Initial insulin level ≤ 10.0	Initial insulin level 10.0-20.0	Initial insulin level ≥ 20.0
Age (years)		20.0 \pm 0.28	20.6 \pm 0.44	20.5 \pm 0.71
Height (cm)		166.2 \pm 0.83	164.7 \pm 0.93	163.8 \pm 1.88
Weight (kg)	b	69.5 \pm 1.42	77.8 \pm 1.95	80.5 \pm 3.58
	a	67.9 \pm 1.39	76.3 \pm 1.91	79.4 \pm 3.43
difference		-1.55 \pm 0.31	-1.54 \pm 0.26	-1.3 \pm 0.39
difference fat	b	29.3 \pm 0.58	33.9 \pm 0.80	33.9 \pm 0.97
	a	26.7 \pm 0.51	31.1 \pm 0.71	32.6 \pm 0.95
difference		-2.6 \pm 0.36**	-2.8 \pm 0.36**	-1.3 \pm 1.14
Body fat (kg)	b	20.6 \pm 0.77	26.8 \pm 1.26	27.5 \pm 1.89
	a	18.3 \pm 0.71	24.1 \pm 1.13	26.1 \pm 1.77
difference		-2.2 \pm 0.30*	-2.7 \pm 0.36	-1.4 \pm 0.23
Fat-free	b	48.8 \pm 0.76	51.0 \pm 0.81	52.9 \pm 1.82
mass (kg)	a	49.6 \pm 0.77	52.2 \pm 0.86	53.3 \pm 1.78
difference		0.7 \pm 0.25	1.21 \pm 0.29	0.3 \pm 0.19
Index Kettle	b	25.1 \pm 0.37	28.7 \pm 0.72	29.9 \pm 0.97
	a	24.5 \pm 0.37	28.1 \pm 0.70	-0.4 \pm 0.14
difference		-0.5 \pm 0.12	-0.5 \pm 0.09	-0.4 \pm 0.14

n=80. b=before, a=after training. * indicates significant difference $P < 0.05$, ** indicates significant difference $P < 0.01$, n.s. indicates no significant difference.

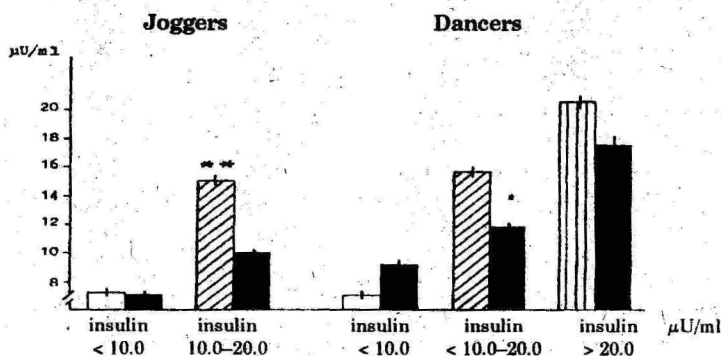


Fig. 1. Changes in blood insulin concentration during training in dependence on initial level in blood serum. White column - initial insulin level ≤ 10.0 , diagonally strated columns - initial insulin level 10.0-20.0 and verically striated columns - initial insulin level ≥ 20.0 uU.ml⁻¹. Black columns -insulin levels after training.

**p<0.01

These results indicate that exercise training normalizes the level of insulin and therefore reduces the risk of obesity. Higher level of insulin did not reduce effectiveness of exercise training with regard to weight reduction.

A dependence between the initial levels of insulin and PWC₁₇₀ was not found. In dancers the training effect on PWC₁₇₀ was reduced when initial level of insulin was over 20 $\mu\text{U ml}^{-1}$. However, in runners who had the initial level much higher (from 10 to 20 $\mu\text{U ml}^{-1}$) the training effect on the PWC₁₇₀ was more pronounced than in case of the initial level of insulin below 10 $\mu\text{U ml}^{-1}$ (Fig. 2). In dancers with the initial insulin level over 20 $\mu\text{U ml}^{-1}$, the training effect on the blood lipoprotein content was not observed (Fig. 3).

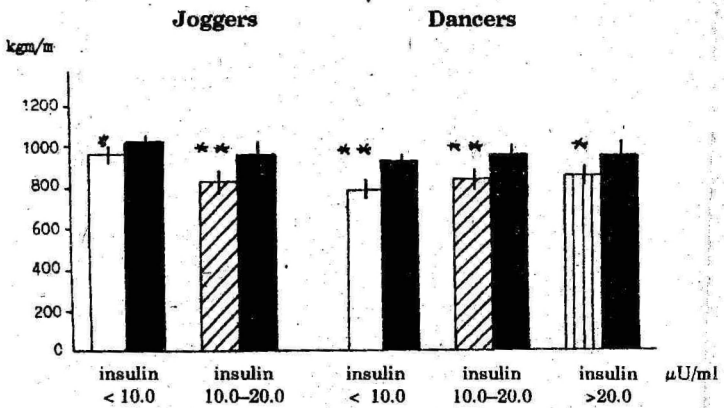


Fig. 2. Changes PWC₁₇₀ during training in dependence on initial insulin level in blood serum. White column - initial insulin level ≤ 10.0 , columns diagonally striated column - initial insulin level 10.0-20.0 and vertically striated columns - initial insulin level $\geq 20.0 \text{ uU.ml}^{-1}$. Black columns - PWC₁₇₀ after training: * $p < 0.05$; ** $p < 0.01$

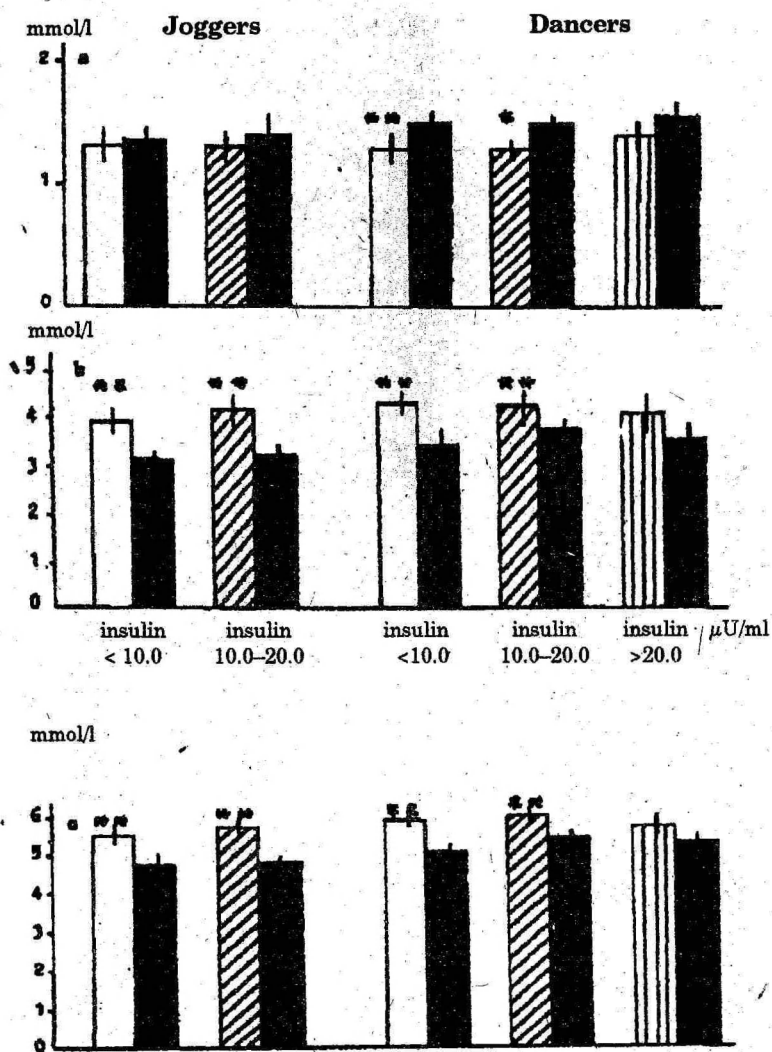


Fig. 3. Changes in blood HDL-C (a), LDL-C (b), CHOL (c) concentration during training in dependence on the initial insulin level in blood serum. White columns - initial insulin level <math>< 10.0</math>, diagonally striated columns - initial insulin level $10.0-20.0$ and vertically striated columns - initial insulin level $> 20.0 \mu\text{U. ml}^{-1}$

* <math>p < 0.05</math>; ** <math>p < 0.01</math>

DISCUSSION

Insulin is known to stimulate the growth of adipose tissue and reduce lipolytic activity [8,9]. The correlation analysis of the obtained results indicated that insulin level in blood was significantly associated with body mass ($r = 0.34$; $p < 0.05$); index Kettle ($r = 0.28$; $p < 0.05$); percent of body fat ($r = 0.46$; $p < 0.001$); fat mass ($r = 0.40$; $p < 0.01$), fat-free mass ($r = 0.28$; $p < 0.05$) in joggers. In dancers insulin level was significantly associated with the percent of body fat ($r = 0.23$; $p < 0.05$), fat mass ($r = 0.25$; $p < 0.05$), fat-free mass ($r = 0.24$; $p < 0.05$), HDL-C ($r = 0.22$; $p < 0.05$). Accordingly to our results, Verschoor, et al [15] have demonstrated a strong correlation between the insulin level and body mass ($r = 0.78$). Our results confirmed the known fact that endurance training decreases insulin level. However, the obtained data demonstrate that this effect of training occurs when the initial insulin level is comparatively high. In dancers the training effect on PWC₁₇₀ was reduced when the initial level of insulin was over $20 \mu\text{U ml}^{-1}$. Therefore, a high insulin level in blood reduced the effectiveness of training on physical working capacity. At the same time a high insulin level did not change the training effect on body fat but excluded the training effect on blood lipoproteins. The obtained results suggest that in cases of high insulin level in blood the training first reduces insulin level. Only afterwards it is possible to improve effectively the working capacity and induce antisclerotic changes of plasma lipoprotein levels in blood.

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LONG TERM BASKETBALL TRAINING ON THE BASIS OF MEDICO-BIOLOGICAL STUDIES

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ABSTRACT

The study was carried out in 1985-1991 and involved members of a basketball team which was placed 23rd at the Soviet Union championships at the beginning of the study while in 1991 it became the champion of the Soviet Union. Endurance exercises were used to improve the poor physical fitness exemplified in 1985. During the first month of the preparation period for the 1986/87 season, aerobic work occupied 1466 min, rehabilitation 966 min, mixed regime training 358 min, alactate exercises 120 min, glycolytic 85 min. As the physical working capacity increased, the proportion of aerobic work decreased and the role of anaerobic exercises became more important.

The biochemical determination of creatine kinase, glucose, alanine, pyruvate, lactate, ammonia and noradrenaline made it possible to estimate the individual adaptation of athletes to different strength training regimes and to find out the disadvantages of the training methods used.

The use of strength exercise blocks in our training contributed much to increasing the absolute strength (1.72 times) and the force (1.62 times) of the femoral muscles of the basketball players.

Key words: basketball training, preparation period, aerobic exercise, strength training, tests.

INTRODUCTION

One of the features of basketball is the steady growth of the role of physical preparation. The defensive play is becoming more intensive, the number of fast attacks is growing, the attack time has gone down to 5-15 sec instead of the earlier 20-30 sec. Changes in the rules of the game (a larger basketball court, 3 point throws, etc.) require quick and very powerful athletes with a high staying power. In modern basketball there are intermittent periods of 5-10 sec intensive play and 20-30 sec moderate load.

The most important energy systems in basketball are alactate anaerobic and aerobic production of energy but during the play (e.g. pressing) anaerobic glycolysis is used as well (2,21,59). While the alactate mechanisms ensure fast movements of the athlete, the aerobic system guarantees a rapid regeneration of the energy resources after each exercise, game episode, game or match (21).

The tendency of modern basketball toward a growing importance of physical sets high demands on the effective pedagogical and medical management of the training process. A close cooperation between the coach and the team's physician in working out the training loads and in preparing for competitions plays an essential role in that process.

The present paper will deal with the structure of the training system of Estonian elite basketball players in the years 1985-1991. The system was based on a close cooperation between the coaches and the team's physician.

At the beginning of our study series the physical working capacity of the team was low and it placed at the bottom of the first league at the Soviet Union championship. Mainly thanks to effective training work which was aimed at increasing physical fitness, the team became champion of the Soviet Union in 1991 and obtained the right to participate in the European Masters Cup series and in the Global Basketball League Championships.

MATERIAL AND METHODS

The subjects were 16 players of the Tallinn "Kalev" basketball team. The athletes were aged between 17-32, with a height of 185-214 cm and body weight of 82-113 kg. The team took part in the Soviet Union championships, in the summer league of American professional basketball (WBL) in 1989 and 1990, and in the European Cup series (Korac Cup). Two of the subjects were members of the Soviet national basketball team and one of them an Olympic gold medalist in 1988.

In the course of trainings in summer camps before each season, the athletes were monitored during 2-2.5 months. All training exercises were registered with ± 1 minute's accuracy and were classified into alactate, glycolytic, aerobic or mixed regime work, according to the intensity of the strain and the duration of the exercise (26).

During each microcycle and also the whole pre-season training period we proceeded mainly from the suggestions of V. Platonov (42) in combining single training exercises. The cycles for developing physical strength were based on Y. Verhoshanski's theory (55,56,57) about concentrated strength blocks. Two weeks prior to the start of the Soviet Union championships, \dot{V}_{O_2} max was determined on the veloergometer by the method of increasing loads (27,48) and using the apparatus "Spirolyt" in the Estonian Centre of Sports Medicine.

At the beginning of each 3-5 day microcycle, the functional fitness of the athletes was estimated by the differentiated electrocardiographic method of Dushanin (7) and the load for the following microcycles was determined according to the coefficient found in the V_6 switch. Altogether, over 200 examinations of athletes were made during the years 1985-1991.

In the training science laboratory of Tartu University the muscular power indicators of the lower extremities were determined at the beginning and the end of each season's preparation period as well as at the beginning of each season of contests. The absolute power and the speed force qualities of the m.quadriceps femoris were studied in isometric muscular work, the power of the extensor muscles of the leg and the sole was measured by special power measuring benches (36,46,47), and the jumping capacity

according to C. Bosco et al. in a 1-minute vertical jumping test (with hands on hips) on the tensoplatform with values determined every 15 seconds and 1 minute (4,35). Totally, 24 examinations of muscular power were made during the study period.

The subjects sat on a straight-backed dynamometer chair with the knee and hip angles equal to 90 and 110, respectively. The force produced by isometric voluntary contractions of the right quadriceps femoris muscle was measured by a strain gauge. An inelastic strap was placed around the distal part of the ankle above the malleoli and connected to the strain gauge. The output of the latter was amplified and recorded on an oscillograph strip. The subjects were instructed to react to light signals (lighting up of the lamp) with their maximum speed and strength by extending the leg against the cuff fixed to the strain-gauge system, to maintain the effort as long as the signals were on (2 sec) and to relax the muscles suddenly at the end of the signal. The power-time curve and the light signal were recorded on the oscillograph strip. The following data were calculated:

- maximal voluntary contraction (MVC, N) was defined as the highest value of force recorded during the contraction;

- rate of force development (RF, N·S⁻¹) was calculated by the formula $RF = F_{0.2} / 0.2$, where $F_{0.2}$ is the force after 0.2 sec from the onset of the contraction.

In the department of Sport Medicine of the Heidelberg University, biochemical responses to playing basketball were determined (blood lactate, glucose, ammonia levels). The subjects were 13 girls of the Federal Germany basketball team, aged 18.5 ± 0.5 .

The blood lactate concentration was determined at rest after a 10-minute warm-up and after two games of 2x10 minutes with a 5 minute break.

Blood ammonia and glucose were measured before the test and after the second game.

The association between the strenght training regimes and the biochemical responses of the single athlete was studied in four members of the Federal Germany rowing team. The blood levels of creatine kinase, glucose, alanine, pyrovate, ammonia, lactate, noradrenaline and adrenaline were determined before and after the load.

With the aim of developing the absolute strength, two different training regimes were used:

1. The athletes A and B (A being a medallist of the World Championships) pressed and jerked from the chest 70% of the maximum; there were 4 series with 15 repeats each.

2. The athletes A and B performed a strength training on the pyramid principle: 10x95kg, 7x100kg, 5x105kg, 3x110kg, 1x120kg, 1x130kg, with 2-minute breaks between the series.

To determine the levels of adrenaline and noradrenaline, blood was obtained from v.cubitalis, in other cases the samples were taken from the hyperemicized earlobe.

Catecholamines were analyzed using high pressure liquid chromatography (HPLC) with amperometric detection described by H.Weicker (62).

Creatine kinase and glucose were determined with the Abbott Vision System, alanine – enzymatically according to O.H.Lowry (33), ammonia – by "Blood Ammonia Checker System" (Kyoto Pai-Idri Kagaku, Japan; agency for FRG HEK Pherma, Lübeck).

Standard statistical methods were used for the calculation of the means (\bar{x}), standard errors of the means (SE) and the coefficients of the correlations (r). The differences between the mean values were tested for significance by using Student's t-test the probability level accepted for the statistical significance was $p < 0.05$.

RESULTS AND DISCUSSION

A physiological characterization of the subjects at the beginning of the study

The athletic performance of the subjects had continuously deteriorated during the recent years. The team that had belonged to the top of the Soviet basketball in the '60s – '70s dropped out of the super league. 1984 saw the team take the 23rd and 1985 – the 24th place at the Soviet Union championships.

The physical fitness of the team members had decreased considerably. In 1984, the \dot{V}_{O_2} max was only

46.2±4.5 ml · min⁻¹ · kg⁻¹ while in the 1978 it had been 60.5±3.1 ml · min⁻¹ · kg⁻¹ (p<0.001) and in the best players who had belonged to the Soviet national team in previous years the mean had been about 64-66 (19). PWC 170 - 3.31±0.6 W · kg⁻¹ was also much lower than it should be in well-trained basketball players.

The Cooper test (6) considers it a good indicator if a player can run at least 3000-3200 m in 12 minutes (44). In 1983, the mean of the subjects was 2872±106 m, there was a high correlation with the $\dot{V}O_2$ max values (p<0.005).

When compared to the team members of the '70s, the results of different pedagogical tests were poorer as well - in shot put, standing long jump, triple jump, 60m and 100m races, etc.

Several players had cardiac changes - the sick sinus syndrome, acute myocardial overstrain syndrome, symptoms of fatigue.

In the season 1985/86 there was a danger of dropping out of the first league of the Soviet Union championships. A thorough pedagogical-medical discussion between the new coaches and the team's physician resulted in the conclusion that the low working capacity was first and foremost due to excessive high-intensity exercises. In the trainings exercises of anaerobic nature were prevailing and practically no attention was being paid to increasing the physical endurance.

The average aerobic working capacity of the team had fallen to a level equal to that of the 19-29 year old Estonian population in general (45). As is well known, there is a competition between the aerobic and anaerobic energy systems (19,21,34) - the inhibition of ferments of aerobic metabolism, due to the falling pH in the mitochondria, is a limiting factor for the rise of aerobic working capacity. It is important to know that in case of a high blood lactate level using fats as a source of energy is inhibited. It has been convincingly proved by now that the accumulation of acid substances in the organism (acidosis) inhibits the mobilization of lipids as a source of energy (11,14).

Such is the physiologic mechanism by which we explained the fact that elite athletes who trained several sessions a day still demonstrated a continuous fall in their exercise capacity during recent years. One of the fundamentals of the training process is the idea of first

building up a powerful aerobic basis and then starting with intensive exercises. The optimal ratio of aerobic and anaerobic loads is one of the key problems of the coach's work in many fields of sports (41,58,60).

Fats are known to be the richest source of energy for the organism while the use of fats for energy can happen during work of aerobic nature. In order to raise their professional performance of basketball players rapidly, we realized that priority should belong to raising their general physical and special endurance. The situation was complicated by the fact that also the best juvenile players who had come to the "Kalev" form juniors' teams had a poor aerobic basis. Their training had also been focusing mainly on intensive exercises and had taken into account neither the athletes' age nor their physical fitness (22).

Improving the functional capacity of basketball players

Improving the functional capacity of the players began with building up their physical endurance. Many authors have emphasized the importance of endurance in basketball (9,21,29,43,51). Reducing considerably the number of special trainings we included the 6-10 km races into training schemes during the season of contests of 1985/86. Already at the end of the 1986 season decisive victories were achieved due to the higher endurance of our players.

Since the preparation period for the 1986/87 season an increased physical fitness was the main aim of the team. The cross country race in "steady state" in the aerobic regime served as the principal method in endurance training. The heart rate during the running was differentiated being individually about 130-160 beats per minute which corresponds to blood lactate levels of 3-4 mmol \cdot l⁻¹. Running at a speed below the aerobic threshold is considered to be most effective for developing endurance (4). The basketballers tended to run either lower speed than the described regimen, and in order to regulate their tempo we used continuous check-ups of their pulse rates. We also lengthened the distance to 10-15 km and later were aided by the Finnish pulse checker "Sport Tester" (24).

In case of athletic games it has been suggested that 70% of all the preparatory trainings should be devoted to

improving physical fitness (1). However, some sports scientists (37,40,43,49,53) suggest that only 45-50% of the time be spent in building up physical fitness.

In the course of the preparation period in the summer of 1986 we used aerobic exercises 48.8% of the training time during the first four weeks (the first stage), altogether 1466 minutes. Exercises in a mixed regime made up 11.9%, glucolytic - 2.8%, alactate - 4.0% and recovery - 32.4% of the time. We practices mostly several successive strenuous singleaimed trainings, the running distances varied between 6-15 km. However, after strenuous aerobic exercises about 48-120h is necessary for the recovery of the organism (42). During that season we didn't take into account the heterochronicity of recovery - different functions require different periods of rest. The disadvantages of single-aimed microcycles with loads of accumulative effect are listed by V.Platonov (42) as follows:

1. They results in a general decrease of the athlete's working capacity due to the accumulation of fatigue from one training session to another;

2. Due to fatigue, there is no possibility to test the extreme capacity of the organism;

3. They bring about a discord in the development of different capacities of the athlete;

4. They may give rise to signs of overstrain.

In spite of the above-listed drawbacks in the summer training scheme, the team's mean $\dot{V}O_2$ max increased to $52.4 \pm 3.5 \text{ ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ by the autumn contest season of 1986. During the season of 1986/87 the team showed a very good performance at the Soviet Union championships. It won the first place in the first league and obtained the right to return to the super league the next season. Many of the coaches of the first league teams explained our success by the excellent functional capacity of the players. There is no doubt that including running at speeds below the anaerobic threshold into the training microcycles during the season of contests also contributed to the athletes fitness. The loads were planned according to S.Dushanin's automatized differentiated electrocardiography - an early morning examination helped in determining the day's training loads (23).

During the first stage (four weeks) of the preparation for the season 1987/88, the proportion of aerobic exercises

decreased to 39.8% (1095 min), mixed regime exercises took up 10%, glycolytic - 4% alactate - 1.8% and recovery - 27.4% of the time. Four test games were played as well. In case of several training sessions a day, we divided them between the main and the additional session mostly according to V. Platonov's suggestions (Table 1).

Table 1

Training sessions of different volume and aim according to V. Platonov (42).

Main session	Additional session
1. Speed, technique at speed. High loads.	Anaerobic working capacity. Moderate or small loads.
2. Anaerobic working capacity. High loads.	Aerobic working capacity. Moderate or small loads.
3. Aerobic working capacity. High loads.	Speed. Technique at speed. Moderate or small loads.
4. Combined method of succession: speed-anaerobic capacity.	Combined aerobic working capacity. Small loads.
5. Combined: aerobic and anaerobic working capacity (parallel). High loads.	Speed, technique. Moderate loads.
6. Combined: speed and anaerobic working capacity (parallel).	Aerobic working capacity. High, moderate or small loads.

The doses of anaerobic exercises were based on the following views (10) (Table 2,3).

Table 2.
Development of alactate capacities (10).

Duration of exercise	Total no. of repeats	No. of series	Repeats in each series	Time ratio of work and rest
10	50	5	10	1:3
15	45	5	9	1:3
20	40	4	10	1:3
25	32	4	8	1:3

Table 3.

Development of glycolytic and aerobic capacities (10).

Duration of exercise	Energy produced	No. of repeats in a series	No. of series	Total no. of series	Time ration of work and rest
30 sec	alactate+	5	5	25	1:3
40-50 sec	glycolytic	5	4	20	1:3
60-70 sec		5	3	15	1:3
80 sec		5	2	10	1:3
1.30-2.00	glycolytic +	8	2	8	1:2
2.10-2.40	aerobic	6	1	6	1:2
2.50-3.00		4	1	4	1:2
3.00-4.00	aerobic	4	1	4	1:1
4.00-5.00		3	1	3	1:1

Prior to the season of contests 1987, the team's mean aerobic working capacity had improved even more – $56.5 \pm 4.0 \text{ ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$. In the middle of the season the team performed well at the international tournaments in Belgium, it placed 10th at the Soviet Union championships, and in the summer of 1988 it played against US semiprofessional basketballers for the first time.

When preparing for the season of 1988/89, we reduced the amount of aerobic training exercises even more – 29.8%, mixed regime exercises occupied 12.6%, glycolytic – 3.5% and recovery – 27.4% of the time. The development of speed and speed force, however, grew more important and filled 8.0%. We also played four test games. During the summer preparation period we followed the example of US basketball players and began tempo running (9,29).

The amount of aerobic exercises increased as well, since \dot{V}_{O_2} max had already reached $59.1 \pm 3.8 \text{ ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ (Figure 1). The team finished 6th at the Soviet Union championships and the tournaments in Europe and the USA were successful for the team.

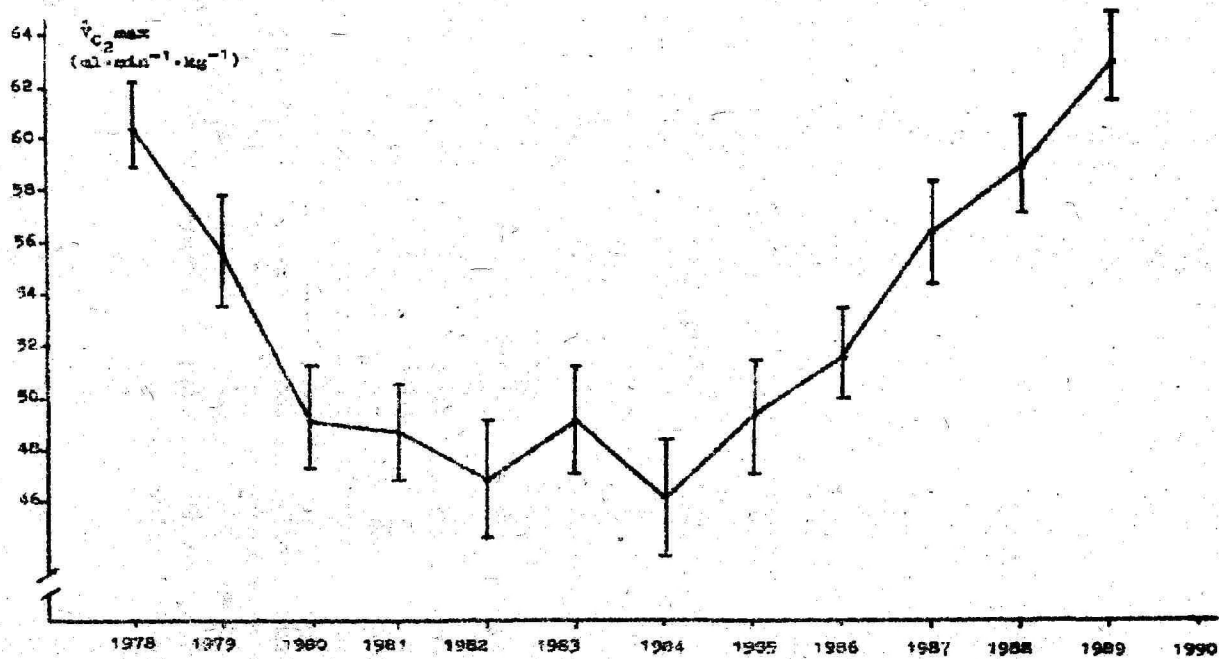


Figure 1. Means of dynamics of aerobic capacity ($\dot{V}O_2 \text{ max}$, $\text{ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$) in basketball players.

During the summer before the 1989/90 season, our trainings were based on the experience of the previous years. The amount of aerobic exercises decreased even more (26.5%) and the number of anaerobic exercises increased. If the proportion of the first stage of the preparation period in 1986 had made up 92.5% and basketball training 7.5% of the time, in 1987- 88.6% and 11.4%, respectively, in 1988 - 79.7% and 20.3%, then in 1989 the special training occupied 37.6% of all the time already during the first stage of the preparation period. That autumn the V_{O_2} max mean value was $63.2 \pm 3.5 \text{ ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ and the intensity of the training session increased a lot during the season.

The proportion of different training exercises during the preparation periods in 1986-1989 can be seen in Table 4, and the shares of exercises aimed at raising either physical fitness or basketball skills are presented in Figure 2.

Table 4.

The overall physical proportions of training exercises (in minutes) during the first month of the preparation periods in 1986-1989.

	1986	1987	1988	1989
Alactate	120	51	130	158
Glycolytic	85	110	100	122
Mixed regime	358	275	360	335
Aerobic	1466	1095	552	715
Restoring	966	757	830	1026
Competitive games	-	360	480	240

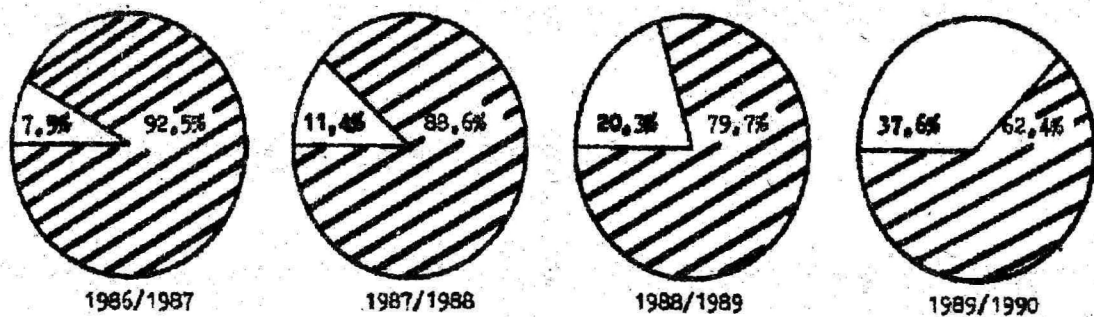


Figure 2. The ratio of physical fitness exercises (hatched part) to special basketball trainings during the first month of the preparation periods in 1986-1989.

The season of 1989/90 resulted in the 5th place at the Soviet Union championships. The values of aerobic work capacity in all players were from 48 to 57 ml · min⁻¹ · kg⁻¹ at the end of the season and the indices of muscular power were at an optimal level as well. So, when preparing for the next season no supervised training camp for conditioning the athletes was practiced as it was the duty of each player to achieve a good physical form during the summer.

However, the training scheme still included aerobic running between matches, and in December there was a 3-week cycle of intensive physical preparation. At the Soviet Union championships the team placed 1st at the main tournament and won the gold medal after the play-off games.

To sum up, it can be said that paying the main attention to increasing the players aerobic endurance helped a lot in increasing the team's physical fitness. More intensive training sessions after achieving a reliable aerobic basis contributed considerably to the improvement of the team.

Physiological responses to playing basketball for 2 x 10 minutes

After the warm-up, no changes in the blood levels were detected. After the first game the blood lactate in the girl players was 3.42 ± 0.68 mMol · l⁻¹, i.e significantly higher than at rest ($p < 0.005$). The lactate levels were higher also after the second 10-minute game when compared to those before the test but significantly lower than after the first game ($p < 0.005$). In spite of the considerable increases of lactate after both test games the absolute values were still relatively low. Evidently the lactate levels do not reach the anaerobic threshold, hence the test of 2 x 10 minute play did not trigger the anaerobic metabolism of the organism.

The mean values of the blood biochemical indices are presented in Table 5.

Table 5.

Blood levels of lactate, ammonia and glucose (mean \pm SE) after 2 x 10 minute playing of basketball (*significant difference when compared to levels at rest $p < 0.001$)

	Lactate mMol \cdot l ⁻¹	Ammonia μ Mol \cdot l ⁻¹	Glucose mg \cdot 100 ml ⁻¹
Before test	1.18 \pm 0.26	10 \pm 2	89 \pm 18
After warm-up	0.99 \pm 0.15	-	-
After first game	3.42 \pm 0.68*	-	-
After second game	2.20 \pm 0.51*	21 \pm 3*	93 \pm 17

The increase in ammonia levels, though statistically significant ($p < 0.001$), was still small in absolute values. This points to the fact that the load did not bring about an extensive work of fast twitch fibres in the athletes.

The mean values do not show changes in the blood glucose, although in five individual cases it decreased after the load. This signifies the depletion of the carbohydrate depots (5). On the one hand, the low lactate levels could be explained by this fact but, on the other hand, it is more important to recognize that in basketball the athlete's main energy systems are the alactate and aerobic ones (21,58). The same evidently explains the low lactate levels after the second game.

Naturally, fatigue should be considered in case of several players. The athletes with decreased after-load blood glucose values had relatively high morning levels of creatine kinase, and objectively concentration and coordination disturbances could be observed. Most of the players had low blood magnesium and hemoglobin concentrations. There was a significant negative correlation between the coefficient determined by Dushanin's differentiated ECG switch V₆ that characterizes the athlete's fitness, and the blood creatine kinase ($p < 0.005$) and hemoglobin ($p < 0.001$) levels. It follows from what has been said above that several of the players were not capable of maximum effort during the whole of the 2 x 10 minute test.

Most certainly the acyclic nature of basketball must also be taken into account - the load of individual players is different during the play.

In conclusion it can be said that although the 2x10 minute basketball test does not fully characterize the

aerobic and anaerobic capacity of the organism, it is still very informative for assessing the athlete's fitness at the given moment. A parallel determination of lactate, ammonia and glucose helps to estimate both the amount of the load and the current energy resources of the organism.

The effect of different power training regimes

In the athletes A and B, regime 1 brought about a considerable rise in their blood lactate levels (12.8 and 11.1 mMol · l⁻¹, respectively). That testifies to a marked anaerobic effect of the training load. There was a rise in the levels of ammonia as well (Table 6) indicating extensive work by the fast twitch IIB type muscle fibres due to the strength training (31,32,65).

Table 6.

Biochemical responses of athletes A and B before and after weight lifting (4 series of 15.7% max).

	A		B	
	before	after	before	after
Creatine kinase (U · l ⁻¹)	251	301	180	217
Glucose (mg · 100 ml)	92	84	119	103
Alanine (mMol l)	0.490	0.924	0.724	1.015
Pyrovate (mMol l)	0.077	0.262	0.110	0.251
Lactate (mMol · l)	1.27	12.8	2.14	11.1
Ammonia (μMol l)	1	49	9	64
Noradrenalin (nmol l)	0.78	6.14	1.59	11.21
Adrenalin (nmol · l)	0.38	1.74	0.38	0.73
Noradrenalin/adrenalin	2.05	3.99	4.18	15.3

The increased release of alanine into the blood was obviously a biochemical defence reaction against excessive rises of both lactate and ammonia (8,20,60,63) in the organism. Changes in catecholamines had a different pattern. The much better trained athlete A (a silver medallist at the World Championships) showed a relatively small rise in noradrenaline while that in adrenaline was marked – a fact that is evidently connected with the strong emotional response to the load. In the athlete B, however, there was a comparatively small increase of blood adrenaline and a notable increase of noradrenaline,

indicating a strong response to the load. As we know, changes in the blood catecholamine levels are important in estimating the effects of loads (25,30,54,61). Catecholamine values have also been used in prognosticating performance in different fields of sports (28). The much more marked effect of the load in the athlete B is also evident from the significantly increased post.load ratio of noradrenaline to adrenaline.

Power training caused a decrease in blood glucose in both athletes. It evidently results from the carbohydrate depletion (5) due to excessive exercise. A complete recovery of the athletes after their previous training had not yet taken place as can be seen from high starting levels of creatine kinase. Creatine kinase is known to be found in different tissues, most of all in skeletal muscles. In case of physical loads, there is a significant rise in the blood creatine kinase (13,16,17,18) – the usual levels of about $80 \text{ U} \cdot \text{l}^{-1}$ can increase up to $200\text{-}500 \text{ U} \cdot \text{l}^{-1}$, as a result of strength trainings. That was the case also in our study.

Before the training session, the aim of the coach had been to develop the absolute strength of the athletes. Our data demonstrated, however, that the session had a strong influence on anaerobic capacities instead. The great number of repeats and insufficient recovery time between the exercises did not allow the development of the absolute strength. After discussing the results of our examination with the coach, he made alterations in his training schemes.

The following table (Table 7) presents the biochemical responses to loads in the athletes C and D who worked in the pyramid regimen. In both athletes there was a small increase in the blood lactate values (below the anaerobic threshold) and a rise in the ammonia and catecholamine levels. A small number of repeats during the final series and long periods of rest made it possible for these athletes to develop their absolute strength. The athlete D showed no changes in his glucose concentration, and the high level of creatine kinase makes one suspicious of overfatigue.

Table 7.

Biochemical responses of athletes C and D to pyramid strength training.

	C		D	
	before	after	before	after
Creatine kinase ($U \cdot l^{-1}$)	110	128	294	325
Glucose (mg 100 ml)	65	107	97	97
Alanine (mMol · l)	0.396	0.440	0.223	0.351
Pyrovate (mMol · l)	0.058	0.116	0.032	0.116
Lactate (mMol · l)	1.92	3.17	1.00	2.13
Ammonia (μ Mol l)	7	25	7	28
Noradrenalin (nmol l)	3.01	5.56	1.05	2.16
Adrenalin (nmol · l)	0.66	0.87	0.38	0.47
Noradrenalin/adrenalin	4.56	6.39	2.79	4.59

The comparison of the different training regimens with the help of biochemical parameters fully confirmed our views and tests (3,12,21,27,39,42,55,56) about the management of the training process. These are the very principles that have been followed years by the investigated basketball team in the recent.

Evaluation of the effectiveness of strength in basketball players

Since the preparation period for the season of 1987, more attention was paid to the athletic fitness of the basketball players. At the beginning of the period, their index of absolute strength MVS was $72 \pm 3N, k$ that of speed force $270 \pm 17N/s$. The fact that the strength development exercises were prevailingly aimed at general fitness and scientific training methods were not always paid attention to in practice (3,38) accounts for the absence of more marked dynamics in either index.

The data concerning the MVC and RF in the femoral muscles are presented in Table 8.

Table 8.

Mean maximal voluntary contractions (MVS, N) of m. quadriceps femoris and rate of force development (RF, $N \cdot s^{-1}$) in basketball players in 1987-1990 (mean \pm SE)

Time period	Month, year	MVC · N	RF N · S ⁻¹
Preparatory	May 1987	72 \pm 3	270 \pm 17
Preparatory	Aug. 1987	74 \pm 3	270 \pm 14
Pre-seasonal	Sept. 1987	76 \pm 4	270 \pm 10
Contest season	Oct. 1987	77 \pm 5	252 \pm 18
Contest season	Dec. 1987	81 \pm 5	277 \pm 19
Transitional	June 1988	98 \pm 5	345 \pm 22
Preparatory	Aug. 1988	98 \pm 4	340 \pm 17
Contest season	Oct. 1988	110 \pm 6	386 \pm 24
Contest season	Jan. 1989	103 \pm 5	351 \pm 16
Transitional	May 1989	105 \pm 4	350 \pm 24
Preparatory	July 1989	96 \pm 5	350 \pm 18
Contest season	Nov. 1989	101 \pm 5	401 \pm 24
Contest season	Jan. 1990	103 \pm 6	395 \pm 50
Contest season	Oct. 1990	108 \pm 5	375 \pm 15
Contest season	Nov. 1990	94 \pm 3	320 \pm 10
Contest season	Dec. 1990	124 \pm 4	437 \pm 13

By the end of the season of 1987/88, the MVC and RF had already increased to 98 \pm 5 N and 345 \pm 22 $N \cdot s^{-1}$ (in both $p < 0.001$), respectively. There was also a noticeable rise in the results of C. Bosco et al. 1-minute vertical jumping test when compared to the beginning of the season – from 21.4 \pm 0.6 to 24 \pm 1.4 $W \cdot kg^{-1} \cdot BW^{-1}$ ($p < 0.005$). Hence, the absolute strength of the lower extremities, the speed force as well as the local muscular endurance had improved. It is usual that during a season of contests the physical working capacity of athletes falls.

In our study the difference lies in the fact that from the season of 1987/88 strength development was practiced all the year round. In doing that we mainly proceeded from the views of Y. Verhoshanski. By using special strength development devices we aimed at achieving the greatest possible resemblance of the training exercises to the contest exercises, both in their structure and muscular activity.

In concentrated strength training Y. Verhoshanski differentiates between the stages of motor potential accumulation and its realization (1988). According to him, in accumulating the motor potential it is essential to

concentrate strenuous strength exercises into a 4-12 week period as a strength block. During that period the athlete will develop a marked fatigue, his working capacity and his muscular strength will fall. After switching over to trainings aimed at a different objective, there will first be a recovery of the working capacity and then its extensive increase to values much above the starting levels (55,57).

The increase in the muscular strength after a four-month concentrated strength block (MVC $p < 0.005$, RF $p < 0.05$) during the 4th week of the 1988 summer preparation period confirms Y.Verhoshanski's opinion that the time period necessary for the realization of the residual effect of a prolonged training is more or less equal to that necessary for accumulating the motor potential, i.e. that of the strength block (55). On the other hand, the much more marked increase in strength after the strength block in the season of 1990 we can attribute to having used a great deal of intensive special excises during the period of the realization of the motor potential. In the previous years large amounts of aerobic work were prevailing. Y.Verhoshanski considers it a mistake to apply hard loads during the realization of a prolonged training's residual effect (56). That agrees well with the views of several scientists (50) about the mutual competitive effect of strength training and endurance training. Our study also confirmed Y.Verhoshanski's view that the more marked the decrease in the working capacity during the load concentration period, the more considerable its increase above the starting levels (Fig. 3). Thus, the decrease in both the MVC and RF values of the femoral muscles was significant ($p < 0.001$) due to a 3-week strength block while the powerful realization of the motor potential was reflected not only in the muscular monitoring data but also in the players' excellent performance at a high-level international tournament in Holland six weeks after the end of the strength block.

Our study confirmed the effectiveness of concentrated training methods in basketball. The same methods have proved useful also in other fields like water polo (15) and swimming (52).

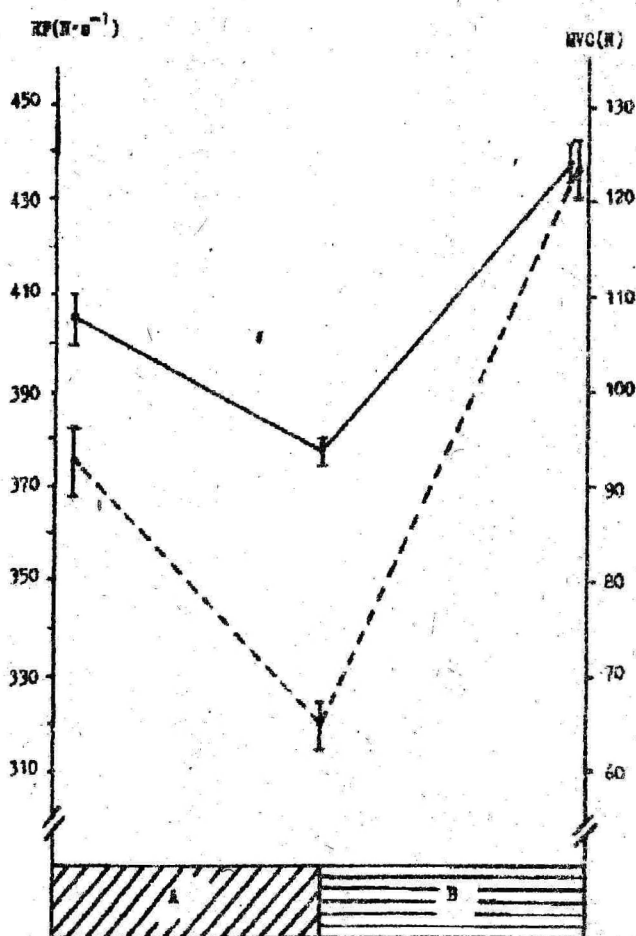


Figure 3. Mean \pm SE of dynamics of maximal voluntary contraction (MVC, N) and rate of force development (RF, N s) before and after concentrated strength blocks (A) and during realization of motor potential (B). MVC - continuous line, RF - dashed line.

Due to effective strength training, the absolute strength of the m. quadriceps femoris in elite basketball players increased on an average 1.72 times during 4 years. Undoubtedly such a considerable rise in the athletic fitness and the functional capacity of the players formed a basis for the team's Champion title in 1991. The rating of the team at the Soviet Union championships during the years of the study is presented in Table 9.

Table 9.

Rating of Tallinn "Kalev" at Soviet Union Championships in 1984-1991

Season	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91
Place	24	20	13	10	6	5	1

To sum up, our study confirmed the great importance of physical preparation in modern basketball. The development of functional capacity and athletic fitness is most essential and can be done best with the help of scientific training methods.

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PHYSICAL LOAD'S INFLUENCE ON THE HEARTS'S PHASE STRUCTURE OF PREGNANT WOMEN

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Abstract

Every healthy woman should cope with active childbirth. In order to be prepared for active child birth she must have some knowledge and special physical preparation to improve the functional state of the cardio-vascular system of her pregnant organism in conditions of higher demand. The results of the research show that the frequency of heart rate tends to increase on the second half of pregnancy. Arterial blood pressure stays within normal limits. At the beginning of the second half of pregnancy there is a tendency of developing a hypodynamic phase syndrome in the cardiodynamics at rest, independent of physical activity during pregnancy. The hyperdynamic phase syndrome developed after physical load. According to the result of this study we can assert that the pregnant endure aerobic load well at the heart rate of 150 beats/min. We may say that the cardio-vascular system of healthy primipregnant women adapts well to the hemodynamic and physical load during pregnancy. Moderate physical load does not have harmful influence on the health of the pregnant and on the development of the embryo.

KEY WORDS: pregnancy, systolic time intervals of the left ventricle, physical activity, PWC₁₅₀.

Pregnancy is a physiological state of a woman's organism. Every healthy woman should be able to bear pregnancy up to the end without any trouble and give birth to a normal child. In order to be prepared for active childbirth a woman must have some knowledge about the course of pregnancy to cope with the load that goes with pregnancy and childbirth.

The development of the embryo and the organism's adap-

tation to pregnancy cause a number of physiological changes in the woman's organism. Greater demands are put to a pregnant cardiovascular system as well as to the other systems of her organism.

Vihljajeva [38] remarks that one of the main mechanisms that guarantees adequate conditions for fetal development and preserves microcirculation in the vitally important organs is the increase of general blood volume. The average blood volume forms 7 % of a person's weight, in case of a pregnant it is 8-11 % [37]. During pregnancy it may increase by 10-48 % [4]. The greatest blood volume has been measured between the 29th and the 32nd weeks of pregnancy. It tends to decrease towards the end of pregnancy but still exceeds the level of the non-pregnants by 27 % [33]. The increase of general volume brings about the rise of cardiac output that reaches its top in the 26th-32th weeks of pregnancy, then diminishes and is 10.8 % larger than that of the non-pregnant during the last weeks before childbirth [33].

A pregnant's heart action is labile. Quite often tachycardia, sometimes also bradycardia is registered and extra-systoles can occur [33].

Most authors maintain that pregnancy causes an acceleration of the heart rate. The highest pulse frequency has been registered in the 7th-8th months of pregnancy. Towards the end of pregnancy the heart rate becomes almost normal and that in its turn lowers the heart's load [34, 37]

There is no common viewpoint concerning arterial blood pressure. According to some authors [34] blood pressure does not undergo any remarkable changes during pregnancy. Some authors [15] maintain that towards the end of pregnancy blood pressure increases up to 140 mm Hg. There are also some opposite viewpoints claiming that pregnancy causes the abatement of blood pressure [33].

In addition to the above-mentioned hemodynamic changes the formation of placental circulation and uterus enlargement cause additional load on the heart.

The heart load increases 30-50 % during pregnancy [21,37]. The heart works with maximal load during the 25-32nd weeks of pregnancy [37] according to N.P. Mihhailova in the 32nd-35th weeks [30].

Though the influence of pregnancy on the cardiovascular system is comparable to that of physical training (general blood volume increases by 35 %, plasma volume 50 %, the amount of erythrocytes by 15 %, the heart increases in size as a result of the myocard's hypertrophy and intensified circulation [7, 13, 14, 18]. It is good to have some more training to guarantee the

additional strength and high adaptation necessary for coping with the load of childbirth.

One should systematically go in for physical exercises before and special exercises during pregnancy in order to improve the functional state of the cardiovascular system. Under the influence of constantly increasing physical load the organism acquires energetic and functional reserves that could be quickly and entirely mobilized in extreme situations, e.g. during childbirth.

Physical exercises improve the state of a pregnant woman's cardiovascular system, train her respiratory organs and muscles. Women start feeling better, they get rid of backache and headache, stop feeling giddy, the work of the intestine improves [11]. Training guarantees the embryo's normal position and development in the uterus [19, 22], childbirth does not take so much time and is less painful. The trained respiratory organs oxygenate the mother and her embryo more efficiently. The skill of calm, deep and controlled breathing is necessary when expelling the embryo [26]. The muscles of a trained woman are elastic, strong and in good tonus. Their contraction efficiency is good. Strong abdominal muscles ensure good labour, the elastic muscles of the pelvic floor and perineum avoid ruptures during childbirth. A trained woman can use her strength economically, have a rest and relax between throes and uterine contractions. A flexible body takes a better position during labor and the child meets less resistance when moving along the birth canals. Physically active women suffer less from such deviations like the loss of blood, weakness of labour, etc. [19].

In the case of the right regime of physical exercises the embryo's development goes without trouble. The mother's strong abdominal and pelvic muscles keep the embryo in good position in the uterus. Her trained and adaptable coronary system and respiratory organs ensure a good supply of the embryo with oxygen and nutrients. The children of trained mothers are usually born in time, in good condition and with a high Apgar index. A woman who has had moderate physical load during pregnancy and whose nutrition has been reasonable is expected to give birth to a child of standard weight [8, 16].

As a matter of fact any kind of physical work causes blood transfer into the working muscles. The uterine blood flow may suffer from that as the blood vessels of the uterus are sensitive to sympathetic influences and to the action of catecholamines [28]. Animal studies show that a single hard physical load (10 minutes at 100 % of the maximum consumption of oxygen) reduces the uterine blood flow by about 17 % and continuous work

(40 minutes at 70 % of the maximum consumption of oxygen) decreases it by 24 % [27]. It also decreases under exhaustion [6]. That does not hold true in case of easy physical work (of low intensity) as the cardiac output at 100-150 kgm/min increases about 1.5-2.0 l/min during physical exercises [17].

As a mother's physical load may reduce the uterine blood flow the question arises about the embryo's possible suffering from hypoxia that brings about changes in the embryo's heart rate.

During the third trimester of pregnancy the heart rate stabilizes between 120-160 beats/min (3). An embryo's heart rate reaction to the mother's physical work depends on the durability, intensity and character of the load. Short time treadmill walking did not change the embryo's heart rate or even decelerated it (8). A mother's physical work on a veloergometer raised the embryo's heart rate from 142 beats/min at rest to 149 beats/min after work. At the same time the mother's pulse accelerated to 140 beats/min. That gives evidence of the embryo's normal reaction to the mother's submaximal work (10). The acceleration of an embryo's heart rate over 16 beats/min after a load is considered a bad indicator. Physical exercises help to improve a pregnant's heart's adaptation to physical load. Investigations show that usually the physical working capacity does not diminish during pregnancy (7, 12). A pregnant's working capacity ranges from 675 to 805 kgm/min (7). Sometimes the ability to work diminishes in the first months of pregnancy. That may be caused by nausea, vomiting, depression (13). Intensive training (running 9-19 km a week) can increase a pregnant's working capacity (16). Training at the heart rate 140 beats/min raised the physical working capacity by 17,6 % (13, 14).

The phase analysis is an informative method to estimate the contraction power (*contractility*) of a pregnant's heart's left ventricle in response to physical load. Changes in the contraction ability of the myocardium depend on the phase of pregnancy, hemodynamic shifts, hormonal status, physical work character.

The generalisation of the data of the phase analysis of the left ventricular systole enables us to draw the following conclusions: During the first half of pregnancy the heart muscle's contraction ability becomes better. In the first two trimesters this rise is connected with the increase of the heart systolic volume (9, 33). The appearance of the hyperdynamic phase syndrome characterized by the shortening of asynchronous contraction phase (AC), isometric contraction phase (IC) and left ventricular ejection time (LVET) (32, 36) is typical of this period. The greatest shifts in heart phase structure occur in the

27th - 35th weeks of pregnancy when there is the greatest hemodynamic load on the cardiovascular system (30). Since the third trimester there appears a shift towards the hypodynamic phase syndrome - IC, AC, lengthen, the cardiac index myocardial contractility (MPI) grows longer, LVET shortens (21).

A physical load cause the appearance of the hyperdynamic phase syndrome (20,34). It shows the adequate reaction of the pregnant's cardiovascular system to a physical load.

Material and Methods

Dynamic complex investigations were carried out with 80 practically healthy pregnant women (anticipating their 1st birth) in their 13th, 20th, 28th and 36th weeks of pregnancy. The cardiovascular parameters were registered in a lying position at rest and after two physical loads. The heart rate was measured on an electrocardiogram according to the R-R interval, the arterial blood pressure was measured on the upper arm using Korotkov's method. EKG, phonogram and sphygmogram was synchronically registered with the help of the electrophonocardiograph "6-NEK". The ribbon's speed in registering the polycardiogram was 100 mm/sek. The systolic time intervals of the cycle of the heart were determined on the polycardiogram using Karpman's method (23). The physical load was administered in the form of a 5 minute walk on the treadmill. The first load was performed with the power of 0.75 W per 1 kg weight, the second with 1.25W. The heart rate and arterial blood pressure were registered in every minute of walking. PWC_{150} was calculated according to the heart rate of the last minutes of both loads using Karpman's (1974) method

$$PWC_{150} = N_1 + (N_2 + N_1) \frac{150 - f_1}{f_2 - f_1} \quad \text{where}$$

N_1 - power of the 1st load

N_2 - power of the 2nd load

f_1 - the heart rate during the 1st load

f_2 - the heart rate during the 2nd load

The subjects of experiment were divided into 2 groups according to the quality of their physical working capacity (PWC_{150}) in the 13th week of pregnancy:

I - a group with relatively high PWC ($PWC > 100$ W)

II - a group with relatively low PWC ($PWC < 100$ W)

The above mentioned groups were divided into sub-groups according to their physical activity during pregnancy. The sub-groups were as follows: the so-called "gymnasts" who did exercises regularly (twice a week à 30 min), "runners" who walked

fast for 30 min two or three times a week, and the "non-active" who did not go in for physical exercises during pregnancy. 25 healthy non-pregnant women were also studied in order to get background data.

The results were processed statistically using the methods of correlation and regression analysis and also with the help of ontogonal polynom regression analysis.

Results

1. The dynamics of physical working capacity during pregnancy.

The results are reproduced in Table 1.

Table 1

The changes of physical working capacity (W) during pregnancy

Group	Periods of pregnancy			
	I	II	III	IV
The group of high PWC	113 ± 3.74	94 ± 3.3*	88.3 ± 3.6*	93 ± 2.0*
The group of low PWC	70 ± 1.9	74 ± 5.1	69 ± 3.2	70 ± 2.5

* - data are significantly different ($p < 0.05$) from the first period

It turns out that in the first group the working capacity diminished up to the 3rd first period, the 28th week of pregnancy ($p < 0.001$), whereby the greatest fall took place between the 1st and the 2nd period ($p < 0.001$). At the end of pregnancy the physical working capacity increased a bit but the shift was statistically unreliable with regard to the 3rd period. Then were no changes in the physical working capacity.

When viewing the dynamics of the changes of physical working capacity on the background of physical activity during pregnancy the general impression remained the same (Table 2). But the physical activity prevented the great drop of working capacity in the 3rd period.

2. Cardiodynamics of a pregnant woman.

In case of both groups there was a tendency to ward heart rate acceleration during pregnancy. The arterial blood pressure remained practically the same. Similar cardiodynamics could be noticed in the case of "gymnasts" and "runners". The phase analysis of the hearts left ventricle at rest showed that the heart muscle's activity of contraction tended to drop in case of the non-active group with high PWC. A significant shift was registered in

Table 2

The Dependence of the Dynamics of Physical Working Capacity on Regular Physical Activity During Pregnancy

Group	Periods of pregnancy			
	I	II	III	IV
Non-active high PWC	111 ± 5.1	92 ± 3.8 ***	80 ± 3.0 ****	84 ± 8.1 ****
gymnasts high PWC	125 ± 7.0	102 ± 6.0 **	106 ± 7.0	103 ± 3.5 ****
runners high PWC	104 ± 4.2	90 ± 5.2 *	89 ± 4.2 *	91 ± 4.9 *
non-active low PWC	70 ± 4.2	79 ± 6.4	67 ± 3.4	75 ± 7.0
gymnasts low PWC	70 ± 3.4	69 ± 3.0	70 ± 6.0	66 ± 3.6
runners low PWC	71 ± 2.9	73 ± 5.4	70 ± 9.3	63 ± 3.0

data differ greatly from the first period

* - $p < 0.05$ ** - $p < 0.02$ *** - $p < 0.01$ **** - $p < 0.001$

the 36th week of pregnancy ($p < 0.01$). In the case of the group with low PWC the tendency towards the hyperdynamic phase syndrome was registered during the first period of pregnancy and towards the hypodynamic phase syndrome since the second period. Essential shifts towards that occurred by the 28th week of pregnancy ($p < 0.01$).

There were no significant shifts noticed in the cardiodynamics of the "gymnasts" group with high working capacity during the first two periods of pregnancy. Still, there was a tendency towards the hypodynamic phase syndrome in case of the "gymnasts" with low PWC towards the syndrome. During the second half of pregnancy a significant shift towards the hypodynamic syndrome was registered in both groups where by in case of the groups with low PWC it manifested itself in the 28th, in case of the group with the high PWC in the 36th week of pregnancy.

The "runners" with high working capacity had a tendency to improve of the hearts's ability of contraction during the second half of pregnancy. Since the 28th week the fall of the ability of contraction could be noticed. In case of the group with low PWC the fall was already registered since the second period.

In short, we may say that pregnancy brings about significant changes in a woman's cardiodynamics. The activity of the heart muscle's ability of contraction falls irrespective of moderate physical activity during pregnancy. In case of the groups

with low physical working capacity the hypodynamic phase syndrome was registered in the 28th week, in case of the group with high PWC in the 36th week (Figure 1).

3. The influence of physical load on the phase structure of the heart cycle of the pregnant.

The changes occurring in the heart's phase structure after training were similar in all the groups. No significant shifts were noticed in any group after the first lighter training. The second, more intensive physical load brought out important shortenings of LVET, PEP, IC. It was characteristic that the changes were more extensive in the groups with low PWC.

Discussion

The PWC_{150} test that was carried out characterizes the cardio-vascular state and physical working capacity. At the beginning of pregnancy the physical working capacity did not differ from that of the non-pregnants. During the later periods of pregnancy working capacity starts to decline whether there has been moderate training or not. The results of our experiment coincide with those published in literature (35). Regular physical activity during pregnancy stops the further decline of physical working capacity during the second half of pregnancy.

In spite of what the heart rate was at the beginning of pregnancy it tended to increase during the second half of pregnancy (about 8 beats/min.) in all groups. The highest heart rate was usually registered in the 28th week of pregnancy. These results coincide with the data of J. Burg and his coauthors (5). According to them the heart rate reaches its peak on the 3rd trimester of pregnancy when it is 15 strokes more than on the first trimester. Many other authors (1, 2, 29) also confirm the fact that some acceleration of the function of the heart is characteristic of pregnancy.

The analysis of the left ventricle's time intervals allows us to infer that the increased hemodynamic load on the heart during pregnancy causes some changes in the heart muscle's ability of contraction already at rest. Our results coincide with the data of other authors (36) who have found that at the beginning of pregnancy the phase structure of the left ventricle does not differ from that of the non-pregnant. Different tendencies occur between the groups with different physical working capacity. The group with high working capacity had a tendency towards the hypodynamic, the group with low physical working capacity a tendency towards the hyperdynamic phase syndrome. The repeated hypodynamic phase structure occurred in all groups

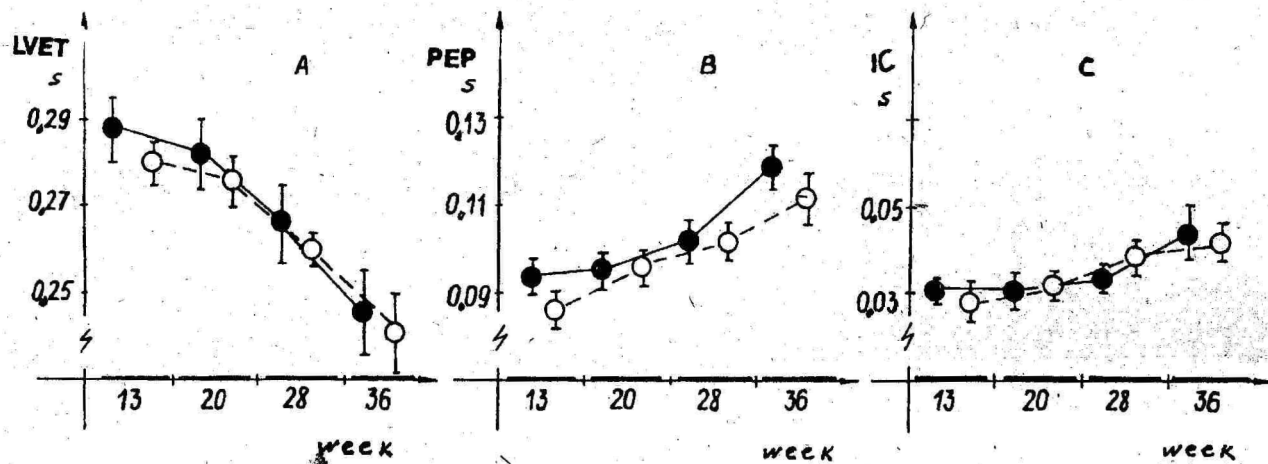


Figure 1. Characteristic changes of LVET (A), PEP (B) and IC (C) in forming of the regulated hypodynamic phase syndrome during pregnancy in calm.

- – the group of low physical working capacity
- – the group of high physical working capacity

during the second half of pregnancy. It may be caused by the decline of the venous blood's reflux into the heart as the vena cava is compressed in a recumbent position (23,25). Elaborate neurohumoral changes in the circulatory regulation may be the other reason.

The decline of the heart muscle's ability of contraction may be viewed as a compensatory adaptation mechanism that is started in response to the changes in a pregnant's organism. The hypodynamic phase syndrome at rest shows the economic work of the heart that increases the heart's functional reserve. It is certificated by the rise of the hyperdynamic phase syndrome after a physical load.

On the basis of the results we can maintain that the pregnant endure aerobic load well by the heart rate of 150 beats/min. But we cannot name the upper limit from what on the pulse rate starts to interfere with both the mother's and the embryo's health during a physical training. Relying on the published data of animal studies it can be said that intensive physical load in anaerobic conditions is not recommended to the pregnant. In addition to the fact that intensive physical load may decrease the provision of blood to uterus, it also reduces the mother's weight accounted for by the decline of the embryo's and placenta's weight. The decrease of the placenta's weight brings about the deterioration of the placental barrier to CO diffusion (31).

To sum up, it can be said that the cardio-vascular system of healthy primipregnant women adapts well to the hemodynamic and physical load during pregnancy. A moderate physical load does not have harmful influence on the health of the pregnant woman nor on the development of the embryo.

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PHYSICAL ACTIVITY EFFECTS ON ADIPOCYTE SENSITIVITY TO HORMONES

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Abstract

The effects of physical training and detraining on the sensitivity of adipocytes to lipolytic and lipogenetic actions of hormones were investigated in Wistar rats (sedentary control rats, rats trained in swimming for 6 weeks, and trained rats after a 4 week period of detraining). The intensity of lipolysis was determined by glycerol release during a 30 minute incubation of isolated adipocytes. The intensity of lipogenesis was detected by the incorporation of labelled glucose into the fat of isolated adipocytes.

The basal rate of lipolysis did not change by training, but it dropped after the detraining period. Addition of adrenaline (10^{-4} Mol·L⁻¹) intensified the lipolysis. The most pronounced changes were observed in trained-detrained rats. Dexamethasone administration *in vitro* ($20\mu\text{g}\cdot\text{L}^{-1}$) enhanced the adrenaline effect only in trained rats. A small dose of insulin ($10\text{ mU}\cdot\text{L}^{-1}$) did not block the lipolytic action of adrenaline but excluded the potentiation of adrenaline action by glucocorticoids. The training increased the basal rate of lipogenesis and the effect of insulin on this process. After 4 weeks of detraining these alterations disappeared almost completely.

KEY WORDS: Physical Activity, Adipocytes, Hormones.

Introduction

Physical training induces an altered sensitivity of adipose tissue to lipolytic hormones as well as to lipogenetic hormones. The enhanced lipolytic action of adrenaline was found in trained rats both after hormone administration *in vivo* [23] and in case of incubation of isolated adipocytes in the presence of hormone

[2, 3, 4, 17]. A common effect of endurance training is also the enhanced sensitivity of adipocytes to the lipogenetic effect of insulin [20] in conjunction with elevated rates of 2-deoxy-glycose uptake and glucose oxidation [8, 17, 22].

These data indicate that endurance training induces improved possibilities both for the mobilization of lipid resources during exercise and for the replenishment of the lipid reserve during postexercise recovery. After cessation of training the previous accordance between lipid mobilization and synthesis may be disturbed: the enhanced possibilities for lipid mobilization remain unused and the enhanced insulin-lipogenetic effect may cause an augmentation of adipose tissue. In order to study the training and detraining effects of the adipocyte sensitivity to adrenaline and insulin the experiments were performed on adipocytes isolated from the fat tissue of sedentary rats as well as of trained rats sacrificed immediately or a month after the end of training.

The adrenaline lipolytic effect depends on the permissive action of glucocorticoids [12, 14, 15] as well as on the opposite influence of insulin [1, 16]. An additional attempt was made to study the training and detraining effects on these hormone interrelations.

Material and methods

Animals and procedure

Wistar rats (body weight 220–280 g) were maintained on standard vivarium conditions (12 h light, 12 h dark; constant temperature, humidity and diet). 6 of these were used as sedentary controls. The other 20 animals were trained by swimming in water of 33°C during 6 weeks. The rats swam the first 5 days of every week. The duration of a swimming bout was 45 min in the first week. At the beginning of every following week the swimming duration was increased by 15 min. Two days after the last training session a test of physical working capacity was performed in 14 of the trained rats and in the sedentary controls.

The test consisted in swimming until exhaustion with an additional load equal to 6 % of body weight. The additional load was attached to the tail. The swimming intensity was stimulated by relatively limited water surface (10 cm² per rat on the average). The rats were taken out of the swimming tank immediately after they submerged under water for 10 sec.

The test of physical working capacity of the remained 6

trained rats was performed 4 weeks after the end of training.

Three days after the test of physical working capacity all rats were decapitated between 8 to 10 a.m. The sample of white adipose tissue was taken from the right side below the liver.

Fat cell isolation

The fat sample was divided into two parts. 30 mg of the tissue was put into a solution of 0.1 M phosphate buffer and 2.5 % glyturaldehyde for the morphometric determination of the diameter of adipocytes. 160 mg of fat was broken up and put into the Krebs-Ringer solution containing collagenase for separation of adipocytes.

Adipocytes were isolated by a modification of Rodbell [19] technique with the help of a 25-min incubation with collagenase [1]. Cell concentration in the adipocyte suspension was measured using a hematocytometer and a light microscope. The cellular integrity was assessed as well.

Measurement of fat cell lipolysis

After a 15 min preincubation of the cell suspension, adipocytes were washed with a fresh Krebs-Ringer bicarbonate buffer and a 350 μ l aliquot was incubated for 30 min in polyethylene vials containing a final volume of 1.5 ml Krebs-Ringer bicarbonate buffer (glucose 50 mg \cdot 100 $^{-1}$, albumin 4 %), kept at 37°C in a 95 % O₂ and 5 % CO₂ atmosphere [10]. Incubation was stopped by transferring the vial content into polyethylene tubes maintained in ice. The glycerol release into the incubation medium was used as the indicator of lipolysis in adipocytes. The determination of glycerol content was performed with the help of an enzymatic method [6], using the kit of Boehringer Mannheim GmbH Diagnostika. The glycerol release was expressed in μ Mol per 30 min per 10⁶ adipocytes. All determinations were made in duplicate.

The suspension of adipocytes was incubated in 6 pairs of aliquots: the first pair without any additions for determinations of the basal rate of lipolysis, the second pair after addition of adrenaline in a final concentration of 5×10^{-4} Mol \cdot L $^{-1}$, the third pair after addition of adrenaline in a final concentration of 10^{-4} Mol \cdot L $^{-1}$, the fourth pair after addition of the same amount of adrenaline in combination with dexamethasone (final concentration 20 μ g \cdot L $^{-1}$) together with insulin (final concentration 10 mU \cdot L $^{-1}$) and the sixth pair after administration of adrenaline in combination with dexamethasone and insulin.

Measurement of lipogenesis

The intensity of lipogenesis was measured by glucose conversion into the triglycerides according to the procedure of Carnie et al. [5]. Isolated adipocyte suspension (600 μ l) was added to 20 ml flasks, containing 400 μ l of Krebs-Ringer buffer with glucose at a final concentration of 5×10^{-3} Mol·L⁻¹ and 100 μ l of D-14C(U)-glucose (13 μ Ci·ml⁻¹) in distilled water. The mixture was gassed with 95 % of O₂ and 5 % of CO₂ and incubated with shaking at 37° for one hour. Each sample was incubated in four flasks, in two flasks with insulin at a final concentration of 10 mU·L⁻¹, in two flasks without insulin. To stop the incubation, 1 ml of 1 M H₂SO₄ was added into each flask. Five ml of chloroform/methanol (2:1 v/v) was added and vortex mixed in glass stoppered tubes. 24 h later, the chloroform phase was retained, washed twice with 3 ml of chloroform/methanol/1 M H₂SO₄ (5:48:47, by vol) and transferred to glass scintillation vials. Evaporation to dryness was performed at 50°C. 9 ml of toluene-omnifluor was added and the triple determination of the radioactivity content was performed by scintillation counting "MINIBETA-1211" of LKB Wallac. Values were expressed in nMol of glucose incorporated per hour into lipids per 10⁶ cells.

Statistical analysis

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

Results

Working capacity

The effectiveness of training was proved by the results of the test of working capacity. The maximal duration of swimming with additional load of 6 % of body weight was in trained rats just after the end of training within 8 h 20 min to 9 h 15 min, in trained rats 4 weeks after the end of training within 5 h 30 min to 6 h 5 min, in untrained rats within 2 h 40 min to 3 h 10 min.

Lipolysis

The basal rate of lipolysis, judged by the glycerol release during 30 min of incubation without addition of any hormone did not change by training but dropped 4 weeks after the end of training (Table 1). The glycerol release increased by addition

of adrenaline in all groups. The highest increase was observed in trained rats after 4 weeks of detraining. No significant difference was found between the effect of two various doses of adrenaline (5×10^{-4} and 10^{-4} Mol·L⁻¹) on the glycerol release. The addition of dexamethasone enhanced the adrenaline effect in adipocytes isolated in trained rats just after the end of training but not in the adipocytes of other groups of rats. The used dose of insulin did not block the lipolytic action of adrenaline but excluded the potentiation of adrenaline action by glucocorticoids in cases of trained organism.

Table 1

Action of hormones on the lipolysis in adipocytes isolated from untrained sedentary rats, trained rats just after the end of training, and trained rats 4 weeks after the end of training (mean \pm S.E.M.)

Experimental conditions	Rate of lipolysis		
	μ Mol of released during 30 min per 10^6 adipocytes		
	Trained rats n = 14	Trained-detrained rats n = 6	Untrained rats n = 6
Basal level	0.36 \pm 0.08	0.07 \pm 0.01	0.31 \pm 0.14
Adrenaline 5×10^{-4} Mol·L ⁻¹	0.66 \pm 0.10*	0.82 \pm 0.23*	0.76 \pm 0.03*
Adrenaline 10^{-4} Mol·L ⁻¹	0.67 \pm 0.07*	1.15 \pm 0.20*	0.75 \pm 0.02*
Adrenaline (10^{-4} Mol·L ⁻¹) with dexamethasone (20 μ g·L ⁻¹)	0.81 \pm 0.09**	1.08 \pm 0.17*	0.72 \pm 0.04*
Adrenaline (10^{-4} Mol·L ⁻¹) with insulin (10 mU·L ⁻¹)	0.75 \pm 0.07*	1.08 \pm 0.21*	0.75 \pm 0.05*
Adrenaline (10^{-4} Mol·L ⁻¹) with dexamethasone (20 μ g·L ⁻¹) and insulin (10 mU·L ⁻¹)	0.57 \pm 0.08*	1.13 \pm 0.17*	0.73 \pm 0.07*

* Statistically significant ($P < 0.05$) difference from basal level

** Statistically significant ($P < 0.05$) difference from both basal level and level after adrenaline

Lipogenesis

In trained rats the basal rate of lipogenesis was significantly higher than in untrained rats ($P < 0.05$). During 4 weeks after the end of training the rate of lipogenesis decreased and the significant difference from untrained rats disappeared (Table 2). Statistically significant stimulation of lipogenesis by insulin was obtained only in trained rats.

Table 2

Basal and insulin-stimulated levels of lipogenesis in adipocytes isolated from untrained sedentary rats, trained rats just after the end of training, and trained rats 4 weeks after the end of training (mean \pm S.E.M.)

Group	n	Rate of lipogenesis	
		$\mu\text{Mol } ^{14}\text{C-glucose}$ incorporated into triglycerides during 1 h per 10^6 adipocytes	
		Basal level	Insulin-stimulated level
Trained rats	14	$14.9 \pm 1.3^*$	$31.3 \pm 6.9^{**}$
Trained-detrained rats	6	11.2 ± 3.4	13.0 ± 2.9
Untrained rats	6	8.5 ± 2.2	11.2 ± 5.4

* Statistically significant ($P < 0.05$) difference from values of untrained rats

** Statistically significant ($P < 0.05$) difference from basal level

Adipocyte size

Adipocyte diameter varied between 32 to 50 μ . The differences between experimental groups were nonsignificant.

Discussion

The measurement of adipocyte diameter did not show any significant differences between groups, nor were the obtained training and detraining effects on lipolysis and lipogenesis in relation to the primary alterations in the size of adipocytes. In accordance with the data of Bukowiecki et al. [4] obtained in rats, and of Després et al [11] obtained in humans, we did not observe the training effect on the basal rate of lipolysis in isolated adipocytes. Differently, a decrease of the basal rate of lipolysis was found in adipocytes of trained rats by Owens et al [17]. Our results showed that this change may be a post-training phenomenon that develops in the course of detraining following

the exercise-training. According to our results 4 weeks after the training the basal rate of lipolysis was approximately five times lower than just after the end of training.

Studies of human adipocytes indicate that the minimal dose of adrenaline for the stimulation of lipolysis is 10^{-7} Mol for trained and 10^{-5} Mol for untrained persons [9]. The maximal stimulating effect was obtained with adrenaline in the incubation medium of 10^{-1} Mol·L⁻¹ [10]. We found a similar stimulation of lipolysis by doses of 10^{-4} and 5×10^{-1} Mol·L⁻¹. Obviously the obtained rate of lipolysis corresponded to the maximal stimulating effect of adrenaline. Our results also confirmed the enhancement of the adrenaline effect by endurance training previously found in adipocytes the isolated from both rats [2, 3, 4, 17] and humans [9, 11]. After a 50-days detraining period Després et al. [11] found in the human adipocytes a normalization of the lipolytic response to adrenaline. We observed, differently, a further increase of the adrenaline lipolytic effect during a 4-weeks detraining. This change may contribute to a homeostatic mechanism inhibiting the increase of adipose tissue after the drop in energy expenditure due to a change in physical activity.

In isolated adipocytes dexamethasone results in a stimulation of lipolysis in concentrations from 1 to 100 $\mu\text{g}\cdot\text{L}^{-1}$ [13]. However, this effect as well as the permissive action on the catecholamine lipolytic effects appear only after a 2-hour or more prolonged incubation of isolated adipocytes with the glucocorticoid [13, 15]. According to that we did not observe the potentiation of adrenaline lipolytic effect by dexamethasone in case of 30-min incubation of adipocytes isolated from untrained or trained-detrained rats. Nevertheless, an enhanced adrenaline effect was found after adding dexamethasone to adipocytes from trained rats. This result suggests that beside the delayed permissive action of glucocorticoids, mediated through the synthesis of regulatory protein(s) [13, 15], there also exists a possibility for the rapid permissive action. The sensitivity of this mechanism seems to increase as a result of endurance training. It was suggested that glucocorticoid influence on lipolysis might be mediated through a subtle effect on calcium binding to the plasma membrane or through the intracellular distribution of calcium [12, 14].

In our experiments the antilipolytic effect of insulin [1, 16] did not change the adrenaline effect. This can be explained by the fact that in isolated adipocytes the antilipolytic effect of insulin appears in the glucose concentration is 2 mg·ml⁻¹ in the incubation medium [1] that is 4 times more than in our experiment. Nevertheless, in the lipocytes from trained rats, insulin

excluded the potentiation of the adrenaline lipolytic effect by dexamethasone. This fact suggests that insulin may be related to the mechanism of rapid permissive action of glucocorticoids.

The results of the study demonstrated an increase of the basal rate of lipogenesis by training. In accordance, Tokyama and Okuda [21] found that in trained rats the rate of free fatty acid synthesis in adipocytes was 10 times higher than in sedentary rats if the adipocytes whose diameter was similar were compared. In adipocytes from humans the training effect on the basal rate of lipogenesis was found [18, 20]. The 4-weeks detraining caused a decrease in the basal rate of lipogenesis.

In this study the insulin effect on the glucose conversion into triglycerides appeared only in adipocytes from trained rats. The enhanced conversion of glucose into triglycerides [20] or CO_2 is pronounced in adipocytes from a trained organism. However, these effects on insulin are not always striking in adipocytes from untrained organisms [8, 20]. During a 4-weeks detraining period the insulin effect on the lipogenesis disappeared. In addition to the elevation of adrenaline lipolytic effect during the posttraining period, the decreased insulin effectiveness may support the avoidance of rapid increase in body fat after a decrease of energy expenditure.

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POSSIBILITIES OF ELABORATING EFFECTIVE STRATEGY OF EVERYDAY FATIGUE RESEARCH

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Abstract

Investigations of elaborating an effective strategy of everyday fatigue research were carried out in several directions:

- (1) Optimum research strategy in experimental science
- (2) Fatigue research strategy
- (3) Practical investigations of fatigue.

The complexity of the fatigue problem has made it necessary to study the questions of effective research strategy which could be divided into three stages:

- (1) The widespread search of no-knowledge
- (2) Pilot experimental investigations
- (3) Experimental control of strategy effectiveness.

Our analysis showed that to examine systematically what we do not know well, the no-knowledge, was essential for the elucidation of optimum research strategy. Search of no-knowledge in case of the fatigue problem pointed out elaboration and widespread use of subjective and some objective methods of fatigue quantification. Thus the tests for the research of subjective symptoms of fatigue, scaling methods of feelings of fatigue, techniques of limb perimeter and skin temperature exact measurement were developed. Traditional methods of fatigue research were also used.

The subjects of investigations were more than 3000 workers of different professions in building material, dairy, automotive and light industry in Estonia, Moldova, Russia as well as students of Tallinn Technical University.

Some interesting facts about the everyday fatigue were found: the lumbo-sacral region and feet are the main regions of physiological changes in the periphery of the organism, the

brain performs an important role in preventing unfavourable changes in peripheral tissues, etc.

Several original recommendations for optimization of fatigue were proposed as the result of the investigation

KEY WORDS: Fatigue, Research strategy, Knowledge, Industry, Ergonomics.

Introduction

Everybody often feels fatigue — a temporal diminishing capacity of activity.

The problem of fatigue, especially its everyday expression, is one of the most important in sport and work physiology and has both theoretical and practical significance.

Investigations of everyday fatigue are urgently needed for the rationalization of work, for the improvement of its productivity, for raising the efficiency of leisure, for improving health and diminishing the morbidity of workers, for ensuring the adequacy of wages with the physiological cost of work.

The physiological mechanisms of fatigue differ essentially depending on the peculiarities and subject of load. By essentially physical loads (for example, in outdoor sport activity or laboratory experiments) they are intensively investigated. At light stages of fatigue which are met by people on mass professions of no-extreme loads these questions are considerably less cleared up, in spite of the huge number of scientific works. At the end of the working day or week under these conditions physiological changes are not so much expressed while they are conditioned by the complex of loads in the production plant and at home and therefore are very different.

The term "fatigue" is often used in different meanings (as the state of exhaustion, every kind of tiredness, body discomfort etc.) that leads to a confusion in the theory of fatigue, to different results of experimental works.

Most methods of fatigue investigation which are used in laboratory conditions are insufficiently sensitive in this case. Inserting a test or a physiological measure, for example for heart rate, changes the whole situation, the physiological processes and behaviour. So the test may be automatically invalid. Sometimes investigators of fatigue have shown that the determination of critical flicker frequency was better than many other methods of workers fatigue measurement. Despite that this method has also been often criticized: it has given contradictory or no coinciding results in different studies and sometimes its

changes are less by bigger physiological work-load. Many investigators consider critical flicker frequency changes to show mainly the rate of cortical activity [10].

Some investigators point out that subjective assessments only partly correlate with physiological measurements but interpret this as a shortcoming of the subjective methods and not as a logical conclusion of low sensitivity and validity of most objective methods.

The role of central regulation in the genesis of everyday fatigue, among this of higher parts of the central nervous system, is still a debatable question. The solution of this question is of great practical importance concerning the directions of optimization of fatigue in a production plant or at home.

So the solution of the fatigue problem needs deep methodological investigations, including investigations of strategy of fatigue research.

Necessity of elaboration of fatigue research strategy

At the beginning of 20th century the difficulties of investigating fatigue compelled. B. Muscio in his article "Is a fatigue test possible?" to write that the term "fatigue" must be absolutely banished from precise scientific discussion and the problem should be investigated as the determination of the effects of different kinds and amounts of work (activity) upon mental and physiological functions [8]. The experimenter must work largely by the method of trial and error. B. Muscio's points of view are popular at present and that paper is widely cited. However Muscio's suggestions are debatable for many reasons:

(1) The problem of fatigue, especially its intensity, is a practical everyday problem and cannot therefore be discarded.

(2) The determination of the physiological effects of different kinds and amounts of work must be integrated with the search of other endogenous or exogenous (physical, chemical etc.) factors contributing to the appearance and development of fatigue, which in case of everyday fatigue may be more significant than the physical or mental workload itself.

(3) One must not limit the search for fatigue problem solution with one discipline, physiology, and ignore its key questions which may be hidden among the problems of some other branches of science.

In 1979 D.E. Broadbent said in his lecture "Is a fatigue test now possible?" that the answer to this question is "not yet" [2]. There is evidence that more research effort will produce more satisfactory indicators of the chronic state of a person which

could be used to assess jobs. Even a more important goal than the production of tests is enlarging the impact of ergonomics beyond the efficiency in the workplace, to the broader themes of quality of working life.

Nevertheless, most groups engaged in fatigue research carry out a tactical and not strategic research at present. Only little attention is paid directly to methodological problems, especially to the elaboration of the strategy of research.

The fundamental investigation of the physiological phenomenon (fatigue) is harder if our knowledge about it is relatively inexact. The knowledge, however, becomes more perfect in the course of investigations. But at first we must know at least one characteristic expression of the phenomenon and in case of everyday fatigue this is the feeling of fatigue. In case of everyday fatigue other essential signs including temporal diminishing working capacity which cannot be measured directly, are more vague.

As the questions of strategy of research are little dealt with in scientific literature we shall do that.

Problems of elaborating research strategy in experimental sciences

Socrates calls attention to the fact that it makes as little sense to search for what one does not know as to search for what one knows. However, every successful scientist knows that there are some methodological rules for elucidation of the prospective course of the investigation. But in experimental sciences, including physiology, the importance of systematic elaboration of research strategy is underestimated. Even by ineffective strategy the researcher does not carry out all-sided work to decide which course of action to take. At present the point of view that the process of scientific discovery or high effective research is mainly intuition (of genius) is popular. Many scientists agree with Karl Popper view expressed in his book "The Logic of Scientific Discovery" where he wrote: "The question how it happens that a new idea occurs to a man — whether it is a musical theme, a dramatic conflict, or a scientific theory — may be of great interest to empirical psychology; but it is irrelevant to the logical analysis of scientific knowledge" [9].

The importance of knowledge depends on its theoretical and practical value.

Strategic knowledge is knowledge to decide what course of action to take when the precise effects of actions cannot be known in advance. Its importance may be great. Sometimes No-

bel prizes are given for the new research strategies, for example, to G. Elion, G.H. Hitchings and J.W. Black in 1988.

Strategy of scientific research (or problem solving) is the all-round grounded instruction of action which shows rational directions of investigations (object aspects, subproblems, stages of their research, nature of the methods, etc.). Strategy can be foreseen for the whole chain from methodological investigations to practical applications but can also include only one of its parts or one aspect. The first of them is the potentially most effective and therefore we shall discuss it.

In the present case we do not deal with problems of strategy (policy) of science which determines the most promising branches of science.

The problem of strategy of scientific research is closely connected with the problem of scientific search (real processes that determine the directions of obtaining new scientific knowledge). However, authors of these works usually do not consider the construction of new effective strategies and therefore they are of little practical use.

There are many recommendations how one can find the most effective directions in research. It is usually thought that knowledge about a problem field is very important but history of science shows that it is not always so. Many literature data contribute to using strategies that are traditional but not effective. Investigations show that the widespread approach to finding research directions where knowledge is based on intuition and the interests of the investigator play the important role has low efficiency [4].

There are some simple methods that facilitate the elucidation of effective directions, for example clearing up the trends in literature or studying citations of different authors. Unfortunately the effectiveness of such methods is deceptive in the case of complicated problems. It is difficult to be a pioneer in the research by this way or surpass other scientists.

The analysis of processes of scientific problems solving in natural sciences and medicine shows that the elaboration of effective research strategy can be divided into the following 3 stages:

- (1) Investigations of such aspects of the problem which the elements and the structure of the strategy depend on: the search of theoretical no-knowledge (what is not known but is of interest for scientists) and theoretical elaboration of the strategy;

- (2) Experimental pilot investigations for clearing up the valuable directions;

(3) Experimental control of the efficiency of strategy. Preliminary investigations which envisage program investigations.

Research is often carried out in directions which are insufficiently effective even by the understanding of these authors. The parallel implementation of these strategy stages would be achievable as in this case the period necessary for its experimental control shortens.

Considering in detail the elaboration of stage I of strategy one can say that all-round knowledge about the known can help to enlarge the area of knowledge in the most expedient direction. It is however not enough.

It is meta-knowledge — the data about the value and reliability of knowledge that is needed. However, meta-knowledge often has local value. More widespread meaning has the search of theoretical no-knowledge (unknown) including methodological no-knowledge, estimation of the probability of getting knowledge this way and forecasting its value if it has become knowledge. It is needed:

- cognize no-knowledge elucidation (what is considered as unknown);

- carry out search for yet uncognized no-knowledge.

The region of cognized no-knowledge is nearer to the knowledge region. It consists of the region of pre-knowledge which have been established by insufficient probability (inexact knowledge) and from intuitive pre-knowledge ("embryonic ideas"). The region of uncognized no-knowledge is farther from the sphere of knowledge. It is not considered as unknown as its existence is not known. But it can be revealed by additional investigations.

For clearing up the no-knowledge the widespread information systems have essential shortcomings.

A new pattern of information system is extremely needed. It is known that less than 10 % of the information on a given problem is ever recorded formally. More than 90 % of the information necessary for a given decision may exist only in the minds [3]. After that, the information system must be guiding.

Historically, a situation was formed where knowledge was highly appreciated in the sphere of scientific and practical activity and very little was written about that which was not known. At first sight knowledge is always very important. Different scientific and technological magazines prefer to publish articles where completely reliable knowledge or practical experience are presented. The study and publication of the unknown is uncomfortable and the researcher may lose the respect of some colleagues. This also may cause trouble and he may not get

funding. Nevertheless, he can start a new scientific revolution. In the case where solution of a scientific or a practical problem is needed and the present knowledge does not make it possible to find it, to know "no-knowledge" is very important. The no-knowledge often gives relevant information about the solution of the problem.

One cannot confuse subjective or practical no-knowledge with objective or scientific no-knowledge.

The conceptions "knowledge" and "no-knowledge" are closely connected with the conception "truth" (true knowledge). There is often no guarantee that all we discover is really the truth. After a while it will be questionable. So while knowledge changes and becomes more exact, no-knowledge also changes.

For unrecognized no-knowledge elucidation the following aspects of deep investigation are useful:

- 1) concepts in use, their cognitive value;
- 2) gaps and differences between problem knowledge and pre-knowledge (hypotheses, theories, facts); going from the well-known to the unknown; possibilities of eliminating differences;
- 3) different possible structures of the problem;
- 4) potential methods of experimental research; possibilities of working out principally new methods.

At present one can seldom find a researcher who systematically works out different schemes of strategy and selects the most expedient from these. The reasons are different:

- (1) Complexity of strategy elaboration;
- (2) Overestimation of old experience and intuition as guides of research direction;
- (3) A point of view that every new knowledge is useful and its scientific value is positive despite the fact that sometimes it was directing researchers the wrong way;
- (4) Underestimation of the study of the unknown and systematic elaboration of strategy.

In the middle ages there was a similar underestimation of experiments. At that time the researcher scorned manual labor and this hindered carrying out scientific experiments.

Elaboration of fatigue research strategy

The aim of our work is not to give a review of the fatigue problem. Often the methodological difficulties, lack of effective methods of obtaining new relevant information are the reasons of no-knowledge.

When explaining the notion of uncognized no-knowledge we paid especial attention to different variations of the used of basic concepts and their definitions by various authors, using operational definitions, search of gaps and differences among hypotheses, theories, facts in different publications, construction of possible structures of a problem, their visual pictures.

The analogy was used also:

- 1) fatigue in sports and cosmic medicine;
- 2) fatigue in laboratory conditions with experimental animals;
- 3) etiology of diseases caused mainly by overstrain of peripheral nerves, muscles, tendons and joints;
- 4) etiology caused mainly by mechanical underload of the musculo-skeletal system.

For systematic search of uncognized no-knowledge we also used the method of the morphological map (Zwicky) where different tissues of the organism and their structures were plotted on the axis absciss and possible physical and chemical changes on the axis ordinate. The reviews of no-knowledge of different subproblems and lists of prospective directions of investigations and necessary experiments were compiled.

The study of the concepts (especially with the possible structures of problem) "professional fatigue", "muscular fatigue" etc. showed that has the concept "everyday fatigue" has high cognitive value. The main reason is that there are hardly distinguishable physiological changes between professional and out of work activity, the result of which is that they cannot be examined separately. By investigation of everyday fatigue there are high potential possibilities of using obtained data in different directions of scientific search, but also for solutions of ergonomic problems in the enterprises.

A list of some dozens of discrepancies was compiled which was essential for elaborating a theory of fatigue. Let us consider some of them.

The search of objective independent of a subject, quantitative indices of fatigue is widespread though work capacity and fatigue undergo arbitrary regulation with the help of auto-suggestion, emotions and notions. So imaginary work increases energy expenditure, pulse rate and blood pressure, changes biological currents of muscles and the brain. These changes exceed changes which appear in case of everyday fatigue.

The more pronounced changes of fatigue indices in case of greater external load are considered as criterion of value quantitative indices of fatigue. However, more substantial changes are often observed at the rest time. So, 20-30 min in the vertical

posture without any motions can lead to a state of unconsciousness. In case of more pronounced external load the physiological changes are often smaller for the complex system of physiological processes regulation. The high correlations with objective indices are often considered as the criterion of suitability of subjective methods of fatigue investigation (tests, questionnaires, subjective scaling) though it is understood that objective methods are not enough qualitative, don't show the stage of fatigue.

The investigation of the structure of the problem points out the first-rate importance of clearing up the localization of the physiological processes of fatigue in the periphery of the organism. These localizations are easily determined by subjective methods already. At the beginning of the century some researchers found correlations between subjective and objective indices of fatigue up to 0.99 [1]. A detailed investigation of the methods showed that exact registration of changes of tissue volumes could give valuable information about the changes of physiological processes of metabolism in these tissues. This could easily be carried out under ordinary working conditions. At present the widely used methods of registration of bioelectric phenomena, the time of psychomotor reaction, critical flicker frequency etc. give information which has more complex ties with these processes and do not help enough to elucidate the fundamental physiological laws of nature.

Sometimes we used physiological investigations in workshops for the elaboration of research strategy, for example, for elucidation of the subproblems of fatigue in the car factory "Kamaz". We also used experimental investigations for strategy effectiveness control there. Carrying out the proposed strategy on a little contingent of workers we achieved an essential up to 54 % diminishing intensity of subjective symptoms of fatigue.

We also worked out information system models of no-knowledge for solving the fatigue problem and for the investigation of the problem of no-knowledge. The search of key-words by which one can find sources with the maximum amount of ideas for solving the fatigue problem was carried out. In addition to traditional key-words pointing out the no-knowledge, e.g. future directions, news outlook, problems, trends etc. in headings and abstracts, some new key-words were found. By evaluating no-knowledge the prospective use of knowledge (new research direction, new scientific discipline, essential influence on the world at outlook) that might be obtained was estimated. By setting up the no-knowledge database system the classification of scientific and technical information sources UDK was used.

ods of fatigue subjective symptoms investigation in different regions of the body for widespread and effective use under conditions of everyday activity. They must be used as basic methods for clearing up the influence of different reasons and conditions affecting the stage of everyday fatigue. At the next stage a widespread search of more pronounced objective physiological changes accompanying everyday fatigue is needed.

Physiological investigations of fatigue and their results

We have set up the following tasks of physiological investigations:

(1) To develop methods of quantitative estimation of fatigue, especially subjective methods.

(2) To elucidate the peculiarities of localization and temporal dynamics of physiological processes of fatigue in the periphery of organism by different kinds of physiological activity, in laboratory conditions, in production plants and at rest.

(3) To study the role of some factors concerning central nervous control of organism functions at work.

(4) To investigate the rate and temporal dynamics of different upper and lower limb segments of man depending on professional work.

(5) To study the correlations between subjective and objective indices of fatigue.

(6) To study the connections between fatigue and morbidity.

(7) To find new ways of physiological rationalization of different jobs and appraise their effectiveness.

The investigations were carried out mostly at work-places. The subjects of investigation were more than 3000 workers of different professions in building materials, dairy, car and light industry: garment-workers; shoemakers, weavers, spinners, engravers, metalworkers, book-keepers etc. in the industrial enterprises of Estonia, Moldova, Russia, as well as students of Tallinn Technical University. There were several directions followed in the studies.

Because of methodical difficulties there were few quantitative fatigue tests. So we needed to develop them. Tests for the research of subjective symptoms of fatigue, scaling methods of feeling of fatigue, techniques of limb perimeter measurement and exact measurement of skin temperature have been developed [7].

For precise quantitative assessment of fatigue we worked out a test of differentiated rating of the feelings of fatigue in various body regions with quantification of their intensity on

the analog-visual 10-stage scale. In the centre of this method is a chart of the 100 regions of the body (Fig. 1) which takes into account:

- 1) peculiarities of symptoms of fatigue in different body regions;
- 2) localization of symptoms, caused by unfavourable changes in the visceral organs;
- 3) symptoms of pathology of the musculo-skeletal system;
- 4) making the distinction between regions of fatigue easy for workers;
- 5) the spatial threshold of discomfort sensations.

The method permits the location of the intensity of fatigue processes in different body regions, the temporal dynamics of these processes, and is suitable in work-shop conditions.

The practical method (perimeter meters and calibrated rulers) for the precise measuring (precision to 0.2 mm) of the girths of human limbs in order to evaluate the range of physiological processes of fatigue in different segments of arms, upper arms, legs and thighs has also been worked out.

We used semi-conductor sensing elements (without contact) for the exact measurement of skin temperature (t within 0.01°C).

We also used about 30 traditional subjective and objective research methods: questionnaires, determination of critical flicker frequency and heart rate, dynamometer and static endurance tests, registration of the number of footsteps, etc.

We often studied the temporal dynamics of fatigue processes [5].

For health prognosis the time during which the symptoms of fatigue disappeared is especially important. If more than 16 hours are spent for it then by the beginning of the next shift the restitution is not yet complete and, therefore, the cumulation of physiological changes occurs.

We studied temporal dynamics of fatigue for more than 1300 practically healthy workers during their leisure time. Representatives of different specialities in light, dairy, car, building materials industries and also office workers were included. The subjects of investigation got a test of differentiated rating of fatigue feelings and regularly after each 15–30 min had to register their feelings, had to mark the time when fatigue had not been felt in the investigated regions of body.

Fatigue always depends essentially upon working conditions.

The working conditions of the subjects under investigation were mostly satisfactory, corresponding to international stan-

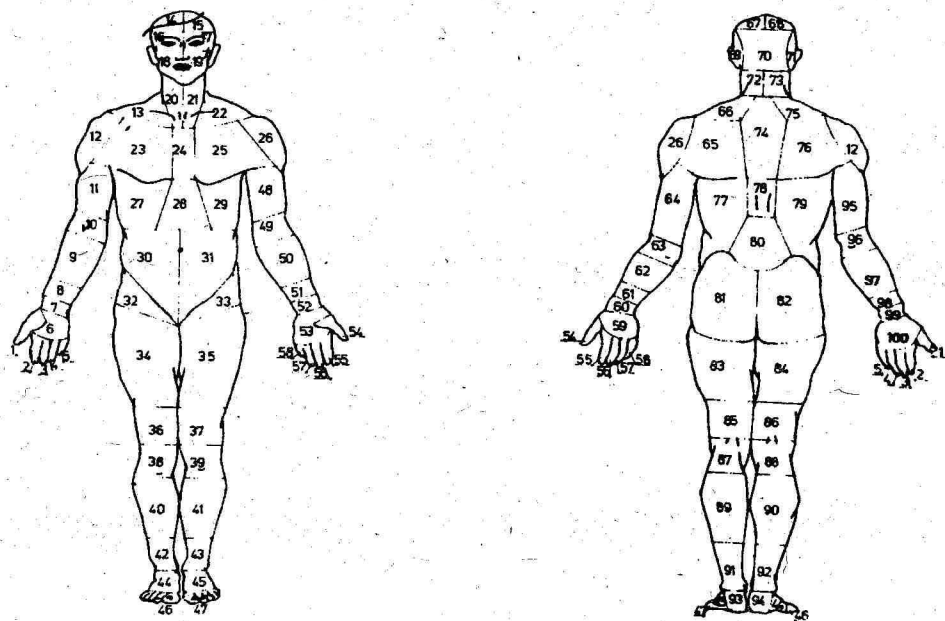


Fig. 1. The chart of 100 regions of the body.

dards. However, sometimes in the textile industry the temperature and humidity of the air were elevated — up to 28°C especially during summer months. In the workshops of textile and mechanical engineering factories it was noisy, mainly 85–95 dB(A). However, often a more intensive noise has less influence on the organism than a weaker one because in such conditions workers use earphones. Concentration of organical dust at some workplaces exceeded norms and reached $6 \text{ mg}\cdot\text{m}^{-3}$.

Most of the workers had a standing and a lesser part sitting posture. Sometimes there was an awkward posture of leaning forward a little. The work of most of the investigated professions was not monotonous.

The external mechanical work-load was often only 2–3 W and only the right upper extremity took part in the work.

The physical activity was average, 5000–7000 footsteps during the shift, but in case of tapestry weavers it was 10 400 footsteps. Interindividual differences among workers of the investigated professions were great. For example, the minimum number of footsteps during a shift in case of terry weavers was 2300, the maximum number 15 700. These differences depend greatly on both the weaver and the procedure. Workers usually did not use remarkable force, only seldom (as in the case of fitters) it reached several hundred N.

The investigations showed that most workers in our factories felt fatigue in few body regions at the end of the shift. This shows that there are considerable reserves left in the organism although the workers think they cannot strain themselves more. The regions where the intensity of fatigue symptoms is the greatest are the lumbo-sacral region, feet and calves [6]. Most large muscles participating in dynamic work do not get particularly tired. The peripheral changes depend more on the individual than on the profession. The constant leaning forward contributed to fatigue in the lumbo-sacral region; standing posture, slightly elevated air temperature and humidity promoted fatigue in feet and calves. The number of regions of the body where the sensations of fatigue are felt increases a little in case of older workers.

Our studies showed that for solving the fatigue problem in the modern industry and everyday life more attention should be paid to investigations of physiological changes outside muscular and nervous tissues. Often such objects are joints. The widespread standpoint that fatigue develops mainly in excitable tissues (nervous, muscular) is debatable. Our studies also show that in addition to physical or mental workload more effort should be devoted to the search of different other factors con-

tributing to the development of the physiological processes of fatigue.

According to our data, in most professions in Estonia and in the USSR fatigue symptoms can be observed for up to 4-8 hours but sometimes 15 hours after the completion of work. It ranges from 1.4 hours for book-keepers to 19.6 hours for tapestry weavers.

In most professions, symptoms of fatigue disappear by the beginning of the next shift. However, for two-fifths of weavers and for one-third of cutters the symptoms do not pass before the next shift. There is a close correlation ($r = > 0.7$) between indices of morbidity from diseases of the peripheral nervous system, the musculo-skeletal system and women's reproductive organs, on the one hand, and the duration of symptoms of fatigue, on the other hand.

It was found that the activity at home on workdays did not correspond to the individual peculiarities of fatigue and its role there was little rest. However, for everyday fatigue development in case of low and middle workloads the main importance belonged to the load at factory. Private life conditions have a lesser role.

The research of fatigue symptoms during the days off showed a favourable influence on the organism: the lumbosacral region, the regions of middle foot and heel were in relatively good conditions in the evening. Weak sensations of discomfort occurred in regions where they could be caused by the functional state of the heart and other inner organs. The fatigue of eyes, however, is relatively intensive which is associated with their load.

The data of subjective scaling of fatigue showed that subjective symptoms of fatigue appeared before objectively measurable indices. Even in case of relatively light work they are noticeable an hour or two after the beginning of the shift. Under these conditions one can register the objective physiological changes of fatigue an hour or more later.

The study of fatigue subjective symptoms cumulation in different body regions during the week showed that their intensity rose especially in the regions of the head and of uncertain localizations and, to a lesser degree, in other regions of the body, for example, in muscles.

A number of our investigations show that an additional load on the central nervous systems higher parts created by heightened noise level, increased neuro-psychical tension (for example, by infringements of work stereotype) raises the intensity of subjective and objective signs of fatigue, especially in the regions

of the body where they were most pronounced already before. Sometimes even in case of physical activity the correlation between the intensity of fatigue subjective symptoms in different regions of the body (in regions of working muscles, joints, etc.) and indices of neuro-psychological tension of work are greater than between the signs of fatigue and physical workload.

Thus in everyday life the central mechanisms play an active part in physiological processes of fatigue in peripheral tissues by preventing the development of unfavourable changes. On the other hand, the sensations of discomfort accompany them keeping back the intensity of activity and diminishing the risk of falling ill.

The measurements of limb perimeters showed that at the beginning of the work-shift the perimeters decreased, especially in the vicinity of the wrist. The size of these changes is usually 0.2–0.3%. During fatigue development the perimeters increase, as much as 1.4% in the middle part of the lower leg and 1.3% in the wrist. Correlations between the perimeter increase and the intensity of feelings of fatigue sometimes reach 0.75. There are also correlations between the perimeter increases and nervous tension. The changes of perimeters depend little on the age of the subject.

So the changes of limb segment perimeters give valuable information about the intensity of metabolic and vascular processes of fatigue in soft tissues of these regions.

Sometimes our results run counter to the widespread points of view. So our investigations showed that the role of overweight contributing was small in case of some professions (spinners). In spite of the fact that some parts of machines are too high for the workers, in case of taller workers some fatigue symptoms (for spinners, especially, in the lumbo-sacral region) are stronger than in case of shorter ones.

A number of inexpensive measures for optimizing the work process and working conditions were recommended.

As the nature of fatigue itself is dependent on the individual, it is necessary for these measures to be individually tailored. Consultations by a labour physiologist are of great importance. One can often improve the general condition of a worker.

Fatigue can be diminished by the use of earphones with radio receivers.

In case of intensive noise which does not exceed sanitary norms or exceeds them little (to 10 dB) and when using of anti-phones and other means of individual protection is not envisaged, it is expedient to use soft protection means (for example, cotton balls) in ears. These means essentially decrease the un-

favourable influence of noise on work capacity, especially when the activity is connected with nervous tension.

Specially constructed footwear and massage apparatus may be effective for reducing foot fatigue.

When working in three shifts, the cases when the workers have no possibilities of rest during daytime shifts should be altered after 2-3 workdays.

In organizing work special attention must be paid to clearing up deviations from the usual work stereotype as even in case of non-monotonous jobs such little deviations markedly accelerate the development of fatigue.

It is often possible to considerably improve the seating equipment in order to minimize the load levels on the different parts of the locomotor system.

Some results indicate that it is possible to reduce physiological and discomfort problems in lower legs and feet during prolonged sedentary work by introducing modest leg activity as a natural part of the seated work.

The improvement of writing and seating equipment is of greatest importance for diminishing students' fatigue.

Conclusion

While elaborating a research strategy for a complex problem it is important to pay special attention to the systematic search of the unknown, no-knowledge, using the latest achievements of methodology of science. For solving the everyday fatigue problem a strategy should be used which begins with elaborating subjective investigation methods and widespread practical use of them.

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MASTERCLASS FEMALE BASKETBALL PLAYERS ECHOCARDIOGRAPHIC, RHEOCARDIOGRAPHIC, PWC 170 AND MAXIMUM OXYGEN CONSUMPTION ANALYSIS

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Abstract

To realize their high qualification sportswomen must be in physically very fit. Complex physiological investigation is needed to characterize aspects of physical fitness. It may indicate a weak point of the fitness to be corrected by a training programme.

Hemodynamic, echocardiographic, PWC 170 and the maximum oxygen consumption are analyses used for this purpose.

The echocardiographic data showed that hypertrophy of the left ventricle is slight as compared to the data in literature. More power training is recommended.

The maximum oxygen consumption level is low and more training in the aerobic regimen is also indispensable. The average MOC of the investigated sportswomen is 41.8 ± 5 ml/min⁻¹/kg⁻¹.

The PWC 170 kg/kGm average index 19.9 ± 2.7 kGm/kg is on a high level and reaches the level of middle-distance female runners (19.3 ± 1.3 kGm.kg).

KEY WORDS: myocardial hypertrophy, central hemodynamic, maximum oxygen consumption.

Introduction

At the end of the last century S. Henschen [6], professor of internal medicine of Uppsala University, published his work

about enlarged hearts in crosscountry skiers. His statement "the biggest hearts will win the race" has become popular. Otherwise said S. Henschen was the first to note the relationship of morphological and functional qualities.

The pathoanatomical investigations confirmed welltrained hearts enlargement [10]. Roentgenological and echocardiographic methods detailed the changes of the cardiac structure as a result of chronical training. We can say that there are two different types of hypertrophy of the heart. J. Morganroth et al. [12] have pointed out that the cardiac adaptation in heavy athletes is "pure concentric hypertrophy" in contrast to "pure dilatation" in endurance athletes. This seemed quite logical keeping in mind the "predominant" volume type of work of the hearts of endurance athletes compared to the predominantly "pressure type of work" during isometric performance.

The dimensions of the body had great influence on the dimensions of the heart first of all the height and the body weight and the body surface area [4].

The influence of sports training lasts many hours a day but the demands caused by the body dimensions continue all the time.

Many functional indices are greatly influenced by the body dimensions and even by the dimensions of the heart. First of all, the maximum oxygen uptake is determined to a high degree by the body mass. Therefore maximum oxygen uptake is often given in $\text{ml}/\text{min}^{-1}/\text{kg}^{-1}$ [2, 8].

Few investigations have been carried out to study the real hemodynamic parameters during veloergometric work and to investigate simultaneously the echocardiographic dimensions of the heart before the work test. M. Ojamaa [13] has studied these problems in male sportsmen but this kind of studies of female sportsmen have not been available to the authors.

Material and methods

Our subjects consisted of 13 female basketball players of ages 17-31, all national level players.

The mean age was 22 ± 4.3 years, height 181 ± 7.3 cm (168-193 cm), weight 72.5 ± 8.3 kg (56-83) and body surface area 1.924 ± 0.15 m^2 (1.632-2.133).

We used the echocardiograph ATL Mark 5 Advanced Technology Labs. M-mode echocardiographic measurements were made according to the recommendation of the American Society of Echocardiography [16]. The following echocardiographic parameters were obtained: enddiastolic left ventricular diameter (LVEDD) measured at the onset of the QRS-complex and

endsystolic left ventricular diameter (LVESD) at minimal cavity dimension, enddiastolic left ventricular posterior wall (PW) and intraventricular septum wall thickness (IVS).

The left ventricular ejection fraction (EF) was calculated by the single-plane area-length volume formula proposed by Teichholz et al [17]. The stroke volume (SV) was also calculated by the Teichholz et al method [17]. The left ventricular mass (LVM) was calculated by M-mode echocardiogram using a modified formula of Devereux et al [5].

The aortic root diameter was measured at the end of the diastole. The left atrial diameter (LAD) was measured in systole from the leading edge of the posterior aortic wall to the leading edge of the posterior left atrial wall.

The bicycle ergometric experiments were two loads on the bicycle ergometer "Ergostat 4". The initial load was 100 W, the second load 250 W, the duration of every load was 3 minutes, the pedalling rate 70 r m. The pause between the loads was 1 minute. After the second load a one-minute lasting load with the maximum pedalling rate was used. The period of restitution was observed during a 3 minute period. For the hemodynamic registration we used the rheoplethysmographic tetrapolar thoracic method by W.B. Kubiček in the modification of J.G. Pushkar [14]. Curves registered on the electrocardiograph EKGM-01, synchronized electrocardiography (ECG), phonocardiography (PHONO), rheoplethysmography (RKG) and differential rheoplethysmography were used.

The registration was performed before the first load, during the first ten seconds after every load and also in the period of restitution on the third minute at a sitting position.

For rheoplethysmography the apparatus PIIF2-02 was used, for the registration of ECG the leads by L.A. Butschenko [3] were performed, for the PHONO the type 056 phonocardiographic sensor was used.

Results and discussion

Anthropometrical data

We compared the female basketball players' height with J. Aul's 1978 [1] height evaluating table for the 18-year old schoolchildren height values. The basketball players' average value of height was greater than that of the "very tall" estimating class, which is in the ranges of 174.8–180.1 cm. Only two of the sportswomen had a height in the "middle" value class, two of them in the "very tall" value class, all the others were taller.

We can draw a conclusion that in this sport extremely tall sportswomen have an advantage.

We also compared the weight of the female basketball players with J. Aul's 1978 weight evaluating table. The average weight 72.5 ± 8.3 kg corresponds to the "very heavy" weight estimating class, 6 sportswomen belong to this class. 3 sportswomen belong to the "heavy" class, 1 belongs to the "middle" class and 1 to the "light" class. Only 2 sportswomen are excessively heavy.

J. Aul [1] draws attention to the height and weight relationship using a correlation method for this purpose. The physical development indices had interdependence. This means that with one of them increasing the other also increases or decreases. This relationship is statistically characterized by a correlation coefficient. The female basketball players height and weight correlation coefficient is 0.93. For schoolchildren the correlation coefficient between the height and weight is 0.561. We can draw the conclusion that the constitution of sportswomen is clearly more proportional than the constitution of schoolchildren. The body surface area of the sportswomen is $(19.24 \pm 1.54 \text{ dm}^2)$ bigger than the body surface area of the schoolchildren $(16.57 \pm 0.04 \text{ dm}^2)$. J. Aul [1] considers the body surface area very essential for bodily strength. The bigger the body surface area the stronger the individual. We can say that female basketball players are stronger than schoolchildren. At the same time the body surface area is an index of proportionality. We may consider sportswomen more proportional than schoolchildren.

Echocardiographic data

All data are given in Tables No 1-6. A.G. Dembo and E.V. Zhemtsovski [4] recommended (besides direct measurements of the heart with electrocardiographic beam) to calculate indices according to the body surface area 1 m^2 .

We compared the data of female basketball players with the data in literature. M. Lintsi et al [11] data showed that young beginners and young good student middle distance runners had smaller aortic diameters. The aortic diameter indices were bigger in groups of runners than in groups of basketball players.

The myocardical mass (MM) was bigger in the basketball players than in all the investigated groups of runners, and the MM index was greater in basketball players than it was in beginners (57 ± 11 g), in good young runners (59 ± 11) but it was smaller than the indexes of student runners [11].

We compared the data of the MM with the MM of softball

players investigated by Rubal et al [15]. The softball players' MM was 168 ± 15 g, the MM of our basketball players was 131 ± 16 g. We can draw the conclusion that the hypertrophy of the left ventricle is more advanced in softball players, and concerning the wall thickness, the left ventricular enddiastolic diameter didn't differ. Using the J. Marganroth et al [12] data and analysis, we can draw the conclusion that the softball players' training is connected with more isometric training than that of basketball players. I. Morganroth et al [12] showed first that the heart wall thickness of heavy athletes increased but the cavity dimensions did not. On the other hand, the heart-cavity dimensions of runners increase, the increase of wall thickness is slight or not noticeable.

Bicycle ergometric investigation

We got the maximum heart frequency on the second load or on one-minute load with the maximum pedalling. The maximum heart rate on the second load was in the range 156–182 and on the load with the maximum pedalling 156–200. According to N.V. Zhimkin [18] the suitable heart frequency for determining the maximum oxygen uptake is 180 beats per min. Further heart rate increase may lead to the decrease of the stroke volume of the heart.

Stroke volume (SV)

Stroke volume was determined rheoplethysmographically [14]. Before the first load the average SV was 86.6 ± 15 ml (minimum 57.6 — maximum 102.1 ml). The correlation coefficient with the height ($r = 0.29$) and weight ($r = 0.31$) was weak.

In the previous study of sportsmen by M. Ojamaa [13] the average SV was 86.5 ± 4.2 ml. M. Ojamaa divided the stroke volume reaction to work into 3 types — hyperkinetic, normo- and hypokinetic.

The hyperkinetic type is characterized with continuously (steadily) increasing stroke volume on every load. The example is sportswoman no. 1. Before the first load the SV was 100.7 ml, on the second load the SV was 146 ml, on the spurt load the SV was 168.8 ml. Sportswoman no. 7 also had the above mentioned tendency — before the first load her SV was 86.7 ml, on the first load 107 ml, on the second load 115.7 ml, on spurt 137.1 ml.

We call this hyperkinetic reaction type A variant. The sportswomen gave continously increasing SV on the I and II loads but on the spurt the SV reduced. This pattern of reaction we called B variant.

Table 1.

Sportswomen	Before	I load	II load	Spurt
No. 3	68.0	80.9	107.0	94.0
No. 6	75.0	128.0	134.0	111.8
No. 8	57.6	77.7	107.8	73.2

What is the reason of this variant? We analyzed the heart rate on the II load and spurt.

Table 2.

Pattern type	Sports-women	II load heart rate	Spurt
A	No. 1	156	156
	No. 7	167	176
B	No. 3	182	182
	No. 6	188	200
	No. 8	176	176

Variant A involves the heart rate below 180 beats per minute, variant B is characterized by a higher heart frequency. It may be the reason of the genesis of these two variants.

Normokinetic stroke volume reaction type is characterized by a rising SV on the I load but the following loads do not increase SV any more. It even diminishes a bit. M. Ojamaa [13] found the next reaction pattern — before work SV 73.8 ml, on the I load SV 95.7 ml, on the II load 89.1 ml, on spurt 89.2 ml.

Table 3.

Sportswomen	Before	I load	II load	Spurt
No. 4	108	151	97	126
No. 5	99	130	92	100
No. 9	102	112	109	137
No. 10	95	146	110	90
No. 11	84	113	96	108

In comparison with sportsmen, sportswomen had a different reaction of SV. If the sportsmen's reaction is characterized by a permanent low level after the first increase then the sportswomen SV reaction is a wavy line.

On the I load the SV increased significantly, on the II load it decreased.

We divided normokinetic SV reaction also into two variants. Variant A is characterized by a new SV increase on the spurt

load. That kind of reaction is characteristic of sportswomen 4, 5, 9, 11.

Variant B is characterized by a steadily decreasing SV after an increase on the I load.

We tried to analyze these problems from the standpoint of heart rate.

Table 4.

The heart rate in case of different load levels

Sportswomen	Before	I load	II load	Spurt
No. 4	43	88	176	176
No. 5	64	100	176	176
No. 9	63	107	158	158
No. 10	67	107	176	176
No. 11	55	97	158	158

It is interesting to remark that no one in this group reached the frequency zone 180–200. And what's more interesting, the spurt didn't change the heart frequency but gave an increase of the SV.

We can explain it with a new immobilization of the myocardial reserves on the maximum effort. A separate type of SV reaction is the reaction of SV of sportswomen 12 and 13.

Table 5.

Stroke volume dynamic on different load levels

Sportswomen	Before	I load	II load	Spurt
No. 12	76	82	86	86
No. 13	74.5	77	68	73

We called them variant C, according to the reaction — inertial (sluggish) type. It is characterized by small changes of the SV.

The hyperkinetic variant SV reaction pattern in the sportsmen is characterized by M. Ojamaa [13] as follows. At the beginning the SV is 99.6 ml, i.e. SV is higher than the starting values of the other cases but on every load it decreases as compared to the initial values. After the spurt the SV reaches the initial level.

Sportswoman No. 2 exemplified this variant of the SV reaction but differently from sportsmen the spurt was followed by a decrease.

Cardiac output (CO) dynamic

CO is the amount of blood in ml-s or in l-s pumped in the circulation by the left ventricle during one minute. The cardiac index (CI) which means the cardiac output ratio to the body surface area 1 m^2 is also frequently used. These indices are often given with the formula $Q_{\text{ml/min}} = Q_{\text{s/ml/fh}} (\text{min}^{-1})$. These indices reflect the contractility and the automatism of the heart. In the vertical position the inflow to the heart diminishes and, accordingly, the stroke volume and the cardiac output also diminish.

By J. Aulik [2] the cardiac output was at rest $4-5 \text{ l/min}^{-1}$. In untrained males the cardiac output increased on the maximal load to 25 l/min^{-1} . Athletes reached even 40 l/min^{-1} .

We compared the average indices of 5 hyperkinetic type sportswomen in every load with the average indices of 5 normokinetic type sportswomen in every load. Separately, we compared the normokinetic type inert variant indices and the hypokinetic type indices.

Table 6.

CO in the level of different loads

Reaction pattern	Before	100 W	250 W	Spurt
Hyperkinetic l/min	5.29	12.1	16.8	20.7
Normokinetic l/min	5.57	13.2	17.4	18.8
Inertvariant	4.82	8.2	13.0	14.6
Hypokinetic	5.9	8.9	13.3	10.3

It is interesting to mention that the individuals of the hyperkinetic type reaction had the greatest variability of the CO values.

The hyperkinetic variant overcame the average indices of the CO of the normokinetic variant, only on the spurt CO

The average indices of the CO of the inert type fell behind both variants of the reaction type.

The hypokinetic type of the CO is represented only by one sportswomen. Her CO indices were lower on all loads compared to the indices of the other variants.

Test PWC 170

The determining of PWC 170 is well-known in the practice of sports medicine. Only two loads were administered on the

bicycle ergometry. At the end of the load the heart frequency was determined. V. Karpman [9] gives the formula for its calculation.

Our basketball players' average PWC 170 1437 ± 232 KGm was higher than the results of the sportswomen investigated by V. Karpman. For example, PWC 170 in women swimmers was 1100 KGm, underwater sportswomen — 950 KGm, bicyclists — 1050 KGm. These differences may be due to the heavy weight of the basketball players.

The PWC 170 KGm kg average index 19.9 ± 2.7 KGm/kg was on a high level and reached the level of the middle-distance runners (19.3 ± 1.3 KGm/kg) investigated by V. Karpman.

Maximum oxygen consumption

Maximum oxygen consumption (MOC) is the greatest amount of oxygen which an individual can use during muscular work. The gas exchange was measured constantly with the apparatus "Spirolyt". MOC is given in liters/min or $\text{ml}/\text{min}^{-1}/\text{kg}$.

The average MOC of the basketball players was 2999 ± 303 ml/min or 41.8 ± 5.0 ml/min/kg.

The individual level of the MOC varied greatly from an individual to individual. The smallest data were 33.1 ml/min/kg and the best data of the sportswomen in our group were 53.8 ml/min/kg. By Wilmore [19] the female basketball players' group's average MOC was 44 ml/min/kg.

By V. Karpman [9] the female basketball players had even higher data of the maximum oxygen consumption 50 ± 2 ml/min/kg with individual variation of the data from 41 to 59 ml/min/kg.

For the women in sports games V. Karpman gives the following evaluation scale:

very high level	> 59	ml/min/kg
high level	52-59	"
middle level	44-51	"
low level	36-43	"
very low level	< 36	"

Using this evaluation scale only one sportswoman had the high level, nine had the low level and only one had the very low level of the maximum oxygen consumption.

T. Jürimäe [7] investigated female untrained students and characterized their evaluation scale as:

very high level	> 44	ml/min/kg
high level	38-44	"

By T. Jürimäe [7] scale we can draw a conclusion that the very high and high level is characteristic to 11 sportswomen, only 2 of them were in the middle class. But only 3 sportswomen had reached the very high level. But T. Jürimäe [7] scale was based on untrained female students' data.

We can draw the conclusion that the investigated basketball players had maximum oxygen consumption within the low level and in the future more aerobic training is recommendable to increase the maximum oxygen consumption.

Conclusions

1. Female basketball players are very tall, in 8 cases, out of 13 they exceed the standard height "very tall" set fore for schoolchildren.

2. It should be noted that the values of female basketball players correspond to the weight scales presented by J. Aul.

3. The weight indices are proportional to the height indices. The weight and height correlation coefficient is higher in sportswomen than in schoolchildrens.

4. The diameter of the aorta of the female basketball players is significantly greater than that of the female student middle-distance runners and greater than that of the USA softball players.

5. The myocardial hypertrophy of the female basketball players is more advanced than that of the female student middle-distance runners but is considerably below that of the American softball players.

6. By the hemodynamic reaction pattern female basketball players are hyperkinetic or normokinetic, only one of them had a hypokinetic stroke volume reaction pattern.

7. In addition to the analysis of the stroke volume reaction pattern found in the literature we recommend to distinguish hyperkinetic variants A and B and A, B and C variants in normokinetic reaction pattern.

8. The cardiac output increase during work is higher on the hyperkinetic and normokinetic SV reaction pattern than the increase of SV on the hypokinetic reaction pattern.

9. The female basketball players PWC 170 is very high, reaching the level of female middle distance runners.

10. The female basketball players maximum oxygen consumption is low by the standards for sportswomen. More training in the aerobic regimen is recommendable.

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THE QUEENSLAND PHYSICAL GROWTH, DEVELOPMENT AND HEALTH STUDY*

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The Queensland Physical Growth, Development and Health Study has been funded for a pilot project by the newly instituted Queensland University of Technology. The four principal investigators represent the disciplines of anatomy, motor learning, child development, the socio-cultural area and exercise physiology and health. The primary purpose outlined in the grant application was to longitudinally evaluate changes in children's growth by measures of anthropometry, flexibility, strength, reaction-movement time, fitness and motor ability performance and assess the effects of sociological and cultural factors and environmental conditions.

The study is specifically designed to replicate in some dimensions the longitudinal study initiated in 1968 in Saskatchewan, Canada, under the direction of the Principal Investigator Prof. Dr. Donald Bailey, as well as the Leuven Study under the direction of Drs. Gaston Beunen and Robert Malina. Direct comparisons between the growth of Belgium, Canadian and Australian children will be possible from the forthcoming data. A major purpose of presenting this study is to stimulate scientific interest in the area of the growth and development of children from the cross-cultural perspectives. The feasibility to undertake similar studies is within the potential of most countries and it is highly recommended that attempts be made to duplicate the principal aspects so that future extensive cross-cultural comparisons can eventuate.

Since the 1960's numerous cross-cultural studies have been undertaken. For example, Gerald Kenyon's [28] work in 1968 focussed on the values held for sports and physical activity by adolescents in Canada, Australia, England and the United States. A much more recent example that could be

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cited would be the study of the basic physical performances characteristics of selected American, Canadian and German Physical Education students by Gary Sinclair, Herbert Haag and David Belka. These two studies are identified here only to highlight the extensiveness and the limitless potentialities of cross-cultural studies which range through the socio-cultural to the physiological parametres. The data from such investigations would contribute to the knowledge of the effects of biological and environmental factors on the growth, development and health of the child.

Rationale for the Study

Children progress through relatively predictable sequences in their physical cognitive, social, emotional and motor development [5,38]. Such similarities in development make children appear more alike than different [5,20] but the achievement of any skilled behaviour is the result of a complex interaction between biologically determined behaviours, environmental influences and cognitive process; an interaction which creates considerable scope for variability [20,26,38,46].

Motor development, for example, in normal children has been viewed as progressing through a relatively predictable sequence of movement patterns which increase in complexity as the child matures [3,22,24,32,33,39]. Early movement sequences are considered to be biologically determined because they are dependent on physiological and neurological maturation [4,19,29,33]. Skilled movements, in contrast, are dependent on maturational processes, environmental interaction, practice and learning [21,31, 42, 43, 45].

The observable changes in physical and motor development are the result of many factors. These include age-related changes in neural structures [44]; physical changes in bone and muscle, which cause greater strength and mechanical advantage [31,36]; changes in the ability to process movement information [43]; increased ability to formulate motor responses [14] and changes in ability control units of a voluntarily movement [16]. Developmental changes in children, then, are dependent upon genetic, physical, neurological and learning factors.

The physical growth and development of children and adolescents is therefore extremely complex. Unfortunately,

there is generally a poor understanding of many aspects of the growth and development process by a wide cross-section of the community including teachers, coaches and parents who are dealing with children on a daily basis. Perhaps the commonality of occurrence of the processes has led to a perceived lack of need to possess more than an overview of issues in the area.

Traditionally, physical growth and development as a discipline area has not received its rightful place in pre-service teacher training courses, often being subsumed in psychology units with little more than a cursory glance being devoted to it. In recent years, greater attention has been devoted to studies of the growing years, but research has been spasmodic and mainly cross-sectional in design. Evidence of an increased awareness is displayed in recent publications in physical education and human movement studies periodicals. For instance, professional organisations in many western countries have formalised position statements on the involvement of children and adolescents in sport and physical activity recognising that children are not miniature adults [2,13,34,35].

There is a strong need to initiate a major longitudinal study of the growth and development of a cross-section of Queensland children and youth. The study would assess the physical characteristics of the sample including full anthropometric, body composition, somatotypic and physiological screening. In addition, the study would seek to ascertain the attitudes of the cohort in broader health and physical activity issues and changes in all parameters across the duration of the study. Although abbreviated versions of the proposed test item battery have been conducted in North America and Europe [9,10,15], no study of such breadth and depth has been undertaken in Australia.

A limited number of related studies, however, have been conducted in Australia but these have been isolated to particular populations and specific areas [11,12,17, 27, 37]. An exception was the comprehensive physical fitness appraisal conducted by the Australian Council for Health, Physical Education and Recreation on a nationwide sample of children aged 7 to 15 years [6]. This particular study, which encompasses only a small number of measures of growth and performance parameters, trialled older age brackets, neglecting the early childhood population. The proposed study would make up for these weaknesses.

Since limited data has been generated in Australia, there has been a heavy reliance on normative data of overseas countries, much of which is inappropriate for the Australian population. An added advantage of Australian longitudinal data is that comparisons of growth and development could then be made using Australian norms.

In addition to the importance of establishing Australian norms on physical growth and development, the study offers numerous benefits to the developing institution, with results being highly applicable to the Queensland community. Such a comprehensive of the health status of Queensland children would have direct application to physical and health education, sport and physical activity initiatives. There is also the opportunity to apply anthropometric data to the ergonomic design of school and sporting equipment and clothing.

Purpose

The proposed study will analyse and evaluate, through extensive laboratory testing and questionnaire analyses, the physical growth, development and health patterns of Queensland children, aged 5 to 15. Specifically the aims of the study are: -

1. To measure physical growth and development;
2. To analyse changes in growth, development and health patterns;
3. To determine the interrelationships in growth, development and health patterns;
4. To evaluate gender differences;
5. To examine the level of physical activity and dietary patterns and to study their influence on the growth patterns;
6. To assess the effects of biological and environmental factors on growth, development and health status;
7. To synthesise the data for utilisation in the planning of physical and health education programs;
8. To conduct cross cultural comparisons with related studies undertaken, e.g. the Medford Study - Eugene, Oregon, U.S.A.; the Saskatchewan Growth and Developmental Study - Saskatoon, Saskatchewan, Canada;

the Western Australia Growth Study - Perth, Western Australia; and the Physical Growth and Motor Performance of Belgian Boys and Girls (Leuven, Belgium).

Methodology

A total of 88 subjects will be tested for the pilot study, eight from each age group 5 to 15 years. The subjects for the five-year study will be a stratified random sample of the Brisbane school population, 350 in number. If additional funds become available, a rural and an aboriginal / Torres Strait Islander sample will be tested as well. Subjects will be tested once a year and questionnaires will be administered on an annual basis. The instruments and the test items to be utilised have been identified as follows:-

1) Anthropometric & Body Composition Assessment

- 1.1 Standing height
- 1.2 Sitting height
- 1.3 Body weight
- 1.4 Sitting height - Standing height ratio
- 1.5 Body Mass Index (BMI)
- 1.6 Bi-acromial Diameter
- 1.7 Transverse Chest Diameter (chest breadth)
- 1.8 Antero-Posterior Chest Diameter (chest depth)
- 1.9 Bi-iliocristal Diameter
- 1.10 Bi-epicondylar Humerus Diameter
- 1.11 Bi-condylar Femur Diameter
- 1.12 Circumferences Measure : Chest
- 1.13 Circumferences Measure : Waist
- 1.14 Circumferences Measure : Hip
- 1.15 Circumferences Measure : Flexed Arm
- 1.16 Circumferences Measure : Thigh
- 1.17 Circumferences Measure : Calf
- 1.18 Ponderal Index
- 1.19 Skinfold : Subscapular
- 1.20 Skinfold : Triceps
- 1.21 Skinfold : Suprailiac
- 1.22 Skinfold : Biceps
- 1.23 Skinfold : Calf

2) Somatotype classification – Heath Carter Method

3) Performance Tests

a) Bruininks –Oseretsky Short Form

- 3.1 Running speed and agility
- 3.2 Standing preferred leg on balance beam
- 3.3 Walking forward heel-to-toe on balance beam
- 3.4 Tapping feet alternatively while making circles with fingers
- 3.5 Jumping up and clapping hands
- 3.6 Standing broad jump
- 3.7 Catching a tossed ball with both hands
- 3.8 Throwing a ball at target with preferred hand

b) Fundamental Movement Pattern Levels

- 3.9 Walking
- 3.10 Running
- 3.11 Jumping
- 3.12 Throwing
- 3.13 Catching

c) Motor Control: Interlimb Co-ordination Tasks

- 3.14 Response Speed Upper Limbs
- 3.15 Total Movement Time Upper Limbs

b) Additional Motor Performance Tests

- 3.16 50m run
- 3.17 Bent knee sit ups
- 3.18 Push-ups
- 3.19 Flexed arm/hand

4) Flexibility Tests

- 4.1 Sit and reach
- 4.2 Hip: Flexion (knee extended)
- 4.3 Hip: Flexion (knee flexed)
- 4.4 Hip: Extension
- 4.5 Hip: External rotation
- 4.6 Hip: Internal Rotation
- 4.7 Knee: Flexion
- 4.8 Knee: Hyperextension

5) Strength Tests

- 5.1 Shoulder
- 5.2 Elbow
- 5.3 Wrist
- 5.4 Knee extension
- 5.5 Wrist
- 5.6 Back
- 5.7 Hip flexion

6) Cardiorespiratory Analyses

- 6.1 Vital Capacity, forced expiratory volumes
- 6.2 Physical Work Capacity (PWC₁₇₀) - treadmill or bicycle ergometer
- 6.3 Predictive MVO₂ - treadmill or bicycle ergometer

7) Physical Activity & Lifestyle Questionnaire

8) Nutritional Intake Analysis

9) Self-Concept & Body Image Scales

10) Schools Questionnaire

11) Medical History (and examination)

12) Additional Information

(Academic achievement; socio-economic status of family; family status).

Unique Features

The Queensland Study will be unique in its extensive procedures which will include, in addition to the physical growth and development measurements, sociological analyses, dietary intake analyses, leisure time and lifestyle questionnaires, as well as motor skill analyses. Moreover girls, as

well as boys, will be studied. Thus, this will be one of the most comprehensive studies of the progressive growth of children ever undertaken, and is most worthy of consideration by other countries.

Initial Problems

Initially the main problems have revolved around the specific set-up, the ordering and preparing of the equipment and the establishment of proper procedures and format. However, the principal concern has been in the final determination of specific tests/questionnaires and the test items. In a study of this magnitude various factors such as ease of portability, reliability and expense have to be taken into consideration before final decisions are made.

One issue has revolved around the utilisation of a treadmill, or bicycle ergometer. The treadmill was preferable, for the reliability and for comparative purposes with the Saskatchewan Study. However, the treadmill is extremely expensive and was not initially budgeted for (although access to one in the city could be relatively easily obtained). The ease of portability of the bicycle ergometer has certain attractions, particularly if the success of the study enables samples of rural and aboriginal children to be undertaken.

Another item of concern has been in the strength measurements. The strength chair at Saskatchewan has obvious merit for comparative purposes, but it was specially designed and its specific usage is now outdated. The Cybex machine (which was not in existence when the Saskatchewan Study started) is available, but at cost of in excess of \$60,000. Access to one in the city was possible, but it means transporting the children to another venue for testing of one specific measure.

One of the major concern areas was that with the questionnaires in the sociopsychological domain and the dietary intake analyses. The problem was in the age range involved in the study and in the obtaining of tests which had been trialled and validated for such young children.

Personal visitations by two of the principal investigators have been undertaken to the laboratories in Saskatchewan and Belgium. Such visitations aided in the establishment of procedures and in the design of comparative analyses.

Summary

The Queensland Physical Growth, Development and Health Study is underway in the Pilot Study phase, Stage One. The researchers welcome expressions of interest from other countries/centres which might consider whole or partial replication to allow for future cross-cultural comparisons of the growth and development of children.

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QUALITY, DAILY PHYSICAL EDUCATION

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Australia is acknowledged to have an enviable position in the world. It is out the way, it offers no threat to anybody and is not itself threatened; it is under-populated; it offers unlimited opportunities for camping, bush-walking and swimming, particularly for those on the coast, where beaches abound in rare splendour. The roll of the waves, the smell of the salt and the feel of the golden sand have a strong hold in the senses of the average Australian. There are a few minor blots on the landscape, like sharks and crocodiles, but these are shrugged off by the locals as aberrations understandable in perfection, in the 'lucky country'. The sun shines on to oblivion, ever tempting in summer and winter, bequiling the citizen to go outdoors in appreciation.

The beaches epitomise the egalitarianism that is heralded as being representative of the Australian way of life. It is tough to see class differentiation when the swim suits of to-day are viewed. The waves accept all classes.

The Australian poet Henry Lawson described Australia as the "land where sport is sacred", where you must make "a hero of a clod".

Keith Dunstan went even further

Sport is the ultimate Australian super-religion, the one thing every Australian believes in passionately. Sport is wholesome. It can do no wrong. It builds stronger Australian men and women, and, best of all, it spreads the fame of Australians overseas. It helps to unify Australia as a nation.

Not to be keen on sport is, therefore, unclean, unmanly, even homosexual, and definitely contrary to the ethics and super-religion of the nation.

So many Australian athletes have graced the world's stage. Its three main heroes have been a horse (Phar Lap), a boxer (Les Darcy) and a cricketer (Donald Bradman). But there have been countless other heroes, and heroines; three time gold medalist Dawn Fraser, Murray Rose, Shirley Strickland, Marjorie Jackson, Herb Elliott, John Landy, Robert de Castella, Australia II (a yacht), Evonne Goolagong, Margaret Smith-Court, Rod Laver, Roy Emerson, Bobby Pearce, Lew Hoad, Greg Norman, and so on.

The world image of the average Australian is somewhere between "Crocodile Dundee" and Tarzan or Jane: obsessed with the outdoors, a people, bronzed, muscular and athletic.

PLEASE NOTE: All of the foregoing is a commercial, a myth carried on through publicity by Australian tourist authorities, nursed along by pale, bow-legged and balding people like myself who mentally see themselves as portraying the image, and only come in line with reality when we look in the mirror.

The problems in Australia are little different from anywhere else in the post-television days. Let us cite a few facts.

1. The National Heart Foundation survey in 1980 in Australia showed that 48 percent of men over 35 years and 42 percent of women over 40 were overweight or obese. A follow-up study three years later showed that the prevalence of the overweight and/or obesity was increasing. The percentage increase for men over 25 was 1.3 percent, while for women over 25 it was 3.6 percent.
2. Overweight is not just a problem for adults in Australia. Studies of Australian children have shown that their body fat levels are 25 per cent greater than those of British children of the same age, and even higher than those found in American children. Five to ten per cent of Australian children are obese.
3. Australia is the fourth most obese nation in the world, exceeded only by Germany, Mexico and Switzerland.
4. Only 16 per cent of Australian men and 9 per cent of women engage in regular, vigorous exercise at least three days a week.
5. Fifty per cent of Australian men and 66 per cent of Australian women rarely or never engage in active exercise.

6. Coronary heart disease accounts for one-third of all deaths in Australia.

The real picture came to light when actual research was done in Melbourne relating to the sport and leisure activities of Australians. The survey highlighted three major groups of the population: the "tuned out", the "drifters" and "tuned in" (Figures 1,2,3).

A. The "tuned out" did not care if they did anything. It was a surprising 19 percent of the sample.

B. The "drifters" were those who had to be convinced and had to have things organised and provided for them. This group comprised 59 per cent of adults.

C. The "tuned in" were those who did not need to be convinced about the need for exercise. This group consisted of 22 per cent of the sample. They, in turn, broke down into three groups: (a) the "young lions", about 5 percent, and these were the fitness addicts, who ran and worked out as much as they could; (b) the "self convinced", who did not need propaganda or campaigns to get involved, and these amounted to about 6 percent; and (c) the "self-improvers", about 11 percent, who would be taking courses and joining clubs to improve their tennis, bowling, field hockey and so on.

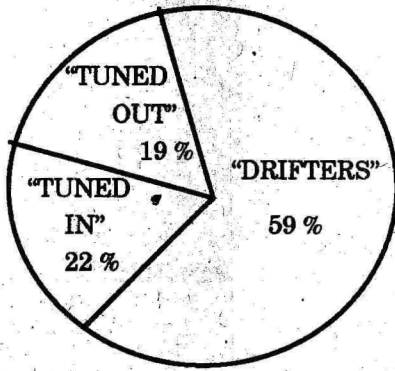


Figure 1.
Adult participation Figures in Sport & Leisure Activities

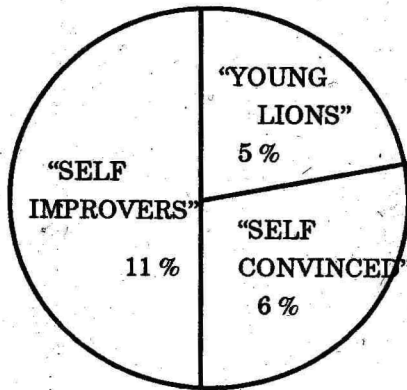


Figure 2.
The "Tuned In" 22 %

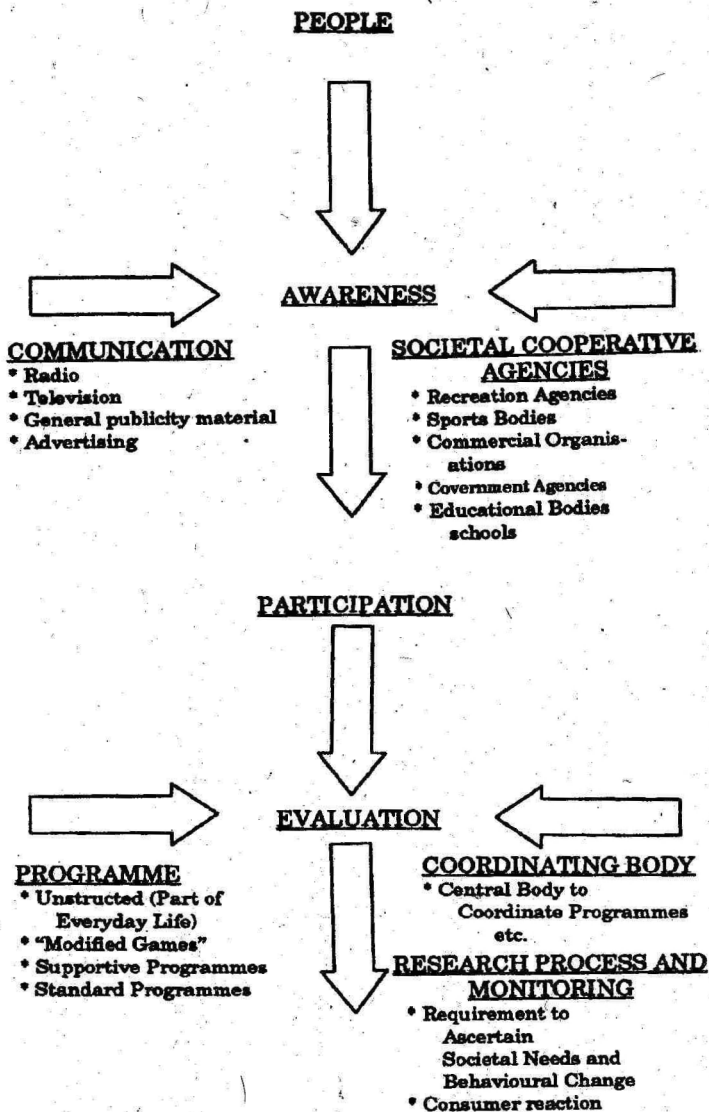


Figure 3. Basic model Utilized in the Department of Youth, Sport and Recreation

(Adapted slightly from Notes on the Department's Recreation Campaigning, Dept. of Youth, Sport and Recreation, Marland House, 570 Bourke St., Melbourne, 1975).

These results started the "Life Be In It" campaign in Australia, similar in principle to the European "Trimm" program or the Canadian "Participaction" program. "Norm" was selected as the cartoon figure around which the Australian campaign was built - Norm, the normal Aussie male. Norma followed, the normal Aussie woman. Norm and Norma, both overweight and underexercised, became familiar figures on television and in various cartoons.

Eventually they were quietly dropped out of the campaign as it was found that people were over-identifying with them. They were replaced by a family: the father (Larry) and the mother (Lucy), two children (Lisa and Lenny) and a dog (Lucky).

The aim of the campaign has been to get Australia moving, and it has been reasonably successful, particularly in creating "awareness".

The following is the model utilised in the campaign.

The emphasis was on simple, non-competitive activities. Enjoyment in participation, enjoyment of life, were the messages.

Some of the programs that were developed:

1. "Call Norm": A telephone number could be dialled for daily information in community events.
2. "Come'n Try": A program aimed at encouraging people to come and "try" a new sport or activity.
3. "Stay'n Play": A holiday travel program which encouraged people to take holidays at locations which provided plenty of recreation facilities.
4. "Huff 'n Puff": A fitness program aimed at the upper elementary (primary) school level.
5. "Time of Your Life": A program designed for the "older" age group recreational activities.
6. "Find 30": A program designed to encourage more active participation, i.e., "find 30 minutes a day", for physical/recreational activities. It was aimed particularly at the work-force.

7. **"Munch 'n Crunch"**: A program aimed to promote sound nutrition among school children. This included the sale of nutritionally balanced lunch packs.

What became obvious in Australia is that were problems from the womb to the tomb. As Canadian Martin Collis put it in In Moving into the Teens, "When it come to bodies, there's only one per customer." and Australians weren't doing too well with theirs. Fanning, in Australia, put it another way: "cohorts of obese children are moving into adult population to produce even more obese adults".

Australian studies paralleled those in other countries. In Canada, following the Canada Fitness Survey, it was concluded:

1. Only 24 per cent of girls in the 15 to 19 age group achieve a recommended level of aerobic fitness compared to 70 per cent of girls age 7 to 10.
2. Less than 50 per cent of boys 15 to 19 attain a recommended level of aerobic fitness, a sharp drop from younger boys - over 80 per cent of whom achieve the recommended level.
3. Muscular endurance improves until the age of 13 for girls and 17 for boys. After this, average performance levels often decline steadily and dramatically.

Considering these and other findings, the Canada Fitness Survey found that:

1. More-active youth report better health practices than their less-active peers. Generally, fewer of them smoke and more eat a regular breakfast and sleep 7-9 hours each night.
2. More-active youth also rate their own health as good or very good and have a more positive emotional outlook than those who are less active.

What became increasingly clear in Canada was that children who learn and more proficient in movement skills are more likely to continue with them in later years. As a consequence, The Quality, Daily Physical Education Program was created by CAHPER in conjunction with Fitness Canada in March, 1986.

The U.S.A. concerns are much the same. As Time magazine reported in January 1987

Nine out of ten believe their own youngsters are physical marvels, a Louis Harris poll reported for Children magazine. In truth, 40 % of boys and 70 %

of girls cannot do more than a single pull-up, according to survey of 19,000 six-to-17 year-olds released last year by the President's council; a third of school-age boys and 50 % of girls cannot run a mile in less than 10 minutes ...

Other studies echo the litany of laxity: in the past two decades the prevalence of obesity increased from 18 % to 27 % among children age six to eleven and from 16 % to 22 % among those age 12 to 17; 40% of youngsters age five to eight have elevated blood-pressure or blood-cholesterol levels or do not exercise at all; any of these factors probably increases their risk of developing heart disease. Teens are cutting back on tobacco, but 18 % of senior high school boys and 21 % of senior girls still smoke one or more cigarettes daily.

What children are doing, however, is watching television in the U.S.A. (and elsewhere), spending an average 24 hours a week glued to the box. The Time reporter says the children "may simply be sprouts of couch-potato parents".

Attempts are being made in the U.S.A. to change these alarming traits. The federal school lunch program, which feeds 24 million students each day, is now revising its menus to reduce salt, sugar and fat. Gamefield Fitness Systems are spreading. Florida schools have initiated a Shape Up program, funded by All American Gourmet. Children take six fitness tests and keep a three-day dietary diary. These are fed into the computer and a 20-page individual dossier results, showing where body fat is deposited and including diet and exercise recommendations. Campbell Soup has sponsored Fitnessgram, a computer-analyzed fitness-performance program which is sent home like a report card. In the meantime, if you are not in a zone serviced by such programs you can buy a foam-padded T-shirt (\$19.95) which gives children make-believe abdominal muscles, and fake pectorals. Forty thousand have been sold, so look a little closer at the next well-developed U.S. child you see, if he can get up from the TV set.

Well, back to the land of the crocodiles and koala bears, where fake abdominal T-shirts could scarcely fit over the enormous beer bellies of many of the inhabitants.

South Australia led the various states in innovation, setting up two pilot projects in 1977, the Hindmarsh Project and SHAPE (School, Health, Academic Performance and Exer-

cise). The Hindmarsh Project gave children two hours extra physical education daily, and Coonan concluded: "The Hindmarsh students covered the same work in less time and with better results. In so doing, they became more self-confident, fitter, more skilful (physically), more sociable and the obese became slimmer."

The SHAPE project utilised a control, fitness and a skill group, the latter two groups spending fifteen minutes each morning and one hour each afternoon on a daily basis. It was concluded that "the fitness groups in particular, and to a lesser extent skills groups, made substantial health gains in comparison to the control group. Both groups also made significant gains in the psychological and social areas."

ACHER, the national professional body thereafter developed and promoted a Daily Physical Education Curriculum for the schools. Resource manuals and pupil work-books were produced by ACHPER. As the program spread, it became known as the "15/30" program, involving 15 minutes of fitness and 30-45 minutes skill training daily. The latter was designed to embrace movement exploration, swimming, water safety and aquatics, gymnastics, games skills and dance.

The program was not designed for specialist teachers, but rather was aimed at the average classroom teacher in the primary (elementary) school. A specialist teacher, where available, would endeavour to assist the implementation of the program in schools, would assist in-service education, class time-tabling, adaptation of the program to differing locales, and so on.

Two other programs need to be mentioned. They are national in scope: the "Jump Rope for Heart Campaign", which basically stresses the value of skipping for cardio-vascular fitness; and a federal government initiated program called "Aussie Sports".

The 'Aussie Sports' program, with a coordinator in each state, developed because of five disturbing trends:

1. The imposition of inappropriate adult values in terms of unhealthy competition and an over-emphasis on winning.
2. A high dropout rate due to stress and unrealistic expectations for successful performance and achievement.
3. Unequal opportunity for sport involvement, especially for girls, the handicapped and the less skilled.

4. Injuries due to mismatching, overtraining and sometimes violence.
5. Children and youth being less attracted to healthy, physical recreation as a consequence of their negative sport experiences.

The following are what Aussie Sports stands for, using "modified sports" – that is sports modified for various age levels – as its base:

1. To improve the quality, quantity and variety of sporting activities available to Australian children.
2. To provide all children with the opportunity to participate in appropriate sporting activities.
3. To encourage participation and skill development in a variety of sports.
4. To reduce the emphasis in 'win-at-all costs' and promote enjoyment and good competition through participation in sport.
5. To promote the principles of good sporting behaviour.
6. To improve the quality of sports instruction available to Australian children.

The basic kit for each school includes a sports activities manual, a sports resource video, a wall chart, a pupil log book, sports certificates, sports posters, bag stickers and badges, and sports bicentennial medallions.

It is not possible to generalise about the developments in all states. Australia is a vast country with state control of education, and the Daily Physical Education Program and its practice and acceptance varies in each locale. The following comments pertain to one state, Queensland, and it is difficult enough to generalise here.

First, in Queensland there is a great variety of approaches to Daily Physical Education.

Second, it is no longer called the "15/30" program.

Third, the aim is for a balanced program.

Fourth, the 'Jump Rope for Heart' and 'Aussie Sports' program are not essential ingredients of the Daily Physical Education Program, but have been merged into the overall program.

Fifth, it is not possible, in many cases, to time-table five days of physical education a week.

The title of this paper is 'Quality, Daily Physical Education', and the concluding remarks will look at aspects of quality. A daily program is in operation in many areas.

Ken Hawkins, in an excellent article entitled "Physical Education and Sport: The Gospel According to Australia", brilliantly summed up the essentials of a quality program as he saw them:

Regardless of the quality and comprehensiveness of curriculum resource, the quality and maintenance of physical education programmes are ultimately determined by the professional integrity and performance of the teachers themselves, be they trained physical education specialists or generalist classroom teachers. Similarly, no curriculum package can succeed without adaptation to local school to district needs. The Daily Physical Education Curriculum is readily adaptable to varied organisational and implementation strategies and individual and diverse pupil needs. However, supportive school administrators, committed staff and co-operative school governing councils and parents are essential ingredients in the process. Competent leaders and advisers also need to be readily available to provide in-service training for school staff.

We are in absolute agreement with these remarks. The Queensland program has been an exciting and successful one, in which there has been continuous experimentation and innovation, followed by expert evaluation. Like most countries, the educational dollar has limitations.

Some Queensland innovations see the use of Exersite Fitness Centres in selected schools, 200 such going to selected communities through the partial sponsorship by the Australian Guarantee Corporation. The Exersite is a series of 15 exercise stations, grouped together in an area of about 100 square metres. There are four series of exercises: warm up and stretching, strengthening and toning, cardiovascular conditioning and cooling down, combined with walking, jogging and running between each series. The exercises are explained, and the appropriate number of repetitions for each level is suggested. Adventure Playgrounds are another innovation, and Gamefield Fitness Courts are being trialled.

These writers are of the opinion that such innovations as the Gamefield Fitness Court and the Exersite area can be of value, but are not the core of what Daily Physical Education is all about - it should be fun, should be enjoyable, should provide skills to continue in later life. Daily Physical Education is likewise more than skipping, and we are also old

enough to be sceptical of government programs that are generated at great cost to glorify a particular commission or minister, and then are withdrawn a year or two later. There are enough time-worn activities and skills to satisfy all aspects of a quality Daily Physical Education Program. Teacher skills and motivation, and a positive approach to assert positive values, are the answer. The human factor is the main ingredient in Daily Physical Education and its success and failure will rest on that.

It is difficult to go beyond the Canadian demands of a quality program:

- * includes daily physical activity;
- * meets the needs of children and youth;
- * nurtures positive attitudes towards activity;
- * is taught by qualified, enthusiastic, well-prepared teachers;
- * has adequate equipment and facilities;
- * has meaningful content and a sound process;
- * incorporates a fitness component;
- * has an appropriate level of competition, and
- * has strong administrative support.

In modern society there has evolved a need for Daily Physical Education for children in all countries of the world. The inroads of modern living are taking their toll on the youth of the world. Daily Physical Education is a must. Once that has been secured, the emphasis should be on quality, to gain the maximum benefit, physically, mentally, and socially. Quality, Daily Physical Education is the goal for all of us.

RESEARCH ON GENDER SPORT AND LEISURE PROBLEMS AND PERSPECTIVE*

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Introduction

This presentation is divided into three parts. The first part discusses different definitions of leisure. The second part characterises feminist research and discusses the relationship between leisure and feminist research. At the end sport as a leisure activity is discussed the questions asked are: do women experience participation in sport as leisure, and can sport promote feminism?

Definitions of leisure

Leisure has been defined in many different ways. Characteristics of most of the definitions are that they don't seem to be relevant or suitable for most women. Libby Coles wrote in 1980 that leisure was a concept that had little or no application to women whether it was defined one way or another, and that lack of leisure was merely one measure of women's oppression. This of course has consequences for research on women and leisure. If we don't have a suitable concept, if we don't know what's meant by leisure, then how can we get more knowledge about women and the phenomenon of leisure? If we don't know what is meant by leisure, then how can we discuss the relationship between sport and leisure?

During the last years some researches have tried to develop a definition of the concept of leisure that seems to be suitable for both women and men. In this connection I will particularly focus on the work of Karla A. Henderson, M. Deborah Bialeschki, Susan M. Shaw, and Valeria J. Freysinger, presented in

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their newly published book titled: "A Leisure of One's Own: A Feminist Perspective on Women's Leisure". Before presenting their work I will briefly examine the most well-known ways of defining leisure.

The classical concept of leisure is rooted in an ancient Greek tradition where leisure was a way of personal growth and social attainment of the "good life" [1]. Aristoteles viewed leisure as a "condition of state, the state of being free from the necessity to labour". This means, however, according to Farina [5] that labour is not excluded from Aristoteles's notion of leisure. What is excluded is the necessity or obligation to labour. Leisure then referred to a condition, a state of being free from the necessity of being occupied, where activity was performed "for its own sake or as its own end".

The Greek occupation — leisure distinction has its counterpart in the modern work-leisure dichotomy. In the post-industrial society the day has been divided into working time and free time [6]. From a women's perspective the problem has been the relationship between paid work and leisure. When not only free time from work, but also free time from family and daily life activities are included in the concept of leisure, it fits women lives even less [9]. This is due to the fact that studies all over the world show that women even when they are fully employed do most of the household work and feel more responsibility for the children and other family members than men do [8]. Women's access to time free for leisure is therefore constrained by not only paid employment but also by other everyday commitments such as childcare, domestic labour and the care of frail or elderly relatives [22]. This doesn't necessarily mean that women don't have any leisure. But it is according to Deem [3] a phenomenon that is not easily separable from other aspects of women's daily lives and is closely interwoven into everyday lives.

Defining leisure by participation in certain activities as, for example sports, arts and media, is therefore also problematic in relation to women because leisure and work often occur simultaneously, since leisure for women often is home-based [11].

The growing number of leisure studies and theories during the last years seem to focus more and more on the psychological dimension of the leisure concept. The most famous author in this area is John Neulinger. He has stressed in many articles and books the leisure is a state of mind, and that necessary conditions for the leisure experience is "perceived freedom and intrinsic motivation". He says further that "leisure is a state in which the person feels that what he is doing, he is doing by

choice and because he wants to do it". Neulinger also introduces the concept of non-leisure, which implies that the same activity can be defined as either leisure or non-leisure. This has been demonstrated empirically by Susan Shaw. She found, for example, that men experienced four times more leisure in household labour activities compared to women [17].

According to Henderson et al [14] researchers have suggested that the definition of leisure as "an experience" that occurs within the context of time and activity is the best approach to the conceptualization of leisure. Thinking of leisure as an experience avoids the work/non-work dichotomy and the problem of activity categorization. I quote:

"This conceptualization is the way that most individuals, both women and men, understand leisure in their own lives. This approach is therefore valid in that it is more meaningful and intuitively congruent with everyday life experience."

Wearing & Wearing [21] come to the same conclusion. After defining three aspects of leisure: activity, time and experience, they question whether it is possible to construct a concept of leisure that is both appropriate and legitimate for women. They exclude the two aspects "activity" and "time". But concerning "experience", they focus on the fact that "when the concept of leisure is extended to the individuals choice, motivation and perception of the activity and its experience, we have a concept that recognizes how little real choice most women have." They conclude their article by saying that the concept of leisure as a freely-chosen selfchanging experience is a concept of leisure that is appropriate for both sexes. To have more choice, however, women need to have more power. By virtue of their gender men have power to have their ideas accepted. Men have access to leisure time, leisure activities and leisure resources which women do not. This also fits into the social-psychological paradigm. Manell states that a cognitive social psychology of leisure would focus on determining the internal (e.g. attitudes, beliefs, motives, emotions and personality) and external (e.g. individuals, social structure and man-made environments) influences on the meaning, quality, duration, intensity and memorability of leisure.

Many researches have tried to identify the components of the leisure experience. According to Henderson et al [14] these include free choice or freedom from constraint, intrinsic motivation, enjoyment, relaxation, role interaction, personal involvement and self-expression.

Freedom then seems to be essential to leisure but it includes both "free from" and "free to". Leisure is time so free from

obligation that the individual can choose how to use it [19].

Free choice, though, can not be equated with leisure. Perceived freedom appears to be a necessary, but not sufficient, condition of leisure. Leisure would imply a positive dimension that may be labelled enjoyment, personal involvement, self-expression or intrinsic motivation. Referring to Gunter & Gunter (1980) and Samdahl (1988) Henderson et al state that the situation of negative freedom, or freedom in the absence of this positive dimension is "anomic leisure". A situation which individuals experience as positive freedom can then only be characterized as leisure. Women, however, have less time or less space which is perceived and experienced by them as leisure.

Saw [18], for example, found in a study that women perceived less free choice in their daily lives than men did. The reason for this has to do with role-constraints.

Much of women's leisure seems to be socially or relationally, rather than intrinsically, motivated. If women's social motivations are role-determined rather than freely chosen, women's leisure possibilities will continue to be restricted. Women therefore often seem to lack opportunities for unconditional or "pure leisure". For many, few activities are done strictly for their own pleasure or enjoyment. Both lack of leisure and anomic leisure may therefore be more common among women than men.

Feminist research and leisure

Feminism is defined as a philosophical framework that embodies equality, empowerment, and social change for women and men. The focusing on feminism is on redefining the value of women's lives by empowering individual women and by making women visible in society [14]. At the end of my paper I will particularly focus on sport within this frame of reference. The following questions will be discussed: Do women experience sport participation as leisure, and is sport an arena through which women may get empowerment?

Issues of feminism relate directly to power. Traditional power has been understood as "power over" or domination. Power can, however, also be understood as "power to" [10]. Feminism assert the need for both men and women to discover their own "power to" in the world. For women power means controlling one's life and body.

Henderson et al [14] focus on the relationship between feminism and leisure. They are inextricably linked by the components of choice and freedom. The authors express the relationship in the following way:

"The intent of both feminism and leisure is to encourage choices, not to set limits. Issues of activity, time, and meaning within leisure have a direct relationship to feminism. At the core of leisure are the elements of freedom and choice, and thus, empowerment."

In what areas do we need more knowledge about feminism, leisure and sport? What kind of research need to be done? Let us briefly focus on how feminist research is characterized. It may be summarized as follows [7]:

1) It should center around inequality, oppression and power-relations

2) Women's practices, experiences and consciousness should be taken as a starting point for theory development

3) It should be for, not only on women

4) The whole context in which people live and behave should be taken into account.

The relationship between feminism and leisure is reflected in feminist research, because the starting point for feminist research is women's own experience.

The knowledge we have to day has clearly demonstrated that women's experience was made invisible in former studies in the social sciences. Barbara Du Bois [4] states that:

"To address women's lives and experiences in their own terms, to create theory grounded in the actual experience and language of women is the central agenda for feminist social sciences and scholarship".

Findings on sex/gender differences in activity participation are inconclusive. An emerging alternative for studying women and leisure is to examine the lives of women only, not in relation to men. Women are such a heterogenous group, so even studying only women means studying different groups of women.

Most leisure research has not been conducted with a feminist perspective. For example it has usually not been for women, i.e. it has not proposed solutions or suggestions for changing the status of women's leisure.

A prerequisite for feminist research is an absence of sexism. Henderson et al [14] exemplify how this has occurred in traditional leisure research by the fact that activity checklists have not contained many of non-traditional activities which may be leisure for women, such as talking on the phone with friends, taking a baby for a walk, or taking a bath.

The authors also exemplify actions that may consciously or unconsciously result in sex-biased research. These are among others: studying only areas of life with which males are familiar, using male-oriented tests and situations, using only male subjects, building theory that is based on one sex, formulating

hypotheses without considering sex-role stereotypes, interpreting sex-related differences as absolutes, etc.

Sport as leisure?

The last part of my presentation focuses on sport participation. What do we really know about the experiences of women in sport? Do women experience sport participation as leisure? Do sports perhaps even better than other activities promote feminism?

In an interesting article by Kelly [15] he asks if sport participation should be defined as leisure. He says that "unlike sport leisure is defined by its meaning to the actor rather than by what people do". Further that

"although play is central to much sport-participation, the elements of freedom and spontaneity may be considerably reduced by the rules and the performance measurement".

I would argue that sport participation may be experienced as leisure even among top-level athletes. The question is if the individual experiences the participation as "positive freedom" or not. "Positive freedom" means that participation in the activity is freely chosen (perceived freedom) and followed by enjoyment, relaxation, self-expression, etc.

Research on women and sport should try to analyze women's experiences in and through sport. From the knowledge we already have, I think that sport participation for many women may be defined as "non-leisure" or "anomic leisure".

If women are forced to participate in sport by, for example, their husbands or children but don't enjoy it, sport may be defined as "non-leisure". If sport participation is freely chosen but the women don't experience it positively, the concept of "anomic leisure" may be the correct one to use in such a situation.

It may therefore be an important area for research to try to find out when and why women do experience sport as "real leisure". What are the inhibiting and facilitating factors?

In doing such research it is important to have in mind that feminist research should be for women. It should address changes in sport. As a result women would probably be more attracted to sport.

Another question is if women through sport participation may be better suitable for a broader feminist political change. Henderson et al [14] state that:

"At the core of leisure are the elements of freedom and choice, and thus empowerment. Leisure has the potential to facilitate self-development, liberation and behavior change in many aspects of women's lives".

I would argue that sport or more precisely physical training may be an important activity in such a process. To have "power to" for women means to control not only one's life, but also one's body. Bodily strength, endurance and flexibility may be important in this connection.

In an interesting article by Nancy Theberge [20] the relationship between feminist political change and sports is discussed. She refers to Hartsock [13] who states that political changes take place on the personal, group and institutional level. Theberge gives examples of how sports participation has been liberating for many women on a personal as well as group level. Concerning the institutional level it is more difficult to see how sports may promote feminist political changes. At this level of liberation economic power is crucial. Theberge states, however, that

"it is likely that the main contribution of sports to feminist change at the institutional level is indirect and occurs through related changes at the personal and group level".

If women experience sport as "real leisure" and thereby develop their feminist consciousness, this may lead to a larger political engagement in society in general. For a transformation of the existing ideology toward a society that embodies equality, empowerment, and social change for women and men, more women have to get into powerful position as well in society as in the sports organizations. In such a perspective sport as leisure may come to play an important role for the futural development of the society.

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PUBLIC INVESTMENT IN SPORT FOR ALL — THE SCANDINAVIAN CASE*

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Introduction

The Norwegian voluntary sports organization is gathered in one umbrella organization called "The Norwegian Confederation of Sport". This is Norway's largest voluntary organization and covers 1.6 million member.

At the regional (country) level the clubs are organized under one of the 19 district associations. The various groups in multisports clubs and the single-sport clubs are also organized at the regional level into sports district associations. At the centralised level the sports districts associations are organized into 45 federations for the individual sports, which in turn are members of the Norwegian Confederation of Sport (Figure 1).

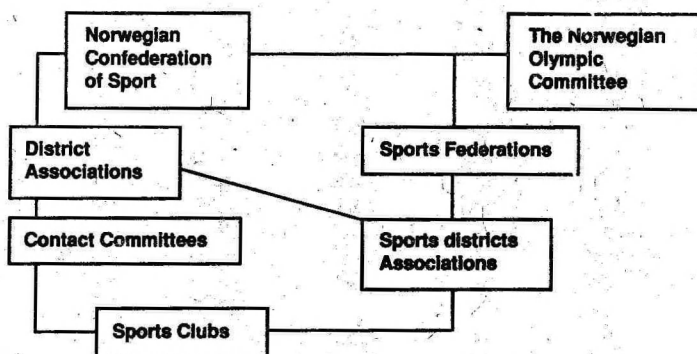


Figure 1. Organizational structure and channels of cooperation

* Invited Paper presented at the International Congress on "Sport for All: Economical Aspects" 4-6 October 1990, Victoria — Gasteiz, Spain.

"Sport for all" is the goal for the work of the Norwegian Confederation of Sport. Keeping fit and work concerning health are very important aspects of sport and of society. This is why about 6000 companies have their own company sports clubs and their own sports association. Handicapped people also have their own clubs, regional associations and federations for individual sports but the Norwegian Confederation of Sport are now trying to get them integrated into ordinary sport.

- 4 out of 10 Norwegians exercise regularly, only a few more men than women [2]
- Hiking and walking are the most popular activities done by the Norwegian adult population
- Only 15 % participate in sports competition
- Almost 50 % of the exercising population go jogging
- Many people who are exercising regularly are not members of a sports club.

Almost as many people exercise in private institutes as in associations. The private sphere seem to have an appeal especially for women, who rather go there than to a sports club.

Due to this and to the fact that cross-country-skiing and hiking are so popular, most training and exercise goes on outside of the sports centres. Since a large part of the public money to sport goes to sport facilities, it is relevant to mention that 2/3 of the regularly physical active population exercise most often in informal settings alone or with family or friends.

The sports associations organize 3 out of 10 adults, but almost 50 % of these are passive members.

One of the conclusions from the latest survey concerning physical activity in the Norwegian population is that there is a tendency towards more individualization and privatization of physical activity. This is a challenge for organized sport. As a response it is recommended that organized sport change its organization towards more diversity, which also is happening in Norway today, e.g. through the project "Focus on Sports Clubs" which will be presented later. Another result from the same survey was that more public funds for "Sport for all" had a broad support in the population.

Financing of Sport in Norway

The public funds to sports in Norway come from two resources. These are grants via the National Budget and pools funds. In 1989 the grants via the National Budget were about 5.3 million Norwegian kroner. Most of the public money that goes to sports come from the pools funds. It is, however, not so

that the sports get all the money from the pools. From 1974 to 1977 the percentage of the surplus of pools funds which went to sports increased from 35 to 50 %. Today it is 67.5 %. The goal for the sports organizations is 100 %. In 1989 the pools money that went to sports was almost 462 millions Norwegian kroner. Not all of this, however, goes to the Norwegian Confederation of Sport. About half of the amount is used for building sport facilities.

Table 1 shows the financing of sports in Norway. The numbers in the table are from a research project that took place in 1988/89 [3]. It shows the total amount of the income registered in the sports, and therefore covers all the different levels in the sports organizations.

Table 1

The financing of Norwegian sports

Income	1980		1988	
	N	%	N	%
1. Membership dues	78.9	(11 %)	284.0	(11 %)
2. Official grants	159.3	(22 %)	383.8	(15 %)
3. Sport arrangements	105.8	(15 %)	438.5	(17 %)
4. Activities outside sport	235.2	(32 %)	751.6	(29 %)
5. Business community	81.3	(11 %)	443.7	(17 %)
6. Other income	74.6	(10 %)	339.6	(13 %)
Total	735.1	(101 %)	2.641.2	(102 %)

Of the six different resources mentioned in Table 1 the official grants account for 15 %. Most of the money almost 30 % comes from activities outside sport. This category includes first of all different kinds of lotteries and sales. If you take a look at the development from 1980 to 1988, some interesting changes have taken place. The business has increased dramatically, from about 735 million Norwegian kroner to about 2.5 thousand million, which accounts, for an increase of 337 %. If we take inflation in Norway, during this period into account we will find that the growth from 1980 to 1988 has been 254 %.

The percentage of the official grants has diminished from 22 % to 15 % during this period, in spite of the increase from 159 to 383 million kroner.

Table 1 also demonstrates that the sport organizations' work is self-financing to a high degree. The independence of the sports organizations in relation to the authorities is thus

more easily maintained. It is nevertheless considered a public responsibility to ensure the sport organizations of a secure financial basis.

As mentioned earlier the table just presented covers all the different levels in sports organizations. If we, however, look at the levels separately, we find large differences in relation to the proportion covered by public money. This is shown in Table 2. Almost all the activities that are carried out by the Norwegian Confederation of Sport are financed by official grants, altogether 94 %, while only 1 % of the business of the individual sport federations comes from public funds. The same relationship is mirrored in the districts associations (22 %) and the sports districts associations (2%). In relation to "sport for all" it is relevant to mention that the individual sports federations are more involved in competitive sport and top level sport, compared to the Norwegian Confederation of Sport, and the districts associations who both cover all the different sports and all levels and aspects of sports.

Table 2

Official grants presented for each level in the sports organization

Level of organization	N. kr. million	%
Norwegian Confederation of Sport	195	94
Individual sports federations	2	1
District associations	28	22
Sports districts associations	4	2
Sports clubs	153	8

The largest part of the economical business in sport is covered by the sports club, altogether 77%. The special federations account for 8 % and the Norwegian Confederation of Sport for only 2 %.

You may already have understood that a so-called horizontal funding system is applied to sports in Norway as well as to cultural purposes in general. The Norwegian Confederation of Sport get grants via the National Budget, whereas the counties provide aid to the regional sports associations. The municipalities then support the sports clubs.

There is a great variation at both the regional and the local level as regards the size of grants provided to the sports organizations in relation to population. In general, public funds constitute a smaller proportion of the sports associations income at the regional and local level than they do at the central level,

which has been clearly demonstrated by the figures just presented.

In summarizing the public and voluntary work with and for sport one can conclude the "sport for all" is the central aim of both the public sports policy and the policy of the organized sport. The authorities, however, place great emphasis on respecting the integrity of the voluntary sports organizations. The Norwegian Confederation of Sport must still be guaranteed a secure official financial basis for its activities.

The public authorities have the main responsibility for the building and maintenance of sports facilities. The authorities also have a particular responsibility for the physically inactive who for various reasons do not take part in organized sports.

Due to this fact I shall in the following focus on the authorities' involvement in building sports facilities and in their work with the development of "Health sports" and "Sport as development aid". I will close my paper by presenting two projects in progress in Norway just now. These are called "Focus on sports clubs" and "Hele folket i form til OL", which can be translated as "A fit nation for the Olympics".

Sports facilities

In line with the guidelines for sports policy, the Ministry when distributing pools funds, has in recent years accorded priority to facilities which will be of benefit to the greater majority of people. It is not an absolute requirement that the design be in accordance with the national and international regulations for a specific sports. All facilities must, however, be accessible to disabled people. Pools funds are also made available for facilities for trim and open-air life in the mountains. The hostels and huts must be open to the general public and located in connection with the network of tracks and trails. Funds are also allocated for developing tracks and trails in the mountain areas. Municipalities, counties, sports clubs or other associations which have no commercial objective can apply for subsidies. When it comes to indoor swimming pools, sports halls and other particularly expensive facilities, only municipalities and counties are normally approved as applicants. Many, particularly small facilities have been built by sports clubs without municipal financing but with subsidies from pools funds. The general rule is that one can receive up to 1/3 of the cost of the facility, with an upper limit equal to the maximum subsidy rates established each year for the different types of facilities.

Subsidies can be provided for sports facilities which are

open for general sports activities and are not subject to commercial interests. Support can also be given for building community centres (local buildings for culture) with sports functions.

No complete registration of sports facilities has been made in Norway. The best indication of the situation is obtained by registering what kind of facilities have obtained grants from the pools funds.

Table 3 gives an overview of the number of some sport facilities that have been built with contributions from the pools funds from 1947 to 1987 [4].

Table 3

**Number of different sports facilities from 1947 to 1987
with grants from pools funds**

Type of facilities	Number	1987 kr million
Club houses and changing rooms	1613	484.5
Football and training facilities	1525	386.8
Football and athletic facilities	1257	466.9
Orienteering maps	1762	32.3
Flood lit ski tracks	1313	166.8
Ski jumps	791	120.2
Community areas with sport functions	619	218.3
Indoor swimming pools	611	500.4
Sport halls	378	706.0
Handball courts	267	22.5

Table 3 also shows how much money (account for in 1987 kroner) has been used for the different facilities. The most expensive facilities during this 10-year period have been the indoor swimming pools and the club houses whereas the orienteering maps and handball courts have been the cheapest.

Statistics have also been made concerning the average amount of money for each sports club and each member of a sports club. These mean figures are as follows: altogether 6704 sports clubs have got financial facilities support. That is a little more than half of all the sport clubs in Norway. The mean support for these clubs is 330,178.85 kroner. The corresponding number for each member is 1,649.95 kroner.

Sport as a means to a better public health

When the concept of "health sport" was launched almost 30 year ago in Norway, no definition was given to it. We can roughly say that it concerns sports for groups with special needs where the health aspect of sport is more important than competition and performance. Today it is generally recognised that everyone can draw benefit and enjoyment from sport, irrespective of their functional level or state of health [5].

The groups with special needs in the context of sport vary with time. We live in an age with a high pace of living which makes great demands on the individual. There are ever-increasing numbers of people who fall a little short and can benefit from special sports programmes.

The Norwegian Confederation of Sport started in 1984 some pilot projects whose prime objectives were to furnish proof that inactive people could improve their health through exercise. The project showed that the appropriate assistance that the ordinary sport clubs offered for inactive people was insufficient, and that it was the cooperation of the voluntary associations and health organizations which often reached the greatest number of inactive people. Country Health Committees have therefore now been established to provide health information.

Sports for the disabled

At the beginning the Ministry took care of the task of establishing sports programmes for the disabled. The organization of voluntary sports was gradually taken over by the Norwegian Sport Organization for the Disabled which was founded in 1971. The Ministry, however, under the Department of Youth and Sports has the responsibility for sports at institutions and hospitals. Today attention is especially directed towards prison-inmates, psychiatric patients and people with alcohol and drug problems, while clubs from different fields within the sports movement are busy taking up sports for the mentally retarded.

Sports as development aid

With support from the Norwegian Development Agency (NORAD) the Norwegian Confederation of Sport has been involved in a development-aid project in Dar-Es-Salaam from 1982-1989. Based on the objective of Norwegian sports which is "Sport for All" the attention was particularly focused on sports

for children and women. The Ministry has contributed financially and otherwise to this project, and has been concerned with integrating sport into the official Norwegian development programmes. After finishing this project the Norwegian Confederation of Sport is planning a similar project in Zimbabwe and Zambia.

Focus on Sports Clubs

As mentioned earlier I would like to close my paper by presenting some projects run by the Norwegian Confederation of Sport and financed by official grants.

The first one is called "Focus on Sports Clubs" — FOOSC [6]. It represents a major effort on the part of Norwegian sport to meet new challenges and strengthen the position of sports clubs in the local environment. It covers a great many areas.

The basis for this project was the fact that the Norwegian Confederation of Sport realized that organized sport in Norway was facing a crusade. There were warning signals like: loosing memberships, a struggle for leaders, a difficult financial situation. To meet these challenges sports clubs had to take the offensive and think along new lines and work differently, which was the background for the start of the project in 1988.

What are the aims of the work of sports clubs? Are we organized in an old-fashioned way? What steps must we take to bring about changes in the Clubs are the central questions asked in the project.

A fit nation for the Olympics

The latest project I would like to mention has just been launched and is planned to end at the Olympic Winter-Games in Lillehammer in 1994.

The project is called: "A fit nation for the Olympics".

It has a total budget of 30 million Norwegian kroner and is financed through the Norwegian Confederation of Sport and The Ministry of Health and Social Affairs. These two contribute half of the money each. The project is therefore financed through public funds only but from two different Ministries: The Ministry of Church and Culture through the Norwegian Confederation of Sport and the Ministry of Health and Social Affairs. The Minister of the later Ministry is head of the project. The overall objective is to get the Norwegian population into a better health condition. The following concrete aims have been formulated:

During 1990–1994 6 out of 10 Norwegians shall exercise regularly.

The use of tobacco should be reduced by 10 percent and one should stimulate a reduction of alcohol and drugs. The level of knowledge of the population concerning diet and food habits should also be increased [7].

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GROWTH DYNAMIC AND MUSCULAR STRENGTH IN YOUTH SPORTS

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Abstract

Short term measurements are very useful to describe the growth dynamic, the muscle development and strength. The results of the study of 56 fourteen-year-old boys, investigated every 28 days, and 910 track-and-field athletes aged 12 to 19 years measured every six month, were:

1. to develop the methodical fundamentals indicating the growth dynamic, and to get the relationship between the growth dynamic and performance for one year during puberty,
2. to estimate annual body growth during puberty,
3. to carry out talent selection by means of anthropometrical methods,
4. to prepare prognostical estimates about body development,
5. to recognize the growth dynamic of muscular strength.

For coaches it is useful to use the knowledge about:

- different growth types,
- different growth dynamics according to growth velocity,
- timepoints of reduced or increased growth acceleration, and development of the muscle mass,
- describing and evaluating the prognostical development of growth processes.

KEY WORDS: Sportanthropology, Growth Dynamic, Muscular Strength

Introduction

Growth dynamic and muscular strength are basic fundamentals for developing physical performance [2, 5]. Because of

the fast morphologic and functional changes that occur in the growing individual, much attention must be paid to the optimal design of training studies. Particular care is needed to point out such variables as growth, maturation, secular changes, habituation, and preselection as well as final selection [7]. To compare trainability across ages, one must equate the training stimulus given to all age groups, especially for developing strength.

Some physiologic characteristics change gradually from childhood to adulthood. With anthropometric measurements the changes of body composition, body structure and the growth dynamic can be fixed at that time. Other characteristics such as sweating capacity, strength, rate of glycolysis, aerobic trainability, endurance, and gender-related differences change primarily during or around puberty. Much research is still needed to understand puberty from the exercise perspective [1]. For example, to find the optimal time or age to start training or to develop strength.

The best way is to investigate the natural course of life with short-term longitudinal studies for definite answers.

Relations between muscle and strength

It has been observed and repeatedly confirmed that the performance of sportsmen showed a high relation to the muscle mass.

But knowledge about the dynamic process of muscle and strength is always a quite difficult problem. Macroscopically, muscle mass can be measured by means of anthropometrical measurements [3, 9]. 80 percent of blood flow goes through the exercising muscles during exercising, during rest 15 to 20 percent of blood flows in the exercising muscle.

The growth process and training enlarge the individual muscle fibers. Moreover, within the muscle cells there is an increase in the aerobic enzymes which utilize oxygen for contraction [10]. Muscles are our basic instrument of mobility. During exercise this unique tissue can increase its metabolic rate more than fifty times. In addition, the muscle responds to repeated stress by adapting itself to increased workloads [8]. The relatively stable somatopsychological effects of a regular training (epigenetic adaptations) generally result in an improved stress tolerance [4].

Muscles comprise 40 to 50 percent of the total body weight of males, sometimes in sportsmen it may reach 60 percent. The same data for females are 20 to 30 percent and more than 40 percent for sportswomen. More than 60 percent of body water is in the muscles. Muscle is the main component of our lean body

mass. Training increases muscle weight and size, while it also decreases total body fat [6].

Overall muscle strength is easy to measure. We have used the standard test: a one repetition maximum (weightlifter) and the best effort in the shot put. Very important is also the relationship between the muscle mass and speed (e.g. 30m sprint) as well as endurance (e.g. 800m running). These tests, however, must be correlated with an athlete's muscle and strength performance.

Earlier we found that if one develops the muscle mass about one kg he will reach a better strength, for example, in weightlifting about five kg. If you increase only the body weight about one kg you reach a better strength performance about 2 kg.

For some kinds of sports power is defined as strength times speed. Most power events, such as shotput or weight lifting take less than 3 seconds and require maximum muscle strength with a burst of maximum energy.

But we don't know what is the growth dynamic of the muscle mass, especially during puberty, how it changes with age.

Methods and material

During one year 56 fourteen-year-old boys (weightlifters) were investigated every 28 days. The second group were 910 track-and-field athletes between twelve to nineteen years studied of every six months.

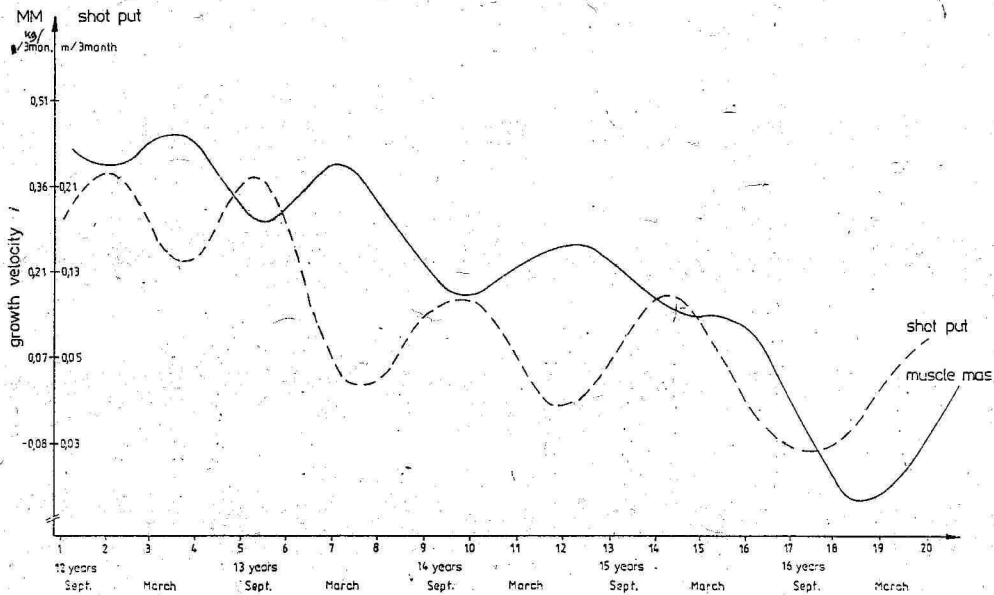
The growth dynamics of muscle mass and maximal strength, shot put, speed (30m sprint), endurance (800m running) results are described. Further, we also used the body height, weight, skeletal mass, muscle mass, biological age data.

After calculating the growth velocity according to numerical differentiation of body composition and performance test, the relationship of growth dynamic and performance were described with the help of growth curves. Numerical differentiation, cluster analysis and multiple discrimination analysis were used for this purpose. After this it was possible to estimate the growth types and the prognostical growth and development.

Results and discussion

Aging inevitably brings along changes, and there is a measurable increase or loss of muscle mass during puberty (Figure 1, 2, 3).

We know that muscle changes caused by regular exercise are possible. In the longitudinal investigation we found enlarged muscle fibers (hypertrophy) in boys between 12 to 18 years:



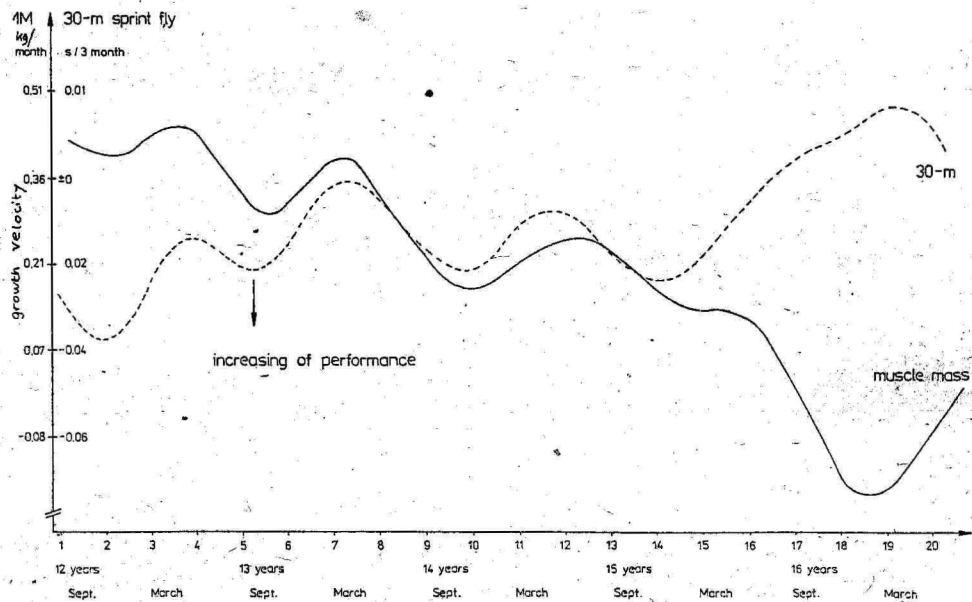


FIGURE 2. Growth velocity of muscle mass and 30m sprint (speed) of 12 to 18 years old athletes.

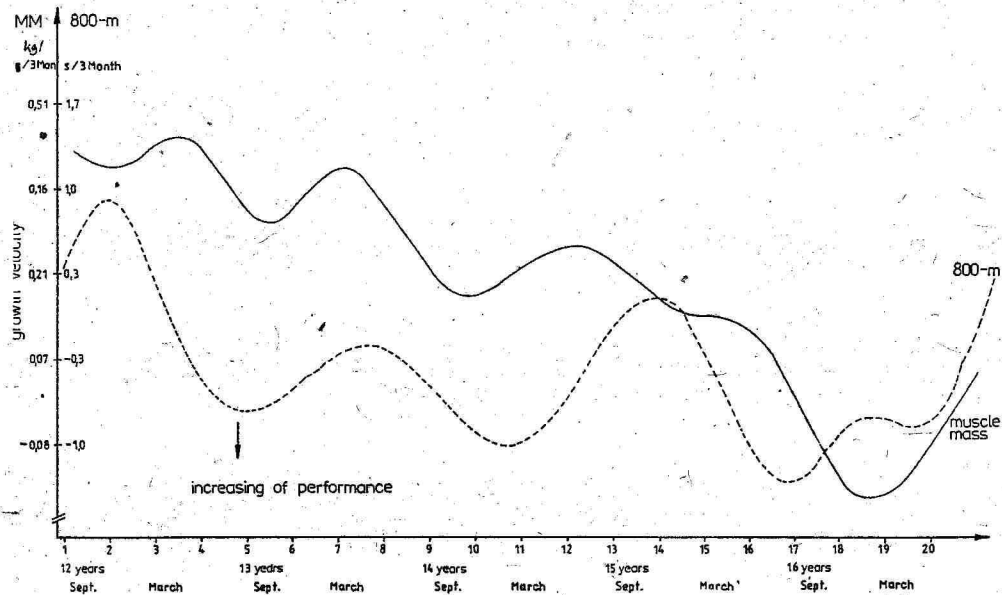


FIGURE 3. Growth velocity of muscle mass and 800m running (endurance) of 12 to 18 years old boys.

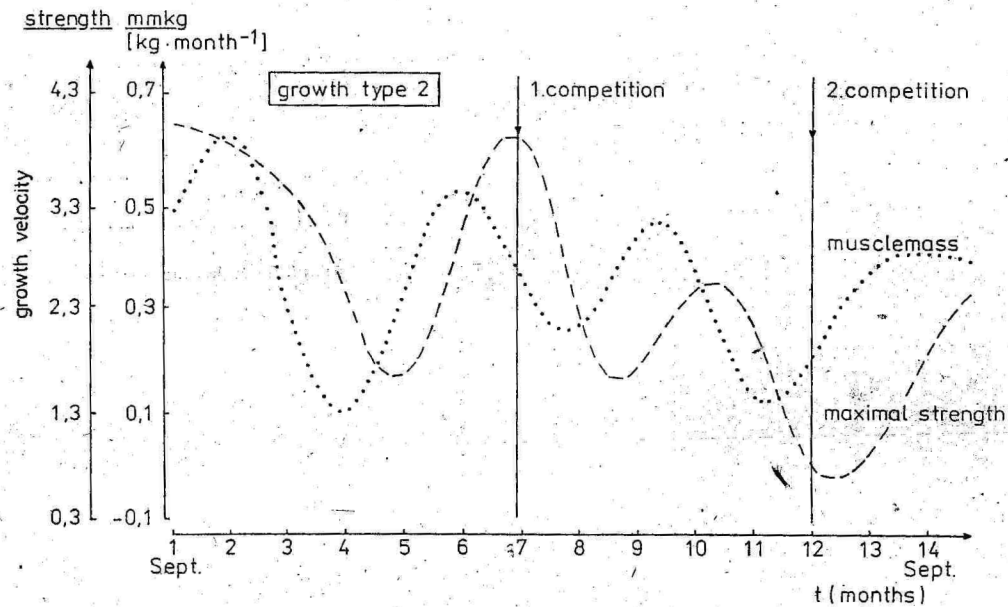


FIGURE 4. Growth velocity of muscle mass and maximal strength of 14 years old weightlifters during one year.

The individual muscle fibers increase in diameter with training and age during growth and development, as a result of an increase in intracellular protein fibrils.

The enlarged muscle mass in young track and field athletes, we found at the time before increasing strength (Figure 1). For example, in case of developing maximal strength there is a higher growth velocity 1 to 1.5 months before a major competition (Figure 4).

A bad way is the decreasing of the muscle mass before the competition (see Figure 4 the second competition).

For the development of endurance it is better if we have a decreasing of the velocity of the muscle mass (Figure 3). So the individual can perform the best result in endurance with lower level of muscle mass.

For the speed training we can say, it is like the power training you have to develop the muscle mass in the time before the competition. Figure 3 you can see that if you like to develop endurance, it is better if you have a decreasing of muscle mass velocity, at the same time to reach the best endurance result. For the speed we can say, it is like the power training for maximal strength.

In summary, the growth process and training produce changes in both, the performance on the one hand and the muscle on the other hand.

But we also see that the muscle growth velocity curves have with aging a periodical decreasing course (Figures 1-3).

A further result was the estimation of growth types like the dynamical or the stable type while considering their body weight, height, muscle mass, skeletal mass and biological age. This estimation of growth types is possible by the following equations (Figure 5). It is important that the muscle mass has the main influence on the growth type [3].

The investigated athletes were grouped as having dynamical or stable growth type at the start and the end of the study, and provides the possibility to estimate the prognostical way of growth for one year (Figure 6).

Finally, increments in strength and muscle mass were compared with the time points of the smallest or largest growth velocity as observed from the body mass and body height (Figure 7).

The facts mentioned in the table indicate correlations between growth dynamic and training, e.g. a growth stagnation in the time points of the highest loading and catch up growth in the time during a break in training (e.g. summer holidays).

BEGIN OF TRAINING (14 YEARS OLD BOYS)

GROWTH TYPE 1 = DF 1 < -23.5

GROWTH TYPE 2 = DF 1 > -23.5

DF 1 = 0.0296, BODY WEIGHT (kg)
- 0.14 BODY HEIGHT (cm)
- 0.313 MUSCLE MASS (kg)
- 0.0919 SKELETON MASS (kg)
+ 0.358 BIOLOGICAL AGE (years)

BEGIN OF TRAINING (15 YEARS OLD BOYS)

GROWTH TYPE 1 = DF 2 < -16.9

GROWTH TYPE 2 = DF 2 > -16.9

DF 2 = -0.183 BODY WEIGHT (kg)
-0.0922 BODY HEIGHT (cm)
-0.127 MUSCLE MASS (kg)
+0.451 SKELETON MASS (kg)
+0.45 BIOLOGICAL AGE (years)

FIGURE 5. Formula for estimation of growth type 1 (stable) and growth type 2 (dynamical)

Conclusions

1. The result from the short term longitudinal study showed that the young athletes are followed according to the genetic and environmental influences from prepubescence through puberty, several growth dynamic for strength or muscle are monitored.

2. There are different relations between muscle and strength in different age groups.

3. For talent selection and strength development in sport, you have to recognize the time points of in- or decreasing or finishing of natural growth process of muscle growth.

From the time of puberty, human nature has an inclination toward physical laziness.

	REDUCED GROWTH ACCELERATION	INCREASED GROWTH ACCELERATION
BODY HEIGHT	<ul style="list-style-type: none"> - AFTER THE BEGINNING OF TRAINING YEAR - AFTER BEGINNING OF TRAINING PERIODS, FOR EXAMPLE MACRO-CYCLES - IN THE COMPETITION PREPARATION PERIOD AND DURING THE HIGH COMPETITION POINTS AND WITH GREAT PARTS OF SPECIFIC TRAINING 	<ul style="list-style-type: none"> - DURING BREAK OF TRAINING, FOR EXAMPLE DURING CHANGE OF YEAR OR SUMMER HOLIDAYS - WITH GREAT PARTS OF GENERAL TRAINING OR DURING THE PERIOD OF REDUCED TRAINING INTENSITIES - AFTER ADAPTATION TO THE HIGH SPORT LOAD
BODY WEIGHT	<ul style="list-style-type: none"> - AFTER ADAPTATION TO THE HIGH SPORT LOAD - WITH GREAT PARTS OF GENERAL TRAINING - IN THE STAGES OF COMPETITION PREPARATION 	<ul style="list-style-type: none"> - AFTER BEGINNING INTENSIVE SPORT LOAD - WITH GREAT PARTS OF SPECIFIC TRAINING - WITH THE INTERRUPTING TRAINING

FIGURE 7. The time points of reduced or increased growth acceleration of body height and body weight during the progress of a year

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THREE AMPLITUDES IN THE FLEXIBILITY OF JOINTS AT COMPETITIVE SWIMMING

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Abstract

Flexibility of a joint can be triamplitudinal with a tension free or relaxation amplitude between two antagonistic activities (flexion and extension). This very approach is available when assessing and evaluating the work of joints on the basis of two initial positions.

Footwork and the role of the ankle joint in breast stroke as well as in crawl stroke was studied. One test group consisted of 26 young swimmers aged 10–14. The other test group consisted of 24 young swimmers of 11–13 years of age.

The tests proved that there is a close relationship between the parameters of triamplitudinal flexibility of joints and the swimming results of athletes.

KEY WORDS: flexibility, swimming

Introduction

The widely accepted methodology for the assessment and evaluation of the flexibility of joints at a particular stage of motion is based on the amplitude between two reciprocal acts of moving. At the split of the amplitudes the body segment assumes its neutral position that is also called anatomical initial position [1]. In our research we have discovered that any flexibility of a joint can be triamplitudinal with a tension free or relaxation amplitude between those two antagonistic activities (flexion and extension) [2]. This very approach is available when assessing and evaluating the work of joints on the basis of two initial positions.

Materials and methods

One test group consisted of 26 young swimmers (15 boys and

11 girls) of ages 10-14. Their initial flexion (PO) and maximal dorsal extension (DE) of the ankle was measured. The triamplitudinal flexibility of the joint (Fig. 1) was measured by using the compass-goniometer according to our own methodology [2]. In order to determine the significance of the ankle in different breaststrokes all the swimmers were asked to cover 50 meters against time with the help of feet only. Four types of footwear were suggested: thrust, screw, wedge-like, individual.

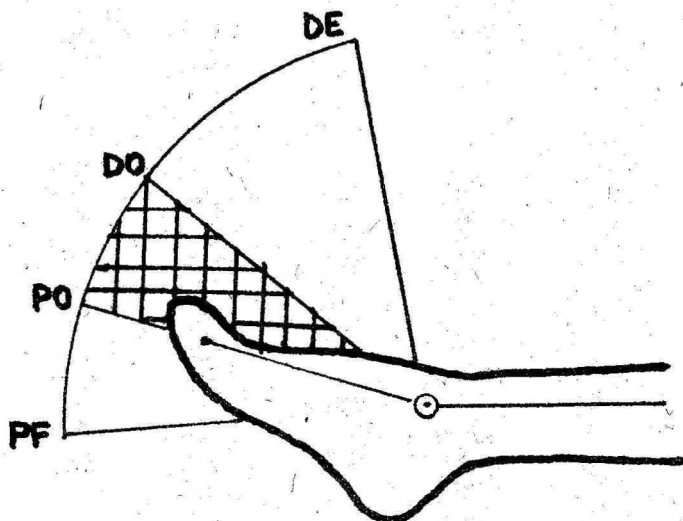


Figure 1. The parameters of triamplitudinal flexibility of the joint. PO — neutral (0) position of the flexion; DO — neutral (0) position of the extension; PO-DO — free of relaxation amplitude

The other test group consisted of 24 young swimmers (12 boys and 12 girls), 11-13 years of age. They were all put through biomechanical stimulation by means of a vibrator (28 Hz frequency) on two consecutive days for the improvement of flexibility. Their initial plantar flexion (PO), initial dorsal extension (DO) as well as the maximum plantar flexion (PF) and maximum dorsal extension (DE) were taken both before and after the biomechanical stimulation according to the methods described in [2]. The subjects had to swim 50 meters in crawl stroke against time only with the help of feet both before and after the biomechanical stimulation.

Results and discussion

In the first group the analysis of statistics showed that there was no relationship between the maximal instep dorsal extension and the effectiveness of footwork in 50 meters breast stroke. However, the higher PO index usually accounts for a better result in the 50 m distance. It should also be mentioned that different types of footwork yielded different relations. Thus the initial instep plantar flexion had no connection with the screw-like motion of feet, whereas connections with the individual, thrust and wedge-like styles were rather weak ($r = 0.35$, $r = 0.38$, $r = 0.58$ respectively). These data confirm our assumption that different types of footwork in breast stroke may be due to individual differences in the work of feet joints and their appropriate compensatory combination in swimming techniques.

The statistical analysis in the second group showed that the results of footwork in crawl stroke depend on the initial instep plantar flexion (PO). After the biomechanical stimulation the increased effectiveness of footwork in 50 m crawl stroke improved the result by 1.8 ± 1.6 sec. on the average, whereas the only relation was noticed between the instep plantar flexion (PO) and the very result ($r = 0.50$).

Those tests proved effectively that by including the two initial positions and three amplitudes in the methodology of research on joints movement the functional analysis of flexibility and professional performance of swimmers can be enhanced considerably. For example, the playback analysis of footwork in crawl stroke shows that in the down-kick or stretched phase of the foot instep it is in the maximal passive state of plantar flexion ($PF = 195^\circ$), then on the upward movement or lifting phase of leg it equals the numerical value of the zero or initial position ($PO = 154^\circ$) as indicated in Fig. 2.

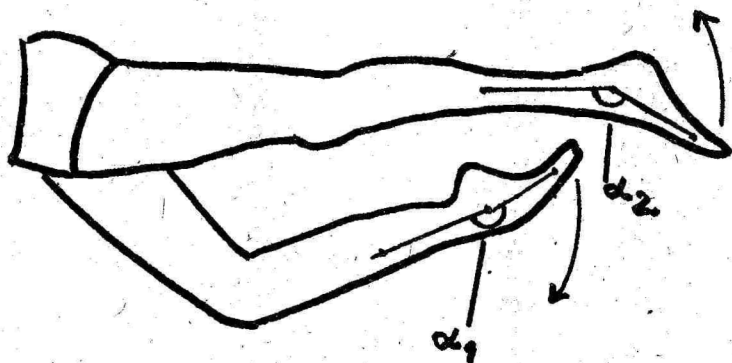


Figure 2. The joint position of foot work in croul stroke. α_1 — \rightarrow PF;
 α_2 — \sim PO

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THE BIOMECHANICAL DIAGNOSTICS OF THE MOTOR SYSTEM OF ATHLETES

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Abstract

The aim of the biomechanical diagnostics of the motor system is to estimate the functional state of the skeletal muscle, connective tissue and joints. Such estimates are necessary in conducting training periods and drawing up training plans. The following parameters provide information for the diagnostics of the functional state of the skeletal muscle: the degrees of relaxation contraction and the damping characteristics of muscles. For the diagnostics of the functional state of the connective tissue the dynamics of post-load residual deformation and their rigidity are essential. For estimating the functional state of the skeletal muscle a method of functional diagnostics has been devised at Tartu University. This is based on measuring the natural oscillations of a muscle after a dosed impact. An apparatus automatically carries out the registration and primary processing of data. The fast adaptive reactions of the connective tissue are estimated using the method of differential diagnostics based on the dynamics of the results of the linear measure of the segments of the motor system. The obtained information enables to individualize the training process as well as to prevent the risk of traumas in the preparatory period.

KEY WORDS: diagnostics, biomechanical properties, skeletal muscle, connective tissue.

The development of an athlete's motor system depends on training facilities and methods. During sports activities substantial morphological and biomechanical changes take place in the tissues of the motor system. They may assist or hinder a

sportsman in achieving high sports results. During the training process and when drawing up training plans it is essential to know the morphological and biomechanical changes taking place in an athlete's muscles and connective tissue which reflect the preparedness of a sportsman for extreme exertion in competition.

Meerson [4] has established that long-term adaptation causes thorough changes in an organism while short-term adaptation involves mainly the functional mechanisms. From this we may draw the conclusion that by observing the short-term adaptive reactions of the motor system it is possible to plan the training process in such a way that as a result of long-term adaptation such kind of morphological and physical abilities evolve which are necessary for establishing records. Arndt [3] found that an increase in the intensity and extent of training is not limited by the adaptive possibilities of the heart and the circulatory system but of the motor system.

An important biomechanical criterion of the functional efficiency of the motor system is its ability to recuperate mechanical elastic energy [2, 5, 12], while an athlete is in motion. In correspondence with the new biomechanical model of the skeletal muscle [14] the recuperation of mechanical energy in the range of the mechanical deformation of the crimps of the collagen fibres of endo-, peri- and epimysium occurs in the skeletal muscle, also in the collagen fibres of the tendon. Both muscles as well as the structures of connective tissue (intervertebral discs) are involved in recuperating elastic energy. From this aspect their functional state is characterized by such biomechanical property as stiffness. In the case of too little or too much stiffness the ability to recuperate mechanical energy is small. This applies both to muscles and the vertebral column. The second important biomechanical criterion is the functional economy of the motor system. Its nature is as follows. It is known that a muscle while fastening itself with its cartilaginous part on the bone lever makes the latter turn round the axis of a joint if the generated torque is bigger than the torques caused by the tonal tension of the antagonist muscle and gravitation. Besides stiffness muscles are characterized by damping [3, 6]. It is expressed by the extent of resistance offered by a muscle depending on the speed at which it is stretched out. At higher stretching the torque of resistance shows sharp increase and if the torque generated by synergists is very big, the high damping qualities of the antagonist may cause the latter to break (trauma). It follows that a heightened muscle tone as well as the damping qualities substantially influence the expenditure

of energy during sports exercises. In other words, the biomechanical properties of the motor system enable one to estimate the preparedness of a sportsman to set up a record. The studies carried out in the last couple of years have shown that the instant adaptive reactions of the motor system caused by physical loads can be followed with biomechanical methods [7, 13]. This involves first of all constant measuring of the stiffness and damping characteristics of the motor system and evaluating the results with corresponding methods [7].

Biomechanical diagnostics makes use of both the methods of differential as well as functional diagnostics. The method of differential diagnostics is used when estimating the trace left by the training load on the structures of the connective tissue. This trace is expressed by the dynamics of residual deformation in the course of a training microcycle. The diagnostics of the functional state of muscles is based on the methods of functional diagnostics. Here the parameters of stiffness and damping of peripheral muscles are followed according to the set aim: in the course of diurnal, weekly or training macrocycle [11].

The method of the diagnostics of the functional state of muscles elaborated at Tartu University is based on damping oscillations. The mechanical response of muscles to mechanical impact on the level of constant efferent activity enables to measure the degree of the muscles' stiffness and the characteristic of damping. Our apparatus makes it possible to measure the above mentioned parameters in any optional point in all peripheral muscles and outputs can be made in the form of numeral indication, charts or printouts. It is also possible to process the results by using a special computer programme which calculates the indices necessary for evaluating different states, carries out the statistical analysis of the subjects and determines the succession of athletes in accordance with the functional state of their muscles [10]. It is also possible to evaluate the direction of changes and the extent of shifts in the functional state of muscles if the results of at least two examinations of the same sportsman can be used. Our research results showed that the parameters of damping and the stiffness of muscles of sportsmen of the same age depend on sex, sports activity and the muscles themselves [8, 9]. The age-caused differences in the stiffness and damping properties in the muscles of 4 to 18-year-old girls' lower limbs (*m. tibialis anterior*, *m. rectus femoris*, *m. gastrocnemius*, *m. biceps femoris*) were studied. All together 386 girl-gymnasts and 91 girl-athletes divided in nine groups were studied. Four- to five-year-old girls' muscle properties were used as background material. From 6 years upwards all subjects went

in for sports. Before training sessions the oscillation period and the logarithmic decrement of damped oscillations during maximal intentional relaxation and maximal isometric contraction of the above-mentioned muscles were measured in all persons with the myotonometer.

The statistical processing of the results testified to a firm correlative connection (on the level $p < 0.01$) in all four muscles: 1) between the oscillation periods in both studied states and among decrements in the state of contraction in gymnasts, 2) between the oscillation periods of contracted muscles in girl-athletes. This refers to the fact that while estimating the functional state of lower limb muscles there is no need for an increase in the number of studied muscles, if the aim is to assess the level of force training.

In other cases differential estimation is required. The changes in the mean value of the muscles' oscillation periods between the ages of 4 and 18 allows to conclude that statistically significant changes in both relaxed and tense muscles take place up to the age of 9. At older age the value of mechanical tension is connected only with the increase of the cross-section of a muscle.

The dynamics of the mean value of decrements differs in different muscles. *M. tibialis anterior* — monotonous decrease of numerical values in both states, while the greatest slope is found between the ages 4 and 8. Depending on age, statistically significant differences occur in all parameters in 4- to 5- and 6-year-old girls, later in 7- and 8-year-olds only in the oscillation period of a contracted muscle and in 9- to 10-year-olds between the decrements of contracted muscles.

M. gastrocnemius has similar dynamics while the decrement of contracted muscle shows a statistically significant decrease up to the age of 9. Beginning from the age of 7 there is no statistically significant difference between the mean value of the decrements of relaxed and contracted muscles.

Mm. rectus and *biceps femoris*. The change in the decrements of a tense muscle depending on age is entirely homogeneous, while an intensive decrease takes place up to the age of 8 and after that numerical values are stabilized.

In accordance with the new biomechanical model of the skeletal muscle the functional state of the structures of connective tissue determines the dampferity and stiffness of the muscle as a whole organ [14]. This allows us to make a supposition that at the age of 8 the development of the contraction apparatus has reached a level where later changes are minimal. In the case of a relaxed muscle the decrement estimates increase up

PLACE OF RESEARCH : TALLINN
 DATA : 7.12.1989

SPORTS EVENTS : GYMNASTICS

 * CARD OF MEDICAL *
 * RESEARCH *

NAME : SELIVANOVVAA

AGE : - CATEGORY : -

DATA OF PREVIOUS RESEARCH : -

INJURIES AND DISEASES :
 -

PARTICIPATION IN COMPETITIONS AND TRAINING :
 -

GROWTH : -

WEIGHT : -

 * RESEARCH OF EL.MYOT *

* NR *	* NAME OF MUSCL. *	* REL. MUSCL. * * PER. * DECR. *	* CONTR. MUSCL. * * PER. * DECR. *	* IDX. * * STIFF. * * DAMP. *	* IDX. *
* 1 *	* M.TIB.A.-R. *	* 48 * .73 *	* 28 * .65 *	* .714 *	* 1.273 *
* 2 *	* M.TIB.A.-L. *	* 56 * 1.1 *	* 32 * .71 *	* .75 *	* 1.4 *
* 3 *	* M.REC.F.-R. *	* 92 * 1.31 *	* 40 * .88 *	* 1.3 *	* 1.263 *
* 4 *	* M.REC.F.-L. *	* 88 * 1.1 *	* 38 * .91 *	* 1.316 *	* 1.142 *
* 5 *	* M.GAS.C.-R. *	* 84 * 1.24 *	* 30 * .77 *	* 1.8 *	* 1.375 *
* 6 *	* M.GAS.C.-L. *	* 78 * 1.13 *	* 30 * 1 *	* 1.6 *	* 1.061 *
* 7 *	* M.BIC.F.-R. *	* 72 * 1.54 *	* 44 * .92 *	* .636 *	* 1.297 *
* 8 *	* M.BIC.F.-L. *	* 90 * 46 *	* 46 * 1.09 *	* .957 *	* 1.875 *
* ARITHMETICAL MEANS - R *				* 1.113 *	* 1.302 *
* ARITHMETICAL MEANS - L *				* 1.156 *	* 1.37 *
* ARITHMETICAL MEANS *				* 1.134 *	* 1.336 *

FINAL DIAGNOSIS :

ADVICE FOR TRAINING AND TREATMENT :

* COMPUTER *TARTU**

Figure. Card of biomechanical diagnostics of a sportsman

to the age of 10, after that they show a statistically significant decrease in *m. rectus femoris* but stay on a constant level in

m. biceps femoris. The latter level is statistically significantly higher than the level between the ages 4 to 7.

The above-stated facts allow us to draw the conclusion that the studied muscles have different dynamics of age-caused changes, depending on their function. A characteristic feature is the stabilization of biomechanical properties after the age of 9. Knowing the regularities of the changes enables us to ascertain the biological processes which take place in skeletal muscles according to age and the effect of training. It also helps to specify the semiological questions of biomechanical diagnostics [15].

A special observation chart has been elaborated for the functional diagnostics of the motor system (Figure). The following data besides general anamnesis are printed: parameters reflecting the state of muscles, the intensity and means of training prior to testing. Relying on these data the expediency of training methods is evaluated.

One of the most loaded segments of the motor system is the foot. Its ability to absorb blows and to recuperate mechanical elastic energy depends on the height of its longitudinal and cross arch. The same functions are fulfilled by the vertebral column. Sports results are very much dependent on the functional state of the intervertebral discs. Our research has shown that the height of a sportsman, the height of his/her ankle joint, the dynamics of the changes in the front diameter of his/her Achilles tendon are informative parameters in the biomechanical deformation of the motor system [7]. For this purpose the deformation of the vertebral column and the arch of foot caused by body weight are determined on the basis of which it is possible to calculate the corresponding parameters of rigidity. Their diurnal or training microcycle dynamics allows the evaluation of the instant adaptive reactions of the structures of connective tissue.

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THE ROLE OF PARENTS AND PAEDIATRICIANS IN THE DEVELOPMENT OF CHILDREN AND PREVENTIVE METHODS OF RISK FACTORS OF DISEASES

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Abstract

The deterioration of children's health in the last decades has caused a strong need to pay more attention to healthy ways of life. Therefore, the teaching of a healthy life style should be started in childhood.

The purpose of this study was to find out social, demographic and psychological peculiarities of parents and to estimate their knowledge of health and the importance of healthy habits.

This paper analyzes the answers of 200 parents of children who were given medical aid and for whom complex physical activities at the Polyclinic of the Tallinn 1st Children's Hospital were organized.

In the course of this work we saw that introducing a healthy life style can only be done by a team of teachers, medical workers, psychologists and, especially, parents. So we had to work with children as well as with their parents.

KEY WORDS: Healthy life style; physical activity; social, demographic, psychological peculiarities of parents.

Introduction

The deterioration of childrens health in the last decades has caused a strong need to pay more attention to healthy ways of life.

Children's higher rate of illness recently has been conditioned by the fast increase in both environmental pollution and lack of exercise. Very little attention so far has been paid to the innate need to move and exercise; to the establishment of suitable health centers; to children's health education and to the formation of their parents' healthy habits.

The most important part of healthy life style is physical activity, rational nutrition, optimal spending of free time, hygiene [1, 10].

Changing one's habitual way of life is known to be rather difficult. The knowledge and understanding of the need to have healthy habits do not make a person give up his or her customary way of life. Changing one's way of life requires great effort, self-compulsion, ability to overcome inconveniences, patience [1, 4, 5, etc.] Therefore, the teaching of healthy life style has to be started in childhood. We think that the effect of teaching people a healthy life style depends entirely on the effort of parents, teachers, psychologists and medical workers [3, 7, 9].

While dealing with children we have to know about their parents as they determine the possibilities of bringing up healthy children. The parents have to understand that without their help it is hopeless for the children to become healthy and acquire good health habits [3].

The purpose of this study was to examine the social, demographic and psychological peculiarities of parents and to estimate their knowledge of health and the importance of healthy habits.

Subject and methods

A questionnaire was composed to carry out this study. The questionnaire was sent at the end of 1990 to the parents of children who were given medical help at the Polyclinic of the Tallinn 1st Children's Hospital. This paper analyzes the answers of 200 parents.

Results

The analysis of the data shows that most of the investigated families were living in communal flats ($83 \pm 2.66\%$), $6.5 \pm 1.74\%$ lived in hostels and $10.5 \pm 2.17\%$ in private houses' $52.0 \pm 3.53\%$ of the families lived in 1-2 room flats and $3.0 \pm 1.21\%$ in bachelor flats. The remaining $45.0 \pm 3.52\%$ had 3 or more rooms in a flat. The amount of floor space per capita was less

than 4 m² in $9.5 \pm 2.07\%$ of the families.

The results show the equal level of education of fathers and mothers. In $46.5 \pm 3.53\%$ cases both of the parents had higher education, only $3 \pm 1.21\%$ had primary education and the rest $50.5 \pm 3.54\%$ had secondary or specialized secondary education. Nearly $90 \pm 2.12\%$ of parents considered themselves healthy at the present time.

$42.5 \pm 3.49\%$ of fathers and $26.0 \pm 3.1\%$ of mothers were regular smokers, $7.0 \pm 1.8\%$ of mothers had been smoking when they were pregnant with the child under question. In $84.0 \pm 3.1\%$ of families alcohol was used rarely and in small quantities.

Most of the children ($87.5 \pm 2.34\%$) were born by normal delivery. $35.5 \pm 3.38\%$ of the children were given early artificial nourishment. Mothers considered their children's food in early childhood and pre-school age adequate to their age. $43.5 \pm 3.51\%$ of parents started the physical developing of their children already from the birth, $38.5 \pm 3.44\%$ did not do it regularly and $18.0 \pm 2.71\%$ had never done it.

From the questioned families $72.0 \pm 3.17\%$ estimated the relations in the family friendly. In most of the families the atmosphere was quiet during pregnancy as well as at the time of questioning ($84.0 \pm 2.77\%$).

Among the hygienic habits of children the parents named brushing teeth and washing hands equally in $72.0 \pm 3.17\%$. Most of the children sleep 9–10 hours during night ($78.8 \pm 2.82\%$) and $61.0 \pm 3.45\%$ of the parents said the child slept at daytime, too.

The time dedicated to children is 3–4 hours for $88.0 \pm 2.29\%$ of parents, less than 1 hour for $8.0 \pm 1.92\%$. The remaining 4% did not respond. $43.5 \pm 3.51\%$ of parents exercise the children regularly starting from their birth, $18 \pm 2.72\%$ have never done it and $38.5 \pm 3.44\%$ do it sometimes when they happen to have time.

We were interested in the parents activeness in preventing their children from falling ill and in trying to get more knowledge about it. Only $6.0 \pm 1.68\%$ of parents said that usually they did not read about medicine or education. If changes occurred in children's health, most of the parents ($54.5 \pm 3.52\%$) read popular literature on medicine and $21.0 \pm 2.88\%$ on education and psychology in addition to that.

$42.5 \pm 3.49\%$ of the parents go to their district paediatrician only when the child is ill. $17.5 \pm 2.69\%$ of the parents try to visit their paediatrician as seldom as possible and $3.0 \pm 1.21\%$ do not do it at all.

If the child falls ill, $41.5 \pm 3.48\%$ of the parents call their

district paediatrician to visit the child at home at once, $20.5 \pm 2.85\%$ will start treatment themselves. Part of the parents ($11.5 \pm 2.26\%$) think they would call a doctor only in emergency.

$39 \pm 3.45\%$ of parents trust their district paediatrician and another $39.0 \pm 3.45\%$ could not answer this question. $57.0 \pm 3.50\%$ of parents think of the paediatrician only as about a consultant but suppose that the treatment has to be carried out by the parents themselves. Some of the parents ($13.5 \pm 2.42\%$) think of the paediatrician only as about the person who gives them the medical certificate of illness and only $6.5 \pm 1.74\%$ consider their paediatrician as an authority in all questions of bringing up the child or treating him in case of illness. $48.0 \pm 3.53\%$ of parents describe the relations with their paediatrician as good or sufficient, $31.0 \pm 3.27\%$ satisfactory, and $6.9 \pm 1.79\%$ unsatisfactory.

In the autumn of 1987 a workgroup was organized in the Polyclinic of Tallinn 1st Children's Hospital to work regularly with children from 4 to 12 years of age with regular medical control. We organized complex physical activities (swimming + indoors gymnastics + outdoors physical activities). At first we made up a group of healthy children to control this method. Later groups for children with overweight and scoliosis were set up.

In the above-mentioned work we tried to:

- 1) normalize the needs for physical activities and nutrition. It was hard when children had got used to a lack of physical activities or when because of regular overfeeding they had disturbances in the balance between brain centers of hunger and saturation;
- 2) create habits of hygiene in children and to assure their parents in their usefulness;
- 3) pay attention to the straight bearing of children and to explain its connections with health;
- 4) explain to the parents how important peaceful and friendly relations in the family are for the child's nervous system.

In our work with parents we used individual conversations, lectures and seminars on different subjects, we also distributed printed texts.

We saw that introducing a healthy lifestyle can only be done by a team of teachers, medical workers, psychologists and especially parents. So we had to work with children as well as with their parents.

Most parents ($76.7 \pm 3.00\%$) thought that their children had become more self-assured, calmer and skillful ($76.7 \pm 3.00\%$), they fell ill less than before ($66.7 \pm 3.33\%$). There were also

motives for parents to bring their children to trainings while a lot of the parents also mentioned that their children insisted on going there (73.7 ± 3.11 %). Quite a number of parents also started some kind of sports following the example of their children.

The children's motives were as follows: a nice, kind and encouraging instructor (82.3 ± 3.48 %), being able to show their skill to the parents (72.5 ± 4.08 %), being together with other children (60.0 ± 1.41 %)

It is important that 87.5 ± 3.48 % of parents realize their role in improving the health of their children and creating healthy habits.

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HEART RATE PATTERN IN SESSIONS OF AEROBIC GYMNASTICS

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ABSTRACT

The heart rate of 20 women of various age was recorded during 4 sessions of aerobic rhythmic gymnastics (Table 1). The highest heart rate values were found in 18-25-year-old gymnasts performing highly intensive aerobic dance elements. The heart rate was comparatively low when the aim of used exercises was the improvement of flexibility or correction of carriage. The heart rate was substantially lower when the same exercises were performed without music accompaniment. The heart rate over 120 beats per min persisted in two groups of gymnasts in most sessions. In other groups the exercises were without sufficient intensity to suggest an improvement of cardiovascular fitness. In most cases the heart rate dynamics showed a decrease in the exercise intensity during the second part of a session.

KEY WORDS: Aerobic gymnastics, exercise intensity, heart rate, training session.

Introduction

Evidence was provided in a number of studies that continuously (without any interruption) performed gymnastic exercises (aerobic rhythmic gymnastics) or modern dances (aerobic dance) result in an improvement of aerobic working capacity [1, 2, 3, 5, 6, 8, 10, 12] as well as in changes in blood lipoprotein contents [3, 5] which is considered to warrant the metabolic antisclerotic effect of training [9]. In both cases a certain minimal level of exercise intensity and duration is necessary [5, 9]. One of the simple ways to assess the exercise intensity is to record the heart rate during exercise. Despite the fact that there are certain limitations in accurate monitoring of dance exercise intensity by heart rate [7] this method was used to answer the questions: (1) is the exercise intensity sufficient to suggest its stimulating effect on cardiovascular improvement? (2) what are

the most typical patterns of heart rate dynamics during aerobic rhythmic gymnastics session?

Material and methods

Heart rate changes were monitored in 5 groups of aerobic gymnastics during 4 sessions each (Table 1). In each session heart rates were recorded simultaneously in 4 women by palpitation of the carotid artery. The same women were used for heart rate monitoring in various sessions. All subjects were considered practically healthy by medical examinations. The heart rate was recorded during 10s after each 5 min of exercising. The duration of a session was 45 min including a warm-up and the relaxation exercises at the end of sessions. All sessions were performed to musical accompaniment. The only exception was the 4th session in the 5th group. All groups practiced two times a week.

Table 1

Groups of study

Group	Age (years)	Period of previous participation in aerobic gymnastics (years)	Characteristics of persons
I	30-40	up to 5	Rather low level of fitness
II	18-25	2	Various level of fitness
III	40-50	20-25	Most of persons overweight
IV	16-18	First year	Low level of fitness
V	20-40	2	Various level of fitness

Results

The highest heart rate values were found in the 2nd group (Table 2), i.e. in 18-25 year old women. However, the age was not the main reason because in the 4th group of 16-18 year old girls the heart rates were significantly lower. The differences between the 2nd group and other groups were mainly due to the exercises used. In the 2nd groups the sessions consisted of highly intensive aerobic dance elements. In the 4th group the used exercises were less intensive and directed to the development of various muscle groups as well as for the improvement of flexibility. In this group the lowest heart rate values were observed in the 4th session which consisted mainly of stretching exercises. Similar heart rates were found in the 4th and 5th groups when using similar exercises. In the 5th group attention

should be paid to the comparison of the 3rd and 4th sessions. Both sessions consisted of similar exercises and the instructor tried to maintain a similar intensity of performance. The heart rate however rose in the 3rd session up to 135 ± 5 in the 4th session only up to 120 ± 2 beats per min (Figure 1). The difference can be accounted for by the lack of music in the 4th session.

Table 2

Mean values of the highest levels of heart rate during exercise sessions and the time during which the heart rate was over 120 beats per min (mean \pm standard deviation)

Group	Age of persons		The highest levels of heart rate during exercise sessions (beats per min)	The time during which the heart rate was over 120 beats per min (min)	Characteristics of exercises
I	30-40	1.	$126 \pm 5,4$	10 min	Exercises for improving strength and stretching exercises
		2.	$126 \pm 5,4$	25 min	
		3.	$108 \pm 3,9$	—	
		4.	$120 \pm 3,0$	—	
II	18-25	1.	$153 \pm 6,0$	45 min	Aerobic dance elements
		2.	$156 \pm 7,8$	45 min	
		3.	$168 \pm 7,5$	45 min	
		4.	$174 \pm 6,3$	—	
III	40-50	1.	$111 \pm 3,9$	—	Various exercises of moderate intensity
		2.	$102 \pm 3,0$	—	
		3.	$114 \pm 3,0$	—	
		4.	$108 \pm 5,2$	—	
IV	16-18	1.	$147 \pm 3,9$	40 min	Exercises for development of various muscle groups and improved flexibility Stretching exercise
		2.	$141 \pm 10,8$	40 min	
		3.	$138 \pm 10,8$	40 min	
		4.	$108 \pm 4,5$	—	
V	20-40	1.	$132 \pm 10,5$	20 min	Exercises for development of various muscle groups and improved flexibility Same exercises without music
		2.	$135 \pm 9,3$	40 min	
		3.	$132 \pm 15,0$	15 min	
		4.	$120 \pm 2,4$	—	

The lowest levels of heart rate were in case of 40-50 year old women (the 3rd group). It was mainly due to exercises of moderate intensity. Comparatively low levels of heart rate were also observed in the 1st group when exercises for improving strength and stretching exercises were mainly used. In the 2nd session more intensive exercises were used during 25 min. In the 3rd session the main attention was paid to the correction

of carriage due to which the overall intensity of sessions was moderate.

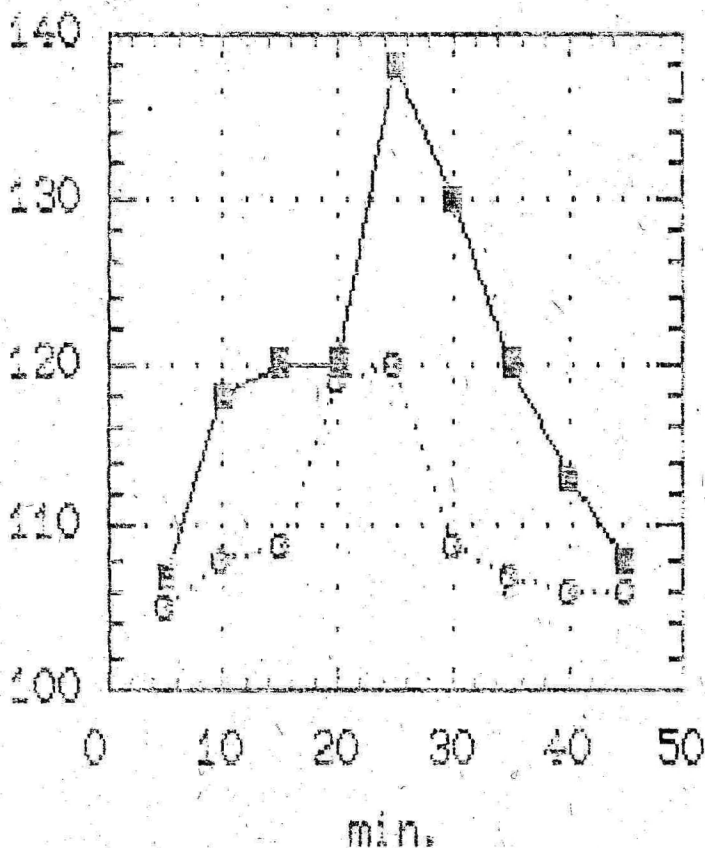


Figure 1. Patterns of heart rate dynamics during similar sessions of aerobic gymnastics (means values of group \pm S.E.M.) performed with music (solid line) or without music (interrupted line).

The heart rate over 120 beats per min was maintained for most of the session in the 2nd and 4th groups (Table 2). In other groups the corresponding exercise intensity was maintained 20 min or more in one session only in the first group and in two sessions in the fifth group.

There main patterns of heart rate dynamics were discriminated (Figure 2):

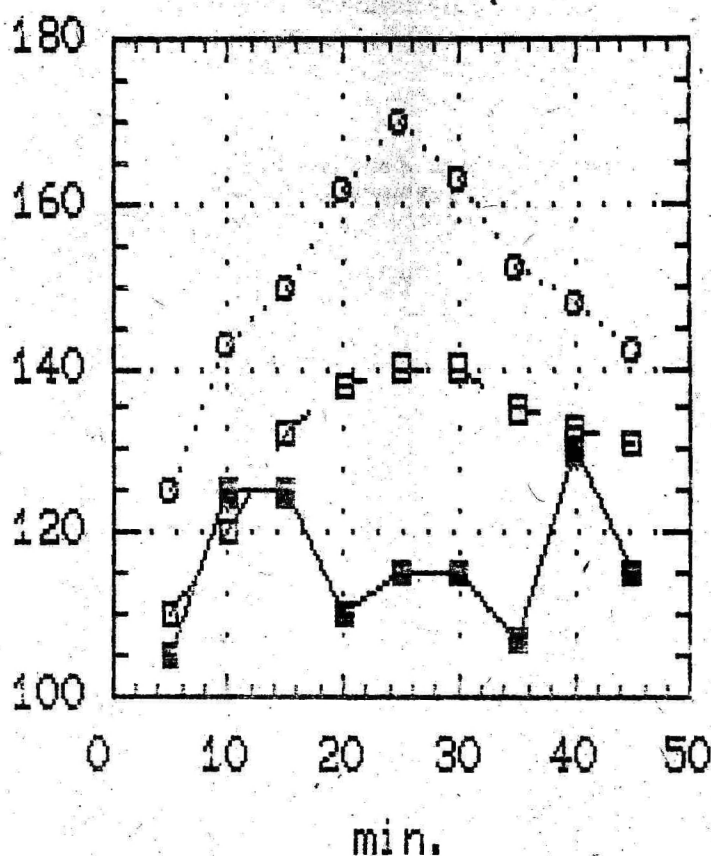


Figure 2. Patterns of heart rate dynamics during sessions of aerobic gymnastics (mean values of group)
 a relatively constant level of heart rate (the differences between heart rate values are not significant during session — 5th group, (2nd session)
 the increase of heart rate during the first half of session, followed by a heart rate decline 2nd group, 2nd session)
 two peaks of heart rate dynamics (1st group, 1st session)

- (1) a constant level of heart rate,
- (2) the increase of heart rate during the first half of the session followed by a heart rate decline during the second half
- (3) two peaks of heart rate during the sessions.

In most cases the second pattern of heart rate dynamics was established (Table 3).

Table 3

**Statistical analysis of changes in the heart rate
during gymnastic sessions**

Group	Session	Heart rate dynamics	Evaluation differences between heart rate levels	
			t	p
I	1.	Two peaks of heart rate	3.0	< 0.05
	2.	Constant level of heart rate	2.0	> 0.05
	3.	Constant level of heart rate	1.4	> 0.05
	4.	Increase in heart rate followed by a decline	2.7	< 0.05
II	1.	Increase in heart rate followed by a decline	3.5	< 0.05
	2.	Increase in heart rate followed by a decline	3.0	< 0.05
	3.	Increase in heart rate followed by a decline	3.2	< 0.05
	4.	Increase in heart rate followed by a decline	5.0	< 0.05
III	1.	Increase in heart rate followed by a decline	3.1	< 0.05
	2.	Increase in heart rate followed by a decline	2.8	< 0.05
	3.	Increase in heart rate followed by a decline	5.0	< 0.05
	4.	Increase in heart rate followed by a decline	2.7	< 0.05
IV	1.	Increase in heart rate followed by a decline	6.0	< 0.05
	2.	Increase in heart rate followed by a decline	2.4	< 0.05
	3.	Increase in heart rate followed by a decline	2.4	< 0.05
	4.	Constant level of heart rate	2.2	> 0.05
V	1.	Constant level of heart rate	2.1	> 0.05
	2.	Constant level of heart rate	1.8	> 0.05
	3.	Constant level of heart rate	1.4	> 0.05
	4.	Increase in heart rate followed by a decline	5.0	< 0.05

Discussion

Heart rate levels within 157–167 [6] or 120–190 beats per min [4] were recorded during aerobic dance or aerobic gymnastic session in previous studies. The results of this study indicate lower levels in most cases. It is suggested that for the development of cardiovascular fitness the training intensity should be 60 to 90 % of the maximum heart rate, i.e. 120–170 beats per min [9, 10]. This level of heart rate was maintained during exercise sessions in two groups of women on most sessions and only in some sessions in other groups. Therefore it cannot be said that all the studied training sessions were effective in regard to improving cardiovascular fitness. However, there are a lot of various tasks that have been fulfilled in sessions of aerobic gymnastics, including improvement of strength, flexibility, carriage, etc. Consequently we can not conclude the uneffectiveness of these training sessions either. When the aim of training sessions is to develop cardiovascular fitness, more intensive exercises have to be used.

During sessions of aerobic gymnastics the heart rate level depends not only on the exercise intensity but also on the music accompaniment.

In most cases the heart rate dynamics showed a decrease in the exercise intensity during the second part of a session. In another study heart rate dynamics with two or three peaks were found [4]. The effectiveness of various patterns of heart rate in improving cardiovascular fitness has to be evaluated in the future.

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KNOWLEDGE OF HEALTH AND EVALUATION ON ONE'S STATE OF HEALTH GIVEN BY 11TH FORM PUPILS

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ABSTRACT

In order to study knowledge of health, lifestyles and evaluation of health condition of schoolchildren, a questioning was carried out in the 11th form of Tartu schools.

The students are relatively dissatisfied with their current state of health. At the same time they are not taking enough care to promote it. Physical activity is rather low. The youngsters of this age bracket are impetuous, which account lifestyle are not widespread. The students do not only have insufficient knowledge of their health but very often they just understand several things in a wrong way. They would like to have better information about their health.

KEY WORDS: health, lifestyle, students

Introduction

The deteriorating state of public health in Estonia has recently become of serious consideration. For the benefit of maintaining a healthy nation it is indispensable to change people's attitude to health-care. A sanophiliac way of thinking ought to get the upper hand (11). The appropriate attitude can be developed in youth and adolescence and consolidated in later years. To that end, knowledge, motivation and condition will be necessary which in turn creates a need for a particular social programme [2, 6]. Estonian-based strategy of public health should be worked out considering the principles laid down in the programme "Health for all by the year 2000" [14].

We have recognised major hazards and taken tentative steps to improve the situation [3, 13]. As a basic constituent of the scheme, health education will also be introduced into the school curriculum. The subject is intended to educate children to promote good health by gradually applying the knowledge and experience gained. Prior to opening this course the educators are looking forward to some preliminary information on how

much our youngsters know about their health, what are their attitudes and what lifestyles they follow. The present paper is aimed at studying some of those aspects.

Methods

Subjects. Eleventh-grade students of Estonian language schools in Tartu were questioned. Answers were received from boys and girls aged 16–18.

The majority of the 37 questions asked had multiple choice answers (Table 1–3). Questioning was carried out in groups, and each time it was preceded by a careful instruction of the subjects on the methods of answering. The students were not expected to consult one another. All in all, 240 girls and 138 boys were questioned.

Results

Evaluation of personal health condition (see Table 1). Only 21.8 % of girls (♀) and 41.2 % of boys (♂) feel healthy. Half of the pupils do not feel physically fit and trained. 30 % ♀ and 23.5 % ♂ feel tired. As for girls, this is due to mental strain, boys have mentioned both reasons — mental and physical tension. About half of the ♀ would like to take off weight.

Regime and physical activity (see Table 2). The majority of pupils sleep 7–9 hours. This is not enough for half of them. 13.1 % and 11.6 % have wholesome breakfasts, most of pupils have no meals at lunchtime. 3.5 % ♀ and 15 % ♂ of pupils do not brush teeth regularly.

Physical activity is rather low. Only 33.2 % ♀ and 45.4 % ♂ go in for sports for 3 and more times a week. 9.2 % ♀ and 1.8 % ♂ do not have any kind of physical exercise. In most cases girls go in for sports individually, boys prefer sports-schools. Sports on this level gives satisfaction and is a pleasant change.

Disposition and unhealthy habits (see Table 3). 53.4 % consider life to be too strenuous, caused by other people (55.3 % ♀ and 52.8 % ♂) and themselves (44.7 % ♀ and 46.8 % ♂). Only 7.4 % ♀ and 13.1 % ♂ think themselves as not aggressive. Conflicts are mainly with parents (57.9 % and 44.2 %). 58.9 % ♀ and 43.3 % ♂ of pupils often or sometimes experience depression and anxiety. 47.3 % ♀ and 41.5 % ♂ have a friend whom they fully trust. 26.7 % ♀ and 28.8 % ♂ have never used alcoholic drinks, 38 % ♀ and 37.4 % ♂ use them once a month. 80.4 % ♀ and 65.9 % ♂ are non-smokers, but 15.2 % of boys smoke every day.

Knowledge. In order to study their knowledge of dietetics, a list of different sorts of food was presented and the students

Table 1

Evaluation of personal health condition (%)

	♀	♂	♀	♂	♀	♂	♀	♂
1. Do you feel healthy?	always 21.8	41.2	sometimes 76.1	57.3	seldom 2.1	1.5		
2. Do you feel physically fit and trained?	yes 37.3	44.9	not quite 53.0	52.0	I am rather 9.7	weak 3.1		
3. Are you often tired?	rather 7.9	seldom 11.0	sometimes 61.7	65.4	rather frequently 30.0	23.5	all the time 0.4	
4. You feel tired due to:	physical 21.7	tension 38.2	mental 52.1	tension 37.0	tiring environment 26.1	24.8		
5. Have you got a good bearing?	yes 33.0	36.8	not quite 60.1	59.4	no 6.3	3.8		
6. What do you think about your weight?	normal 45.9	65.4	I would like weight 50.4	to lose 14.0	I would like weight 3.7	to gain 20.6		
7. Have you got good eyesight?	yes, I have 40.8	47.8	sometimes I exert my 21.8	must eyes 19.4	no, I have not, but I do not wear glasses 13.9	12.7	no, I have not and I wear glasses 23.5	20.1

Table 2

Regime and physical activity (%)

	♀	♂	♀	♂	♀	♂	♀	♂
8. How many hours do you usually sleep?	less than 7 hrs		7-9 hrs		more than 9 hrs			
	21.2	28.2	74.3	77.4	4.5	4.4		
9. Is it enough for you?	yes		I need more		no			
	49.8	47.7	43.9	44.5	6.3	8.0		
10. What do you have for breakfast?	I do not eat in the morning		I have breakfast at times		cold meal		cooked food	
	16.7	6.5	13.9	16.7	56.3	65.2	13.1	11.6
11. Where do you have your dinner?	in school		have a snack somewhere		at home		I don't have dinner	
	37.4	38.6	8.5	4.2	52.3	56.6	1.8	0.6
12. Do you have a light or a big meal for supper?	big meal		sometimes light, sometimes big		light meal			
	25.0	42.8	54.1	47.9	20.9	10.1		
13. Do you brush teeth?	after every meal		2x a day		1 x a day		not regularly	
	3.3	1.5	34.2	29.3	59.1	54.1	3.4	15.0
14. How many times a week do you perform physical exercises?	5 x		5 x		4 x		3 x	
	6.3	8.0	9.6	8.9	7.6	10.7	14.2	17.8
	2 x		1 x		-			
	24.4	26.7	28.7	26.1	9.2	1.8		
	in sports school		with friends		with family		individually	
	13.1	29.0	28.4	24.4	6.5	4.0	38.5	23.2
15. How do you evaluate this activity?	in school after classes		it is a pleasant change		it develops my abilities			
	13.5	19.5	28.4	24.4	6.5	4.0		
I appreciate it	it gives me satisfaction		change		abilities			
	84.6	87.1	92.2	84.1	62.3	67.5		
it is quite acceptable			7.2	14.8	26.9	22.5		
I can't say I like it	12.3	10.9	0.6	1.1	10.8	10.0		
	3.1	1.9						

Table 3

Disposition and unhealthy habits

	♀	♂	♀	♂	♀	♂	♀	♂
16. Do you feel that your life is filled with mental stress?	often 14.1	10.7	rather often 42.3	35.7	seldom 44.2	7.9	not at all 12.4	
caused by others:	55.3	53.0						
I myself caused it:	44.7	47.0						
17. Have you any conflicts?	often 1.2	2.2	rather often 13.6	11.6	sometimes 77.7	74.6	I have no conflicts 7.4	11.6
18. I have conflicts mainly:	with parents 57.9	44.2	with teachers 11.9	17.4	with friends 22.6	25.4	with strangers 7.5	13.0
19. Have you got a friend you can fully trust?	yes, I have 47.3	41.5	yes I have, but I haven't yet entrusted him 46.0	47.2	no, I haven't 6.7	11.3		
20. Do you feel depression or anxiety?	no 4.5	20.6	seldom 37.6	36.0	sometimes 46.3	35.3	often 11.6	8.0
21. Do you use alcoholic drinks?	no 29.6	28.8	no more than 2 x a year 26.5	16.5	no more than 1 x a month 36.0	37.4	3-4 x a month 6.5	14.4
22. Do you smoke?	no 80.4	65.7	sometimes 11.3	10.9	1-2 cigarettes a week 5.4	7.9	every day 2.9	15.2
23. Do you think that you will be smoking in 4-5 years?	yes 4.6	17.6	no 85.0	75.7	I don't know 10.4	6.6		

picked out these which usually cause overweight. Only 31 % ♀ and 10.4 % ♂ have enough knowledge of dietetics. 23.3 % ♀ and 45.5 % ♂ have no idea of the characteristic features of sexual maturity of girls and 40 % ♀ and 53 % ♂ of boys. 22.7 % ♀ and 33.1 % ♂ were not aware of the possibility of becoming pregnant on the first sexual intercourse. On the contrary, 5.9 % ♀ and 6 % ♂ excluded such possibility. One third of the pupils did not know the ways of spreading the AIDS. 20 % ♀ and 16.6 % ♂ could not mention a single contraceptive. 21.6 % ♀ and 17.7 % ♂ were aware of normal blood pressure, 26.8 % ♀ and 26.3 % ♂ knew their blood pressure. 21.6 % ♀ and 17.6 % ♂ did not know how to measure the pulse rate, 70.2 % ♀ and 17.6 % ♂ did not know their pulse rates. 14.2 % ♀ and 18.2 % ♂ could not bring out the benefits of going in for sports. Medicines were used by 49.2 % ♀ and 44.8 % ♂ during the last month but only 25.6 % ♀ and 13.3 % ♂ knew which remedies they had used. In case of falling ill 41.3 % ♀ and 39.7 % ♂ ask parents for advice 32.9 % ♀ and 32.4 % ♂ do not take any medications, 13.4 % ♀ and 12.1 % ♂ use medical aid, 12.4 % ♀ and 13.2 % ♂ use a suitable medication they know and 1.9 % ♂ consult their friends.

Attitude towards health education. The students were given a list of different activities and asked to mark out what they found necessary, may-be necessary or absolutely dull. Most of the girls are eager to get information about self-testing, self-command, first aid, taking care of babies and infants, pregnancy and childbirth. They are not interested in general estimates of Estonians' health, harmful effects of alcoholic drinks, smoking and other harmful substances. Boys are mainly interested in sex life, first aid, self-testing, self-command and physical exercise and sports as a means of being healthy. They are not interested in general estimates of Estonians' health, harmful effects of alcoholic drinks and smoking, or a secure home.

Discussion

The answers received indicate that the students are relatively dissatisfied with their current state of health. Similar estimates were given by scientists who have been studying the health of high school students [10]. With girls the situation leaves much to be desired as the number of those feeling absolutely well is relatively low. Both girls as well as boys have stated that they lack the desired posture and physical fitness. Only half of those questioned were absolutely satisfied with their eyesight. The answers from girls indicate that they have a tendency of getting overweight. It is quite positive that the secondary school students are aware of their health but at

the same time they are not taking care enough to promote it. Physical activity is relatively low among girls. Similar findings have been obtained by R. Silla [10] who concludes that in the post-puberty period the majority of girls experience 40 per cent decline in their physical activity compared with boys. He states that about 75-80 per cent of senior grade students are suffering from insufficient physical exercise. By our estimates the figure of youngsters having acceptable regular fitness exercise (i.e. 3 times or more per week) is 39.5 per cent. The answers obtained from a similar questioning performed with the same age group in Denmark reveal the percentage of students practicing sports 3 times a week as 57 [4]. Low physical activity of people underlies their frequent periods of fatigue. Physical activity is rather low among young people in Finland too [12].

As to regimen, the majority of students need 7-9 hours of sleep but do not consider that enough. It is quite amazing that about 15 per cent of boys do not brush their teeth regularly.

It should be mentioned that the youngsters of this age bracket are rather impetuous which accounts for their conflicts with parents, friends and teachers. They find their life to be quite unnerving, full of distress and dejection. V. Karu [5] has found that 2.7-7.7 % of students suffer from sporadic neuroses. However, it can be supposed that by today this figure has become much higher and can basically depend on the youngsters' rapport with their parents. About fifty per cent of the students questioned had not got a close friend to rely on, which in turn affected their mental health. The figures of those abstaining from alcohol are almost the same with both sexes the figure of those overindulging in alcohol, however, was higher in the case of male persons.

Another fact causing anxiety is the 15.2 per cent of young males who smoke regularly. In Finland this number was 29 % [12]. It has to be stated that the principles of healthy lifestyle are not widespread among young people [8]. On the average, youngsters start smoking at 17.1 and using liquor at 17.2 years of age [7]. T. Aitsam [1] has stated that 1/3 of senior grade students had got substandard hygienic education and about a half of those lacked the necessary knowledge of sex education, several diseases, etc. Up to now there has been no improvement in the situation. Many young people have not developed proper nutrition habits, they are not well aware of many questions relating to sexual maturity and pregnancy. There may be cases that people at the age of 16-18 cannot even take their pulse rate. Another thing to be mentioned is that the students do not only have insufficient knowledge of their health but very often

they just understand several things in a wrong way. Our questioning showed that the students of this age bracket would like to have better information about their health. And in spite how much or little they know of their health and physical fitness they are not doing anything about it. The only breakthrough in such a situation can be achieved through updated courses of health education.

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P.D. GOLLNICK IN MEMORY

June 26, 1991 was the day when the heart of P.D. Gollnick stopped beating. The outstanding scientist, Professor of Washington State University, was only 56.

The publications of P.D. Gollnick and the research team that worked under his supervision are well known to all scientists and students engaged in exercise biochemistry and physiology in the world. His fundamental researches dealt with a great variety of the most actual problems of exercise biochemistry: skeletal muscle adaptability and its dependence on fiber content and characteristics of performed exercises, substrate mobilization and utilization, as well as with the regulation of related enzyme systems in exercise, biochemical foundations of physical working capacity, biochemistry of fatigue, etc. He was among the first in line in the discovery of improvement of mitochondrial function in training, the endurance training effects on cholesterol metabolism, biochemical peculiarities of acute exercise performance and training effect in dependence of recruitment of muscle fibers of various types. A great deal was done by him for the clarification of such problems as training effects on the number of muscle fibers or on the transformation of fiber types. He was among the first scientists to use the biopsy method for studies of muscle biochemistry in exercising humans. Undoubtedly, a number of his studies have to be considered classic works in biochemistry and physiology.

P.D. Gollnick was one of the leading specialists in the Research Group on the Biochemistry of Exercise, International Council of Sports and Physical Education, UNESCO.

Our personal contacts with him were extremely fruitful not only due to his wealth of scientific ideas but also due to his personality. He was a very kind man, a real humanist. The wide spectrum of his cultural interests extended to Russian literature, art, music. He participated repeatedly in scientific meetings in Leningrad and Moscow. In 1988 he lectured at Tartu University.

All those who had the opportunity to meet P.D. Gollnick will forever maintain a vivid memory of a talented scientist and a nice person.

N. Yakovlev, A. Viru

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**BIOLOGICAL AND PEDAGOGICAL PROBLEMS OF PHYSICAL
EDUCATION AND SPORT. II**

Töid kehakultuuri alalt

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