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PLASMA ISLET HORMONES, GLUCOSE, AND INSULIN SENSITIVITY IN PHYSICALLY ACTIVE, PREMENOPAUSAL FEMALES USING ORAL CONTRACEPTIVES AS COMPARED WITH REGULARLY MENSTRUATING NON-USERS WITH MATCHED PHYSICAL ACTIVITY

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Abstract

Malara M, Lutosławska G, Kęska A, Skierska E. Plasma islet hormones, glucose, and insulin sensitivity in physically active, premenopausal females using oral contraceptives as compared with regularly menstruating non-users with matched physical activity. *Med Sport* 2007, 11(3): 56-62.

Introduction: It is well known that synthetic female sex hormones affect many metabolic processes including islet function, immunity, carbohydrate and lipid metabolism. However, there is no studies concerning OC action on circulating islet hormones, glucose and insulin sensitivity with respect to menstrual cycle phase in young, physically active subjects.

Aim of the study: This study aimed at evaluation of the effect of OC use on plasma islet hormones, glucose and insulin to glucose ratio in physically active females - OC-users and non-users. This objective was accomplished by comparison of the tested variables in two phases of the menstrual cycle and the assessment of dietary habits.

Methods: Fasting venous blood was collected between days 5-8 and 19-22 of the menstrual cycle. Glucose was determined colorimetrically. Insulin and glucagon plasma levels were assayed by standard radioimmunoassay techniques. Circulating C-peptide and proinsulin were determined using ELISA method.

Results: Circulating glucose, insulin, C-peptide and proinsulin were not affected by OC use. However, in OC-users circulating C-peptide concentrations were shifted to higher values than in non-users. In contrast, insulin to glucose ratio in OC-users were shifted to lower value than in non-users. OC use induced significant elevation in circulating glucagon. Plasma insulin and glucose levels in were significantly correlated in OC non-users ($r = 0.561$, $p<0.001$) but not in OC-users.

Conclusions: OC-use did not affect insulin synthesis in the pancreas. However, it seems feasible that OC slightly stimulated insulin uptake and significantly depressed glucagon uptake by the liver and in consequence disturbs *de novo* glucose synthesis. This assumption is supported by the lack of correlation between insulin and glucose plasma levels in OC-users. Our finding may be of importance for female athletes especially in the context of significant role of glucose homeostasis in successful performance.

Key words: *oral contraceptives, islet hormones, insulin sensitivity*

Introduction

Despite its role in the reproduction female sex hormones are known to regulate many metabolic processes including food intake, brain activity, endothelial function and immune response (1-4). Well-established is a protective role of estrogen against ischemia-reperfusion injury of myocardium and blood vessels (5,6). Numerous studies have confirmed estrogen contribution to antioxidant protection (7-11).

There are data indicating the existence of ovarian hormone receptors many tissues as in the liver, pancreas, and skeletal muscle (12-17).

Estrogen has been found to interact with insulin receptor substrate-1 (IRS-1) in different tissue either upregulating IRS-1 in low doses and increasing insulin sensitivity, or downregulating IRS-1 in high doses and favoring insulin resistance (18). Thus, affecting insulin cascade ovarian hormones contribute to the control of the whole body glucose homeostasis. In the mice ovariectomy resulted in increased gluconeogenesis and depressed glycogen content in the liver, cardiac and skeletal muscle (19). On the contrary, estradiol treatment of ovariectomized animals markedly reduced gluconeogenesis, but this effect was antagonized by progesterone.

In addition there are data indicating ovarian hormone contribution to the regulation of lipid metabolism. In isolated adipocytes 17ß-estradiol was shown to reduce LPL and to stimulate HSL expression in a dose-dependent manner, and in consequence favoring lipolysis (20).

In humans data concerning ovarian hormone effects on insulin sensitivity and glucose homeostasis are equivocal. Elkind-Hirsch et al. (21) and Escalante

Pulido et al. (22) have indicated that insulin sensitivity in the luteal phase of the menstrual cycle is depressed compared to the follicular phase of the menstrual cycle possibly due to increased progesterone secretion. In accordance are data of Zderic et al. (23), who have found that plasma glucose level in the luteal phase is higher than in the follicular phase of the menstrual cycle. On the contrary, Diamond et al. (24) have not shown any differences in hepatic glucose production, whole-body glucose appearance and utilization in the luteal vs. follicular phase of the cycle. Moreover, Thorton et al. (25) have reported that the administration of micronized estradiol and progesterone to regularly menstruating reproductive-aged women do not affect plasma glucose utilization, hepatic glucose production, or insulin sensitivity. On the other hand, Etchegoyen et al. (26) have noted that estradiol exerts a dual action on insulin secretion from isolated rat islets-stimulating secretion at low (0.001-0.050 μM) and inhibiting secretion at high (0.1-20 μM) concentrations.

Similarly, data concerning the effects of synthetic female hormones provided as oral contraceptives (OC) on plasma glucose level, insulin sensitivity and circulating islet hormones are inconclusive. Jandrain et al. (27) have noted slightly elevated plasma glucose levels after 12 months of OC use, but overall glucose tolerance in response to OGTT remains unchanged. Additionally, marked increase in circulating C-peptide and negligible changes in circulating insulin indicated enhanced islet insulin secretion and increased hepatic insulin uptake. Godsland et al. (28) have revealed that effects of OC on plasma glucose, insulin and C-peptide concentrations varied according to progestin content, since all tested formulas containing similar estrogen, but different progestin content reduced insulin sensitivity by 30-40%. On the contrary, the progestin only formula has no effect on insulin sensitivity. Thus, it seems feasible that the effects of OC use on insulin sensitivity and glucose disposal depends on the estrogen content. This assumption was supported by recent data. Loos et al. (29) have noted that third generation of OC do not affect either circulating insulin, glucose and proinsulin, nor HOMA-IR value. Similarly, Troisi et al. (30) and Skouby et al. (31) have not found any significant effect of low-estrogen OC on indices of insulin sensitivity and glucose disposal. However, data from prospective CARDIA study have indicated that prolonged OC use resulted in slightly, but significantly higher plasma insulin levels suggesting decreased insulin sensitivity (32).

It is well documented that regular physical activity exerts beneficial effect on the whole body insulin sensitivity and glucose tolerance (33,34).

However, according to our best knowledge there is no studies which evaluated the effects of OC use on circulating islet hormones, glucose levels and insulin to glucose ratio in physically active women in comparison with regularly menstruating OC-non-users of matched physical activity. This study was undertaken to determine whether the above-mentioned variables differ in active females - OC-users and non-users. This objective was accomplished by comparison of circulating hormones, glucose and insulin to glucose ratio in the follicular and luteal phases of the menstrual cycle in OC-non-users and on the respective cycle days in OC-users and the assessment of dietary habits of the participants.

Materials and Methods

Subjects

A total of 40 reproductive-age women volunteered to participate in the study. All the subjects were university students. None of the participants have health problems. They were recruited on the basis of an advertisement in students' dormitories. In addition, the information about the study was provided orally before lectures. Among OC non-users only regularly menstruating females were recruited with cycle length not exceeding 31 days. The tested group consisted of 21 regularly menstruating physically active OC-non-users, and 19 physically active OC-users. All OC-users were taken OC for at least 3 months and OC formulas consisted of ethinylestradiol (0.02-0.05 mg) and different gestagens (desogestrel, gestogen, leveonogestrel, norgestrel). All prospective OC-non-users monitored basal body temperature (BBT) 3 months before the study and all subjects accepted for the participation were characterized by biphasic temperature pattern (35). The subjects were informed about experimental procedures and gave their written consent before participation. Study protocol was approved by Ethics Commission in the University School of Physical Education.

Anthropometric measurements

In all the subjects three skinfolds were measured (triceps, abdominal, and subscapular) using Harpenden caliper (United Kingdom). Each measurement was repeated twice and the mean values were used for calculation of body fat according to the following formula: fat = (4.210 x density $^{-1}$) – 3.813, density = 1.1 x 10^4 –(9 x triceps + 7 x subscapular + 4 x abdominal) (36).

Physical activity

None of the participants were high-performance athlete, however they were engaged in different type of activity due to obligatory study program (games, track and field, swimming, gymnastics) for at least 4 weeks preceding the study.

Dietary records

In order to ensure that OC-users and non-users differ with respect to dietary habits, daily intake of energy and macronutrients were evaluated from 24 h food records collected over 4 days preceding blood sampling. A set of pictures of food and meals were shown to the subjects by an experienced interviewer who was blinded to OC use. The household measures of food intake were converted into gram weights. An interviewer assigned codes to the foods reported by the participants and performed computer analysis using the Food 2 program purchased from the Institute of Food and Nutrition in Warsaw.

Analytical methods

The subjects were instructed to take their last meal or snack no later than 10:00-10:30 p.m on the day preceding blood sampling. Fasting venous blood was drawn between days 5 and 8 and again between days 19-22 of the menstrual cycle (assuming onset of menses as the first day of the cycle) into lithium heparin tubes using disposable syringes and needles under aseptic conditions between 8:30-9:00 a.m. The blood samples were taken at least 48 h after the last exercise bout. Plasma and erythrocyte fractions were separated by centrifugation (15 min/4000 rpm, 4°C) and plasma was stored at – 70°C until analysis. All analyses of plasma obtained from one subjects were performed on the same day.

Plasma glucose was determined using oxidase method. Plasma insulin, and glucagon were measured using standard radioimmunoassay techniques and commercial kits (Bio-Source, Belgium for insulin and BioChem ImmunoSystem, Italy for glucagon). Commercial kits used for insulin determination contained monoclonal antibodies against insulin to avoid cross-reactivity with proinsulin. Intra- and inter-assay coefficients of variation (CV) for insulin were 6.8% and 9.3 % and 8.8 % and 8.8 % for glucagon. Plasma proinsulin and C-peptide were determined using ELISA methods and commercial kits (Immuno-Biological Laboratories, Germany). Intra- and inter-assay coefficients of variation (CV) for proinsulin were 4.3 % and 6.6 %, for C-peptide – 8.2 % and 9.8 %, respectively. All analyses were run in duplicate. As and index of insulin resistance insulin to glucose ratio ($\mu IU \cdot ml^{-1}$ to $mmol \cdot l^{-1}$) was calculated (37).

Statistical analysis

Data distribution was tested using the Shapiro-Wilk test. Except for glucagon all other variables were not normally distributed and were logarithmically transformed before statistical analysis (two-ways ANOVA for repeated measures and post hoc Tukey test). Data are presented as means ± SD. Significance was set at $p<0.05$. All calculations were performed using Statistica v.7.1 (StatSoft, USA).

Results

There were no between group differences in the anthropometric data (Table 1). OC-users and non-users

Table 1. *Physical characteristics of the subjects (mean ± SD)*

	OC-non-users (n=21)	OC-users (n=19)
Age (years)	20.5 ± 1.1	21.6 ± 1.1
Body mass (kg)	63.1 ± 7.9	61.4 ± 4.7
Body height (cm)	171.3 ± 7.6	168.6 ± 5.2
Fat (kg)	15.3 ± 2.9	15.6 ± 4.1
Fat (%)	24.2 ± 1.9	25.2 ± 5.3
LBM*	47.8 ± 5.2	45.8 ± 3.7
Physical activity (h/week)	7.4 ± 1.9	6.2 ± 2.6
Cycle length (days)	27.8 ± 1.9	28

* LBM - lean body mass

Table 2. *Energy and macronutrient daily intake in OC-users and non-users (mean ± SD)*

	OC-non-users (n=21)	OC-users (n=19)
Energy (kcal)	1755 ± 606	1714 ± 551
Protein (g)	59.0 ± 20.3	54.0 ± 14.0
Protein (%)	(14)*	(13)
Fat (g)	66.7 ± 34.3	69.8 ± 25.3
Fat (%)	(33)	(35)
Carbohydrate (g)	245.9 ± 84.0	229.8 0 ± 81.1
Carbohydrate (%)	(53)	(51)

* - in brackets – percent of energy derived from the respective macronutrient

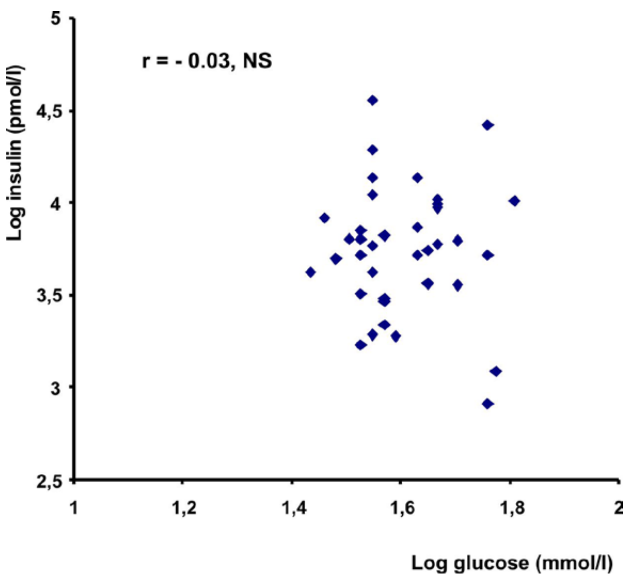

Fig. 1. *The relationship between circulating insulin and glucose in OC-users*

Table 3. *Biochemical variables and insulin to glucose ratio in OC-non-users and users in two phases of the menstrual cycle (mean ± SD)*

	OC non-users (n=21)		OC-users (n=19)	
	Days 5-8	Days 19-22	Days 5-8	Days 19-22
Glucose ($mmol \cdot l^{-1}$)	4.6 ± 0.6	4.6 ± 0.6	5.1 ± 0.5	4.9 ± 0.5
Insulin ($pmol \cdot l^{-1}$)	48.5 ± 15.6	55.7 ± 22.4	41.6 ± 13.8	48.6 ± 17.4
I/G*	1.557 ± 0.428	1.739 ± 0.537	1.238 ± 0.432	1.469 ± 0.516
Proinsulin ($pmol \cdot l^{-1}$)	3.4 ± 1.6	3.7 ± 1.4	3.7 ± 1.4	3.7 ± 0.8
C-peptide ($pmol \cdot l^{-1}$)	518.5 ± 184.6	553.3 ± 164.5	687.1 ± 269.9	744.0 ± 229.1
Glucagon ($pmol \cdot l^{-1}$)	24.9 ± 9.3	32.8 ± 11.6[a]	44.3 ± 10.3[c]	49.3 ± 10.9[b,c]

* - I/G – insulin to glucose ratio (µIU/ml to mmol/l)

[a] P<0.001 – significantly higher vs. days 5-8; [b] P<0.03 – significantly higher vs. days 5-8; [c] P<0.001 – significantly higher vs. respective days in OC-non-users; OC non-users; [d] P<0.004 – significantly higher vs. days 5-8; lower vs. women with high physical activity; [e] P<0.001-significantly higher vs. OC non-users;

[f] P<0.004 – significantly lower vs. days 5-8; [g] P<0.001 - significantly lower vs. OC-non-users; [h] P<0.06 in comparison with days 5-8

Table 4. *The distribution of I/G ratio in OC-non-users and OC-users*

	25 quartile	Median	75 quartile
OC-non-users			
Days 5-8	1.296	1.542	1.859
Days 19-22	1.209	1.795	1.955
OC-users			
Days 5-8	0.989	1.226	1.489
Days 19-22	1.087	1.364	1.744

Table 5. *The distribution of circulating C-peptide in OC-non-users and OC-users*

	25 quartile	Median	75 quartile
OC-non-users			
Days 5-8	414.0	483.0	607.2
Days 19-22	427.8	524.0	662.4
OC-users			
Days 5-8	496.8	607.2	828.0
Days 19-22	552.0	745.2	832.0

did not differ with respect to dietary habits (Table 2). Plasma glucose and insulin levels differ neither in two phases of the menstrual cycle nor between OC –users and non-users (Table 3). Similarly, no differences were noted in insulin to glucose (I/G) ratio and in C-peptide plasma levels. Both in OC-non-users and users plasma glucagon levels between days 19-22 were significantly higher than between days 5-8 (p<0.001 in OC non-users and p<0.03 in OC-users). In addition, in both cycle phases circulating glucagon in OC-users was significantly higher than in non-users (p<0.001).

The analysis of I/G ratio distribution in both groups indicated that in OC-users median, 25 and 75 quartile

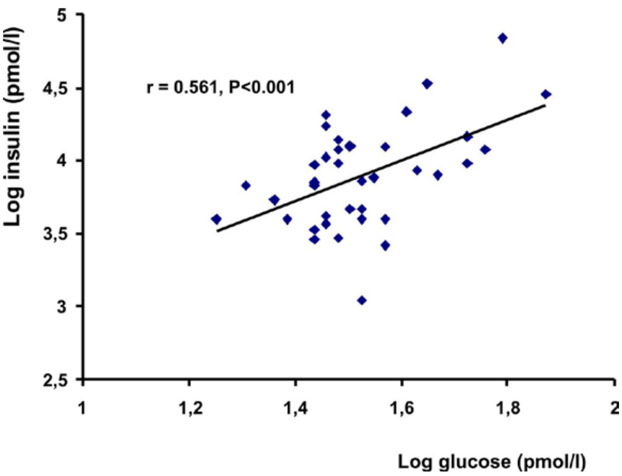

Fig. 2. *The relationship between circulating insulin and glucose in OC-non-users*

were shifted to lower values than in OC-non-users (Table 4). On the contrary, C-peptide plasma levels in OC-users were shifted to higher values than in non-users (Table 5).

In OC-users no correlation was found between plasma insulin and glucose levels for taken together two phases of the menstrual cycle. (Fig.1). On the contrary, in OC-non-users there was a significant correlation between both variables (p<0.001) (Fig. 2).

Discussion

Since our participants did not differ with respect to age, anthropometric characteristics, physical activity and dietary habits it could be presumed that differences in biochemical variables were at least partially due to OC use.

Our data concerning similar circulating proinsulin in OC-users and non-users OC suggested that probably insulin synthesis was not affected by OC-use. Proinsulin, a stable insulin precursor, is synthesized and transformed into insulin inside the pancreatic β-cells and under physiological conditions the biosynthesis of prohormone and hormone are tightly coordinated (38-40). Thus, the lack of differences in circulating proinsulin in OC-users and non-users possibly indicated similar insulin synthesis in both groups.

Despite of the lack of the differences in circulating insulin in response to OC use the shift to higher C-peptide levels in OC users possibly indicates that OC slightly affected either hepatic insulin uptake or hormone clearance from the circulation (41,42).

This assumption is in line with other studies, which indicated that OC use caused greater insulin secretion reflected by higher C-peptide levels, but also induced greater hepatic insulin uptake (43,44). Thus, the disparity between plasma levels of both C-peptide and insulin was noted.

The present study revealed that OC use markedly affected circulating glucagon, significantly higher in OC users than in non-users. This assumption is strengthen by the finding concerning the effect of physiological fluctuation in ovarian hormones on plasma glucagons levels - higher in the luteal in comparison with follicular phase of the menstrual cycle in regularly menstruating participant of our study.

Data concerning the effects of female sex hormones on glucagon synthesis and secretion are fragmentary. It has been demonstrated that in the rat progesterone treatment brings about the elevation in glucagon levels in the portal vein indicating greater hormone secretion from α-islet (45). No changes in circulating glucagon due to menstrual cycle phase has been noted in non-ovulating females characterized by the lack of progesterone peak in the luteal phase of the menstrual cycle (46). Thus, the regulatory role of progesterone in glucagon secretion could not be excluded, especially that progesterone receptors have been identified mostly in glucagon producing α-islets (47).

Our results and glucagon determination in plasma does not clarify if elevated hormone level accompanying luteal phase or OC use is due to increased synthesis or depressed hepatic uptake or both. However, assuming data indicating decreased gluconoegenesis in the liver in response to OC use and glucagon role in this process it seems feasible that OC depressed hepatic hormone uptake (48).

Furthermore, the depression of gluconeogenesis in the liver in response to OC use may be greater than that due to decreased glucagon liver uptake. It is well known that insulin is a potent inhibitor of gluconeogenesis in the liver (49). Thus, assuming mentioned earlier possible greater insulin liver uptake and decreased glucagons uptake in OC users it seems feasible that *de novo* glucose synthesis is depressed in comparison with non-users.

Similar plasma glucose levels in OC-users and non-users in the current study did not provide an answer concerning glucose homeostasis. However, it should be stressed that no correlation between plasma glucose and insulin levels in OC-users and significant correlation of the above variables in non-users possibly indicates OC-induced changes in the mechanism of whole body glucose disposal. It seems feasible since Sandoval et al**.** (50) have shown that estrogen administration in healthy post-menopausal women reduces counterregulatory response to hypoglycemia due to depressed adrenaline and glucagon response and in consequence decreased endogenous glucose production**.**

The lack of between group difference in insulin to glucose ratio suggests that insulin sensitivity was similar in both groups. On the other hand, in OC-users insulin to glucose ratio was shifted to lower values than in OC-non-users. However, it may be due to slightly lower plasma insulin levels in OC-users due to mentioned earlier greater hepatic insulin uptake induced by OC, but not to improved insulin sensitivity.

In conclusion, OC-use in physically active, young females induced significant elevation in circulating glucagon and possibly depressed *de novo* glucose synthesis in the liver. On the other hand OC use only slightly affected circulating C-peptide and insulin to glucose ratio. However, despite minor effect of OC on glucose and insulin levels and insulin to glucose ratio, it seems feasible that a whole-body glucose disposal was affected, since in OC-users in contrast to non-users no correlation between plasma insulin and glucose was noted. These findings may be of importance for female athletes using OC, since disturbed glucose metabolism potentially affects performance (51). In addition, our data suggest that more studies including OGT and insulin response to glucose load are needed in OC-users to elucidate synthetic hormone effects on islet function, whole body insulin action and glucose homeostasis.

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LOSS OF CONSCIOUSNESS DURING PARACHUTE JUMPS

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Abstract

Mazurek K, Plutecka N, Chełmicki S, Klukowski K. Loss of consciousness during parachute jumps. *Med Sports* 2007, 11(3): 63-65. Parachute sport belongs to extreme sports. Parachute jumps may result in hypobaria, hypoxia, hypothermia, overload, physical effort and stress. The case report presented in the paper concerns loss of consciousness during a parachute jump. A 37 year old, experienced jumper performed the CRW-2 task from 4000 m together with his instructor, immediately opening the parachute. At an altitude of 1000m, after finishing his acrobatic evolution, he lost of consciousness for 2,5 minutes. He landed in a tree, next recovered consciousness and safely went down. The results of medical examination were normal. The authors analyze a physiological mechanism underlying loss of consciousness, diagnosing slide hypoxia, physical effort and stress that caused hyperventilation and constriction of cerebral arteries. Interruption of physical effort caused the decreased venous return and cardiac output, critical decrease in cerebral blood flow and loss of consciousness. The jumper was diagnosed as fit for parachute jumping with limitation to 3000m and without excessive physical effort.

Key words: *parachutes jumping, accidents, altitude hypoxia, hyperventilation*

Introduction

Aviation sports belong to extreme sports, entailing increased risk as they are usually done in exposure to adverse and changeable physical factors, such as atmospheric conditions, stress and intensive physical overload (1,2).

Parachute jumps may be performed from airplanes, helicopters, balloons, as well as from bridges, buildings or natural elevations (base jumping). Modern parachutes, of the so-called "flying wing" type act in a similar way as an airplane or helicopter wings. Contemporary forms of sport and recreational parachuting include solo jumps, tandem and group jumps, jumps with certain acrobatic figures, jumps for landing marksmanship and acrobatic jumps. One of the most advanced forms of acrobatic is Canopy Relative Work - Canopy Formation (CRW). In this form of acrobatics, jumpers open their parachutes, usually immediately after jumping from an aircraft, grasping parts of their parachutes or the jumper's clothing and they perform various acrobatic figures (3). The presented case of consciousness loss during a parachute jump was due to a cumulative effect of numerous adverse environmental and physiological factors.

Case description

A parachute jumper, T.B., aged 37 performed 198 jumps between the year 1999 and May 2006. He had a third class medical certificate, so he had a designation for a parachutist. He had never experienced any in-flight incidents or health problems before.

On May the 6th at Chrcynno airport (Warsaw Aero Club) he performed training acrobatic parachute jumps together with his instructor. He also performed a CRW-2 task for the first time in his life. Two jumpers, T.B. and the instructor jumped from an altitude of 4000 m over the sea level, immediately opening their parachutes and they tried to form an acrobatic formation and they failed in their multiple attempts to perform it. At an altitude of about 1000 m over the sea level, the instructor decided to stop task performance and to start landing. After a while, the instructor noticed that T.B. did not respond to his signals (loss of consciousness?) and carried by the wind he landed outside the airfield, in a tree. Later, T.B. reported that he regained consciousness soon, unbuckled his parachute and descended by himself. Based on the estimation of the distance and time of arrival at the venue, we can say that loss of consciousness might last for about 2.5 minutes.

Immediately following the event, the jumper underwent a thorough medical examination. No abnormalities were found in his health condition. It should be stressed that the examination comprised diagnosing, necessary for medical analysis of causes of consciousness loss during the parachute jump. The result of hypobaria tolerance test in the low pressure chamber, under conditions corresponding to the altitude of 5000 m for 30 minutes at rest was normal. A thorough cardiologic examination, comprising echocardiograph, 24-hour Holter ECG monitoring and exercise ECG test, did not reveal any abnormality.

Neither neurological examination, nor magnetic resonance of the brain revealed any changes. The result of resting ECG was normal, the examination following hyperventilation however, revealed changes in the form of numerous polymorphic slow waves. The arrest response was found. The photo-stimulation test did not intensify slow elements. A control examination was recommended. The psychological test revealed no abnormalities.

T.B. was diagnosed as unfit for parachute jumping. After 6 months, the control examination was repeated, including: nuclear magnetic resonance (NMR), hypoxia and tolerance test in the Low Pressure Chamber (LPC) and psychological examination. The results of all these examinations were normal. In March 2007, T.B. was qualified as fit for parachute jumping by the Aeromedical Board, although at the limited altitude up to 3000 m over the sea level and without any over standard physical effort (4).

Discussion

Extreme environmental conditions during parachute jumping include decreased atmospheric pressure, decreased partial oxygen pressure and decreased temperature. Further, parachute jumpers are in exposure to rapid changes in body positioning, which may result in spatial disorientation, G-load in different axes, physical effort and stress (5,6).

Parachutists from the U.S. aero club performed 2100000 jumps including 20 fatal ones, which means one fatality per 105 000 jumps. In Poland there were 5 fatal accidents per 40 000 parachute jumps. The total of 169 in-flight accidents during parachute jumps, recorded in the Archive of National In-Flight Accident Examination Board during the years 2003-2006, 99 (58.6%) in-flight accidents and incidents were caused by the least experienced jumpers, who performed 1-50 jumps. One accident that occurred during jumping was fatal. In this group of parachutists, technical errors were most frequent reasons for accidents (72%). No accident was due to health problems. Among the most experienced jumpers, who performed 501–5000 jumps, 50 incidents and accidents were recorded (29.6%), including one fatal. It was found that 50% of the accidents were due to technical errors, none to health problems (4,7). Considering jumpers medically fit for parachuting is based on examination and certification by the authorised specialists in aviation medicine. Periodic examinations are carried out every 5 years in people below 30, every 2 years in people below 50 and every 12 months in people over 50 (8).

Recreational and sport parachute jumps are usually performed at an altitude of 4000 m, where atmospheric pressure is about 462 mm Hg and 3000 m, where atmospheric pressure is about 526 Hg. Atmospheric pressure values corresponds to partial oxygen pressure, which is 97 mm Hg and 110 mm Hg respectively. The zone of complete high altitude hypoxia compensation is below 3000 m over the sea level. Above this altitude, hemoglobin oxygen saturation drops below 90%, which results in exposure to high altitude hypoxia (2,9).

High altitude hypoxia (hypoxic hypoxia) may result in symptoms defined as acute altitude illness. The cells of the Central Nervous System (CNS), particularly the cerebral cortex are most sensitive to hypoxia. For this reason, the first symptoms of hypoxia manifest as cognitive and emotional disorders (10). The symptoms of hypoxia include: disorders of motor coordination, mental arousal that may lead to euphoria, decreased criticism, rapid breathing (tachypnoea), and muscular tremor. In exposure to high altitude hypoxia, people experience: apnea, accumulating fatigue, restlessness or euphoria, headaches and vertigo, nausea and visual impairment. In most cases, the course of hypoxia is insidious. Loss of consciousness may be preceded by the above-mentioned symptoms, it may also occur suddenly. Tolerance to hypoxia is an individual trait, and it decreases when ascending rapidly at high altitudes, during a long stay in hypoxic zones, physical effort, in exposure to stress and low temperatures (1,6,11).

T.B. descending with his parachute open from 4000 to 3000 m, at a speed of about 5 m/sec, stayed in the zone of incomplete compensation for about 3 minutes. The adverse factors affecting his tolerance to hypoxia included: the time necessary to perform the task, intensive physical effort lasting about 7 min (oxygen effort) and stress resulting from performing a difficult task the jumpers failed to perform.

Hyperventilation was an additional and probably the most important physiological factor, which resulted in the decrease in cerebral blood flow. Hyperventilation, which was probably associated with the circumstances of the in-flight incident, does not affect significantly oxygen blood level, although it decreases the level of carbon dioxide (CO_2) and hydrogen ions (H^+). Blood alcalisation, affecting central chemoreceptors, causes contraction of the cerebral arteries and decrease in cerebral blood flow (11).

We can assume that excessive physical effort while jumping (descending from 4000 m to about 3000 m), increased heart rate (HR) and elevated blood pressure (BP) caused the increase in cardiac output and maintained sufficient cerebral blood circulation. End of physical effort, muscle relaxation, the decrease in venous return, pulse rate and blood pressure probably resulted in the decrease in cardiac output. Partial CO_2 pressure decrease and lowered pH resulted in critical decrease of cerebral blood flow and loss of consciousness.

Analyzing the reported case of consciousness loss during parachute jumping, the Aeromedical Board concluded that:

1) A healthy, experienced parachute jumper experienced loss of consciousness due to the decreased

tolerance to several environmental conditions, which occurred at the same time during an acrobatic jump;

2) The parachutist was considered fit for further parachute jumps, although at a limited altitude up to 3000 m over the sea level, without over standard physical effort.

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DOMINANT DETERMINANTS IN CARDIO-RESPIRATORY ENDURANCE IN 13 YEARS OLD BOYS AND GIRLS

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Abstract

Bronikowski M, Maciaszek J, Szczepanowska E, Tarnas J, Woźniak W. Dominant determinants in cardio-respiratory endurance in 13 years old boys and girl. *Med Sport* 2007, 11(3): 66-69.

Aim of the study: The purpose of the research was to establish correlations between cardio-respiratory endurance (C-RE) and biological maturity rate (retarded, normal and accelerated), body height, body mass, sum of five skinfolds, frequency of undertaking physical activity (PA), and onset of menarche (in girls).

Methods: Research has been carried out in the selected schools in Poznań City and included 237 girls (13.3 y.o. SD 0.24) and 231 boys (13.2 y.o. SD 0.32). The 20m shuttle run test (the endurance run), from the battery of the Eurofit test, has been used to assess C-RE, accordingly to the protocol. The 20m shuttle run test results have been introduced as results of C-RE level. Selected morphological characteristics (body height, body mass and five skinfolds) have been measured.

Results of the statistical complete linkage analysis (furthest neighbor rule) are similar in girls and boys and show two major gatherings of variables. Results of C-RE indicate that only normally mature girls have achieved significant relations between scores of the 20m shuttle run and body mass ($r=-0.16$; $p\leq0.05$). Both in the case of girls and boys there is a significant relation between scores of the 20m shuttle run and sum of skinfolds (for girls $r=-0.28$; for boys $r=-0.21$; $p\leq0.05$). Similarly, the more frequent PA of girls and boys declared in their leisure time the better results they have gained in the 20m shuttle run test (for girls $r=0.24$; for boys $r=0.21$; $p\leq0.05$). The sum of skinfolds influences on the results of endurance run the most strongly only in accelerated girls ($r=-0.44$). Boys with thicker layer of subcutaneous fat have gained worse results in the 20m endurance run. Results of the endurance run together with frequency of undertaking PA are associated with the biological stages of development.

Conclusions: There is a low dimorphic differentiation of 13 y.o. girls and boys, not significant, due to the relatively high homogeneity of the examined groups.

Key words: *Adolescents, girls, boys, cardio-respiratory endurance, physical activity*

Introduction

The period of puberty is associated with changes in body stature and body composition, and influences on physical and motor fitness. Exercises of adequate intensity and duration of stimulating cardio-respiratory fitness seem to be an essential part of human development. Ara et al. (1) have observed that active prepubertal children (9.5 y.o.) attain better results in aerobic fitness than non-active, and additionally their $\dot{V}O_2max$ has shown negative correlation with fat mass. An increased PA over a long period of time already results in improved physical fitness in younger (5-6 y.o.) children (2). On the other hand obesity among children and youth increases with sedentary behaviour (3). Hence, a review of empirical studies about TV, video, computer consumption and body fatness and PA suggests small relationships between those variables (4).

It can be possible that correlation between the level of activity, fitness and fatness depends on differentiation in biological age. It has been reported that maturation is directly related to growth and exercise performance characteristics (5). Children at the same age can present different levels of physical fitness due to their individually different maturity rates (6). Thus it is difficult to specify determinants of aerobic fitness.

The important determinant which can play a crucial role in fitness is gender, especially among pubertal and older boys and girls. Sexual dimorphism differentiates metabolic processes, body composition and level of motor abilities (7–10). However, Saar and Jürimäe (11) have proved that in 13-15 y.o. girls anthropometric parameters have been only in 10-20% of the total variance of motor ability tests. Not only body building differentiates boys from girls. In traditional subsistence populations the workload must be shared among all family members, and thus strict division of tasks is present accordingly to age and sex (12). Males are generally in charge of high-energy-demanding muscular task (13). There are also differences according to age and maturation. Less mature females are more active than more mature ones (14).

The aim of the research is to establish correlations between C-RE (measured as scores of the 20m shuttle run test) and such determinants as: biological maturity rate, body height, body mass, sum of five skinfolds, frequency of undertaking PA, and onset of menarche (in girls).

Material and Methods

Research has been carried out in the selected schools in Poznań City and included 237 girls (13.3 y.o. SD 0.24) and 231 boys (13.2 y.o. SD 0.32). The 20m shuttle run test, from the battery of the Eurofit test, has been used to assess C-RE endurance, accordingly to the protocol (15). The 20m shuttle run test results have been introduced as results of C-RE level. Selected morphological characteristics (body height, body mass and five skinfolds of biceps, triceps, subscapular, suprailiac, and calf) have been measured. The each gender group is divided into three developmental stages: retarded, normal and accelerated in regard to S. Pavilonis's method (16) based on indices of the developmental stages of forehead and pubic hair, growth of breasts, type of body building and presence of menstruation in girls (Tab. 1). A pupil in the normal stage of development is within the score -20 to +20 of Biological Maturity Rate, the retarded stage - below the score -20, and accelerated above the score +20. Examination has been carried out by a qualified physician. A Self-Evaluation Physical Activity questionnaire has been developed in this work by Bronikowski to evaluate the frequency of individual PA.

The Pearson's correlation method has been applied to establish relations between C-RE and selected determinants. Then, in turn, a complete linkage analysis has been used to differentiate subgroups and cluster objects based on the maximum distance between them. This method has been employed to get a picture of possible connections.

Results

C-RE evaluated by the 20m shuttle run test has been previously estimated and reported by Bronikowski et al. (17) as a good example to measure the level of aerobic endurance in adolescents.

Results of the complete linkage analysis are similar in 13 y.o. girls and boys and show (Fig. 1) two major gatherings of variables. In girls in the first gathering results of an endurance run (C-RE) together with the frequency of undertaking PA (frequency of PA) join biological maturity rate (Tanner' stage) and onset of menarche (menarcheal age). In the second gathering body mass is associated with the sum of skinfolds. Re-

Table 1. *Anthropometric characteristics, frequency of P A and results of the 20m shuttle run test (level of endurance) in girls and boys*

		Girls N=237			Boys N=231		
		retarded	normal	accelerated	retarded	normal	accelerated
body height [cm]	M	159.9	160.7	165.5	153.3	161.7	164.3
	SD	10.08	6.23	11.43	8.82	7.13	11.62
body mass [kg]	M	46.4	48.3	54.6	40.3	48.7	53.9
	SD	13.01	8.01	13.24	7.33	8.97	20.28
sum of five skinfolds [mm]	M	66.3	65.2	71.7	42.3	51.5	62.7
	SD	31.77	20.87	31.79	15.47	18.68	27.89
level of PA [frequency per week]	M	1 x per week	2 x per week	1 x per week	3-4 x per week	3-4 x per week	2 x per week
	SD	1.66	1.74	1.96	1.97	1.74	1.52
level of endurance [minutes of run]	M	3.7	4.8	4.3	6.1	6.0	4.7
	SD	1.46	1.89	1.84	2.32	2.22	1.85

M – mean; SD – standard deviation

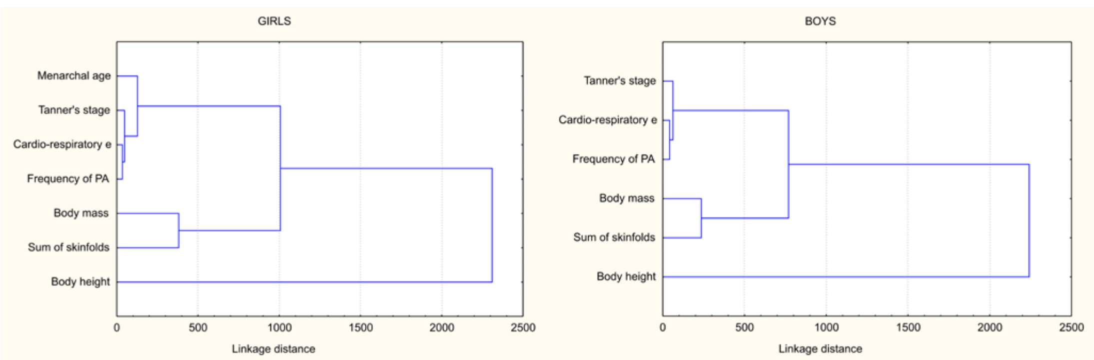

Fig.1. *Results of the complete linkage analysis in 13 y.o. girls and boys*

Table 2. *Values of Pearson's coefficient correlation in girls and boys between C-RE as dependent variable and selected determinants as independent variables*

	Girls N=237			Boys N=231		
developmental stages	retarded	normal	accelerated	retarded	normal	accelerated
age of menarche	-0.26	0.13	-0.13	--	--	--
body height	0.27	-0.05	-0.11	0.08	-0.07	0.07
body mass	0.02	-0.16*	-0.30	-0.12	-0.06	0.26
sum of skinfolds	-0.43	-0.28*	-0.44*	-0.21	-0.21*	-0.27
frequency of PA	0.33	0.24*	0.25	0.08	0.21*	-0.24

* $p \leq 0.05$

sults of the endurance run together with frequency of undertaking PA are associated with biological stages of development (Tanner's stages). The second gathering involves body mass and the sum of skinfolds, too.

Results of C-RE (Tab. 2) indicate that only normally mature girls have achieved significant relations between scores of the 20m shuttle run and body mass ($r=-0.16$; $p\leq0.05$). Both in the case of girls and boys there is a significant relation between scores of the 20m shuttle run and sum of skinfolds (for girls $r=-0.28$; for boys $r=-0.21$; $p\leq0.05$). Similarly, the more frequent PA of girls and boys declared in their leisure time the better results they have gained in the 20m shuttle run test (for girls $r=0.24$; for boys $r=0.21$; $p\leq0.05$). The sum of skinfolds influences on endurance the most strongly only in accelerated girls ($r=-0.44$). Boys with thicker layer of subcutaneous fat have gained worse results in the 20m endurance run. Results of the endurance run together with frequency of undertaking PA are associated with the biological stages of development. There is a low, statistically insignificant dimorphic differentiation of 13 y.o. girls and boys, probably due to the high homogeneity of the examined groups.

In case of 13 y.o. boys results of C-RE positively correlate with frequency of PA ($r=0.21$; $p\leq0.05$), and negatively with sum of skinfold thickness ($r=-0.21$, $p\leq0.05$). Boys with thicker layer of subcutaneous fat have gained worse results in the 20m endurance run (Tab. 2).

Discussion

The introduced study shows difficulties in the simple clear-cut determination of the most essential determinants of C-RE, in particular stages of development: retarded, normal, and accelerated. Biological age is the determinant "disturbing" a value of correlation's coefficient between C-RE and frequency of PA. Garnier and Benefice (14) have observed that less mature girls are more active than more mature ones. Our study indicates that this relation is statistically significant only in normally mature girls and boys. Additionally, an increase of fat mass with age and a decrease with age of muscle mass in girls has also been reported (18,19).

In both groups of 13 y.o. girls and boys a statistically significant ($p\leq0.05$) relation between the result of the 20m shuttle run test (C-RE), body mass, sum of five skinfolds, and level of activity (frequency of PA) have been noticed (Tab. 2). Only in a stage of normal development sum of skinfolds and frequency of PA indicate significance for the endurance level. In normally developed girls it has been also body mass stressed (Tab. 2). It is worth underlying in regard to their declared frequency of PA because this frequency is almost accordant to the level of PA really represented by them. It proves the role and potential effectiveness of education in the increase of their responsibility for own health and also introduction of ability in body care and health monitoring. It gives also a hope to achieve a success in improvement of youth's scan health. In retarded and accelerated stages of development the lack of statistical significance (in the case of relatively high values) can show probably too less number of subjects within examined groups (about 20-25 subjects). Hence, a tendency of this influence can be observed – frequency of PA seems to be an important predictor of a determinant of C-RE. It is shown in our study (Tab. 2) and also reported in other reports mentioned earlier (1–4). In any case active adolescent girls and boys have higher values of $\dot{V}O_2max$ than their less active peers and the decline of aerobic fitness in both genders is mainly caused by the decrease of daily level of PA (9). However, it is necessary to add that some researches show only small relationships between those variables (4).

In our study very similar relations observed between C-RE and other determinants as independent variables can lead to the conclusion of the relatively low dimorphic differentiation of 13 y.o. girls and boys in examined groups. It is expressed only at the beginning of the stage of puberty while Maciaszek (20) in his earlier study shows the different formula of relationship (linear versus non-linear) between C-RE and other variables can be different among boys and girls at the same age, particularly around the age of 14.

The weak relationship between C-RE and frequency of PA in both genders (Tab. 2) supports the conclusions inclosed earlier in other research (8 – 10) that physical fitness is determined by genetic factors as much as by environmental and cultural ones. In the examined age category of 12-14 y.o. adolescents, in the case of endurance, it is also due to the change of structure and functional capacity of lungs and respiratory system at this age (21).

Thus, the level of biological development in association with an adequate level of PA is a condition of related level of aerobic endurance. Additionally, there is already a correlation between the level of physical fitness and a thickness of skinfolds in children (10). Body mass appears to be one of the determinants modulating power and mutual correlation of the introduced determinants. Such a tendency is also reflected here in results of Pearson's linear correlation but only for girls (Tab. 2). C-RE also proves its relation to sum of skinfolds in both genders (Tab. 2). In regard to the idea of health related-fitness (22) it needs to be taken under the consideration while planning the amount and the level of PA sufficient for stimulation of biological development in youth.

Conclusions

1. Menarcheal age in girls and body height in both genders have no influence on the level of endurance.
2. Body mass influences on the level of endurance only in girls.
3. Results of the endurance run together with sum of five skinfolds and frequency of undertaking PA are associated with the biological stages of development.
4. There is a low dimorphic differentiation of 13 y.o. girls and boys in the examined group.

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THE EFFECT OF MAXIMAL EXERCISE ON STATIC AND DYNAMIC BALANCE IN ATHLETES AND NON-ATHLETES

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Abstract

Zemková E, Viitasalo J, Hannola H, Blomqvist M, Konttinen N, Mononen K. The effect of maximal exercise on static and dynamic balance in athletes and non-athletes. *Med Sport* 2007, 11(3): 70-77.

Introduction: Though the effect of different forms of exercise on static balance has been studied, there are only scarce reports concerning its influence on dynamic balance.

Aim of the study: The study deals with postural sway response to maximal exercise.

Methods: A group of 30 athletes and 10 non-athletes underwent in random order in different days balance tests prior to and after maximal exercise bout on the cycle ergometer. Pre-exercise protocol comprised of standard SOT and HS SOT conditions based on the EquiTest dynamic posturography system. In the SOT, during the first three conditions with eyes open, eyes closed, and sway-referenced vision the support surface was fixed and during the same next three conditions the support surface was sway-referenced. In the HS SOT, support surface was either fixed or sway-referenced while subject´s eyes were closed and their head was moving in roll and pitch planes. After exercise only selected conditions were repeated, two static with subjects eyes open and closed and two dynamic with their eyes closed and sway-referenced vision.

Results: There were no significant differences in the equilibrium and strategy scores after exercise as compared to baseline neither with eyes open nor eyes closed while standing on stable platform. On the other hand, in dynamic conditions these values were significantly lower than prior to exercise as with eyes closed as with sway-referenced vision. In addition, sensory analysis revealed that vestibular system is more affected by exercise than somatosensory one. Such an impairment of postural stability after maximal exercise is very probably due to increased ventilation as a consequence of respiratory compensation of lactate induced metabolic acidosis.

Conclusion: In sports dependent on post-exercise postural stability such a metabolic response to exercise has to be taken in account since it seems that this factor plays an important role in maintenance of balance.

Key words: *EquiTest dynamic posturography system, maximal exercise, Sensory Organization Test (SOT) and Head Shake SOT, sway variables*

Introduction

Maintenance of balance involves a complex interaction between sensory organs, central processing, and motor elements. Impairment any of these control mechanisms may influence the overall output of the postural system.

It is known that fatigue (1-3) and hyperventilation (4) induced by exercise have such a detrimental effect on postural stability depending on its type, intensity and duration. Running has been reported to impair the parameters of balance more profoundly than walking and cycling (5,6), short-term abruptly instituted maximal exercise more than longer stepwise exercise with lower contribution of anaerobic glycolysis (7), and longer exercise of moderate intensity more than shorter one of identical intensity (8).

Experience proved that in some sports, such as biathlon (9), gymnastics (10), figure skating, rocken-roll (11), basketball (12), tennis (13), windsurfing (14) or sailing (15) even small changes in post-exercise postural stability adversely affect performance. Assessment of postural sway response to exercise is therefore considered as an important part of functional diagnostics of these athletes. However, contrary to well-known and frequently used static posturography for this purpose, in current literature there are only scarce reports (16) concerning the effect of exercise on dynamic balance.

Sensory Organisation Test (SOT) and Head Shake SOT (HS SOT) based on the EquiTest posturography system are used for the laboratory assessment of this ability. In the SOT, subjects are exposed to series of increasingly challenging conditions in which orientation information from the support surface, the visual surround, or both are systematically disturbed by referencing their movements to the subject's body sway (17). In the HS SOT subjects perform rhythmic motions of the head while their eyes are closed and support surface is either fixed or sway-referenced (18).

As evaluation of postural stability in such conditions provide more information about muscle coordination, synergies, and strategies (19) in comparison with currently used static posturography systems, would be useful to ascertain an acute response of these balance control mechanisms to exercice.

Therefore the aim of the study was to compare sway variables of the SOT and HS SOT prior to and after maximal exercise in athletes and non-athletes.

Materials and Methods

Subjects

A group of 30 athletes (mean age 22.9 ± 2.0 years, height 175.7 ± 13.0 cm, and weight 70.7 ± 9.8 kg) and 10 non-athletes (mean age 22.0 ± 3.7 years, height 172.2 ± 9.8 cm, and weight 67.6 ± 6.9 kg) volunteered to participate in the study. All of them were informed of the procedures and of the main purpose of the study.

They completed questionnaire providing information on their physical activity, health status, history of neurological and musculoskeletal disorders or injury, and self-perceived balance ability. No subject reported a history of diseases known to affect the central or peripheral nervous system and the locomotor apparatus, they had normal or corrected-to-normal vision, no reduced hearing, and no subjectively experienced problems of maintaining of balance.

Dynamic posturography

Sway variables were registered by means of the EquiTest computerized dynamic posturography system (NeuroCom International, Inc., Clackamas, Oregon 2000). The system is consisted of a computer controlled, motor driven dual foot plate capable of both rotational and translational movements, and a visual surround capable of rotational movements about an axis collinear with the subject´s ankles. Force traducers located beneath the dual footplate are used to monitor and record the subject´s weight distribution and reactions torques during testing.

The standardized Sensory Organization Test (SOT) and Head Shake Sensory Organization Test (HS SOT) available on the EquiTest system were used in the present study.

The SOT measures how well the subject maintains equilibrium under six sensory conditions. During the first three conditions the support surface is fixed relative to earth horizontal. During the next three conditions the support surface is moved proportional to the subject´s antero-posterior body sway. The three visual conditions are repeated in sequence, the first and fourth with eyes open and fixed visual surround, the second and fifth with eyes closed, and the third and sixth with sway-referenced vision.

The HS SOT identifies the subject´s use of vestibular inputs for balance while actively moving the head in yaw, pitch, or roll movement axes. To isolate the effect of proprioceptive and vestibular inputs on head balance interactions, HS SOT eyes closed trials are repeated under fixed and sway-referenced support surface conditions.

The program analyses up to three 20 seconds trials per test condition sway variables, such as the equilibrium score, strategy score, and sensory ratio.

The equilibrium score quantifies how well the subject's sway remains within the expected angular limits of stability during each SOT condition. The following formula is used to calculate the equilibrium score:

$$\text{Equilibrium score} = \frac{12.5° - (\theta max - \theta min)}{12.5°} \cdot 100$$

where 12.5 degrees is the theoretical limit of the antero-posterior sway angle range, θmax is maximum sway angle (degrees), and θmin is minimum sway angle (degrees). Subjects exhibiting little sway achieve equilibrium scores near 100, while those approaching their limits of stability scores are near zero.

The composite equilibrium score, the weighted average of the scores of all sensory conditions, characterizes the overall level of performance and is useful in documenting progress over time. The composite equilibrium score is calculated by a) independently averaging the scores for conditions 1 and 2; b) adding these two scores to the equilibrium scores from each trial of sensory conditions 3, 4, 5, and 6; and c) dividing that sum by the total number of trials. The highest possible score is 100.

The strategy score quantifies the ankle and hip movements the subject uses to maintain equilibrium according to the following formula:

$$\text{Movement strategy} = \frac{1 - (Shmax - Shmin)}{25} \cdot 100$$

where 25 lbs is the difference measured between the greatest shear force (Shmax) and the lowest shear force (Shmin) generated by a test group of normal subjects who used only hip sway balance on a narrow beam. A score near 100 indicates that the subject predominately uses ankle strategy to maintain equilibrium, while a score near 0 represents hip strategy.

The sensory analysis ratios are used in conjunction with the individual equilibrium scores to identify impairments of individual sensory systems. The sensory ratios are computed from the average equilibrium scores obtained on specific pairs of sensory test conditions, as follows (Tab. 1):

Table 1. *Sensory analysis*

Ratio	Comparison	Functional Relevance
Somatosensory (SOT)	Condition 2 / Condition 1	Subject´s ability to use input from the somato-sensory system to maintain balance
Visual (VS)	Condition 4 / Condition 1	Subject´s ability to use input from the visual system to maintain balance
Vestibular (VEST)	Condition 5 / Condition 1	Subject´s ability to use input from the vestibular system to maintain balance
Preference (PREF)	Condition 3+6 / Condition 2+5	The degree to which a subject relies on visual information to maintain balance, even when the information is incorrect

Protocol

Subjects underwent in random order in different days, with at least three days in between, the balance tests under various sensory conditions prior to and after maximal exercise bout on the cycle ergometer (Fig. 1).

Pre-exercise protocol was comprised of standard SOT and HS SOT conditions based on the EquiTest system (Smart EquiTest System Operators Manual, Version 7.04), only in case of HS SOT head motions in two planes was added. In the SOT, during the first three conditions with eyes open, eyes closed, and sway-referenced vision the support surface was fixed and during the same next three conditions the support surface was sway-referenced. During the HS SOT subjects performed motions of the head in yaw as well as in roll and pitch planes while their eyes were closed and support surface was either fixed or sway-referenced.

After exercise only two static conditions with subjects eyes open and closed and two dynamic with their eyes closed and sway-referenced vision were repeated. These were selected in accordance with literature (20-22) and in case of dynamic balance also on basis of pre-exercise results of equilibrium score with its the lowest values. Moreover, different visual conditions allow evaluating the stabilising role of vision on balance, known as a Romberg quotient (the ratio of COP in EC and EO conditions).

Subjects stood on the platform barefoot with both feet apart and arms by their sides within the visual surround for three periods of 20 seconds (3 s rest in between) in each condition. They were instructed to minimise postural sway by standing as still as possible. Laboratory assistant stood behind of the subjects to impede a possible fall.

An exercise bout on the cycle ergometer (Ergometrics 800, Ergoline) with an incremental protocol to exhaustion was employed. Following a 3 minutes of warm up at the revolution rate of 40 to 65 W, the initial workload calculated as a 1.5 x bodyweight, was progressively increased by 25 W every 3 minutes. Verbal encouragement was provided in order to achieve maximal intensity of exercise assessed by heart rate, blood lactate, and perceived exertion. Subjects stopped exercise abruptly, without cool down. Twenty to twenty-five seconds after cessation of exercise, measurement of postural stability in selected conditions were repeated, identical to prior exercise.

During exercise on the cycle ergometer as well as during standing on the stabilographic platform the parameters of ventilation (Cortex Biophysik MetaMax 3B) and heart rate (Polar S810, Finland) were continuously monitored.

Blood samples from the fingertip were taken in the 6th minute of recovery for the estimation of lactate concentration (Arkray Lactate Pro, Japan). Enzymatic method was used for the analysis.

The subjective level of exertion was estimated during the exercise by means of the Borg´s 6 to 20 Rating of Perceived Exertion Scale (23), which was documented to correlate closely with several physical

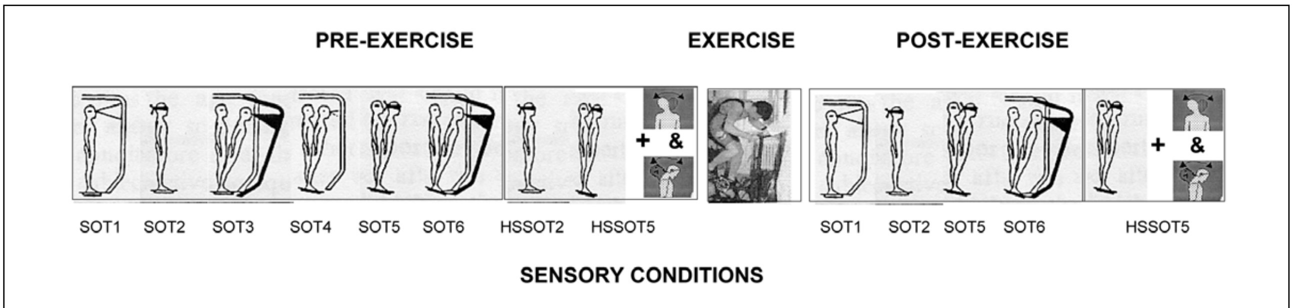

Fig. 1. *Schematic representation of an experimental protocol. Following SOT and HS SOT conditions were used prior to and after maximal exercise: (SOT 1) Fixed support surface and visual surround, eyes open; (SOT 2) Fixed support surface, eyes closed; (SOT 3) Fixed support surface, sway-referenced vision; (SOT 4) Sway-referenced support surface, fixed visual surround, eyes open; (SOT 5) Sway-referenced support surface, eyes closed; (SOT 6) Sway-referenced support and vision; (HS SOT 2) Fixed support surface, eyes closed, roll and pitch head motions; (HS SOT 5) Sway-referenced support surface, eyes closed, roll and pitch head motions.*

variables, including heart rate and lactate production (24). Standardized rating instructions were given before exercise, as described by Borg (25). The rating scales were taped in front of the subjects while they performed the exercise. In the last 15 s of each 3-minute period of cycling they were requested to provide a rating of how hard the exercise feel.

Statistical analyses

A paired t-test was employed to determine the statistical significance of differences between sway variables prior to and after exercise in athletes and non-athletes; $p < 0.05$ was considered significant.

Results

Physiological response to maximal exercise in athletes and non-athletes

All subjects perceived the exercise either as very hard or extremely hard, corresponding to a rate of 18 or 19 on the Borg´s scale (23). Because a rating of 20 is rarely given by subject, such RPEs are considered as a strenuous exercise (25).

Blood lactate, as an indirect indicator of anaerobic glycolysis activation, was after maximal exercise similar in athletes 10.1 ± 1.9 mmol·l^{-1} and non-athletes 9.8 ± 1.2 mmol·l^{-1}, respectively.

Maximal values of ventilation in these groups of subjects were 161.58 ± 11.2 l·min^{-1} and 158.48 ± 12.9 l·min^{-1}, respectively. Non-athletes achieved after exercise higher maximal values of heart rate 189.0 ± 8.3 beats·min^{-1} than athletes 182.8 ± 6.0 beats·min^{-1}.

Postural sway response to maximal exercise in athletes and non-athletes

The equilibrium score (Fig. 2) in athletes did not differ significantly in static conditions after exercise as compared to baseline neither with eyes open (95.75 ± 0.80 and 90.44 ± 3.97 %, respectively) nor with eyes closed (93.06 ± 1.79 and 87.00 ± 4.19 %, respectively). On the other hand, this parameter in conditions of sway-referenced support was significantly ($p < 0.01$) lower than prior to exercise as with eyes closed (78.11 ± 4.10 and 54.56 ± 14.63 %, respectively) as with sway-referenced vision (81.54 ± 4.57 and 56.50 ± 13.91 %, respectively). Within the third trial (the final 20-seconds of the first minute of recovery) its values nearly returned back to the baseline in static, but not in dynamic conditions.

Similarly, this score in non-athletes decreased after exercise from 93.63 ± 0.80 to 90.00 ± 3.43 % in condition 2 as well as from 78.35 ± 5.27 to 58.29 ± 12.28 % in condition 5, however its post-exercise values were slightly higher than in athletes. It is very probably due to shorter duration of exercise (10.97 ± 3.93 and 25.21 ± 7.80 min, respectively) as a consequence of different level of physical performance in both groups examined.

In remaining SOT conditions there were no differences in this parameter prior to exercise between athletes and non-athletes. By adding yaw head movement in HS SOT, the equilibrium score in condition 2 did not differ in athletes and non-athletes (88.72 ± 1.99 and 88.78 ± 2.13 %, respectively), however its values were significantly ($p < 0.05$) lower in non-athletes as compared to athletes (52.87 ± 7.68 and 61.51 ± 4.52 %, respectively) in condition 5.

In highly skilled athletes also roll and pitch head motions was added to even more disturb vestibular input since any changes prior to and after exercise in the equilibrium score in standard SOT condition 5 were observed. Such a head movements during standing on sway-referenced support surface with eyes closed caused significant ($p < 0.01$) decrease of equilibrium score from 60.00 ± 7.78 to 30.00 ± 13.10, 47.00 ± 8.30, and 54.60 ± 9.00 %, respectively in three post-exercise trials.

Furthermore, pre-exercise equilibrium composite score was similar in athletes and non-athletes (86.21

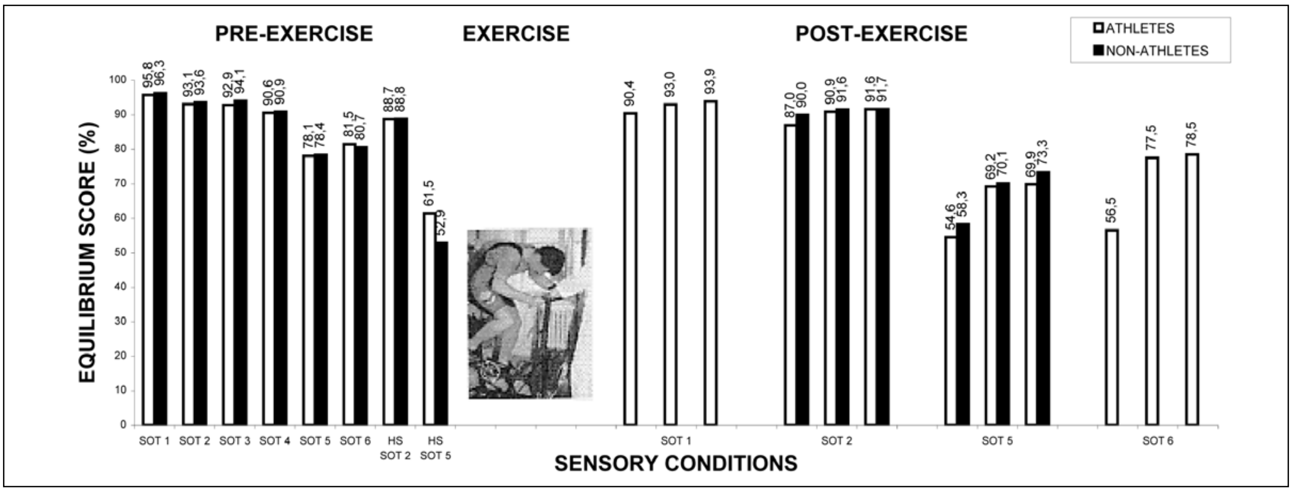

Fig. 2. *Equilibrium score in different SOT and HS SOT conditions prior to (an average of three 20 seconds trials) and after maximal exercise (a three 20 seconds trials) in athletes and non-athletes*

± 2.78 and 86.60 ± 3.10 %, respectively). However, because of reduction the measurements after exercise in the present study, post-exercise values could not be calculated.

Concerning the strategy score (Fig. 3), no significant changes in athletes in static conditions prior to and after exercise with eyes open (97.23 ± 0.71 and 93.89 ± 2.37 %, respectively) as well as with eyes closed (96.12 ± 1.40 and 90.30 ± 3.77 %, respectively) were found. Contrary to this, in conditions of sway-referenced support its values significantly ($p < 0.01$) decreased as when subject´s eyes were closed (81.37 ± 5.53 and 59.11 ± 17.19 %, respectively) as when vision was sway-referenced (85.17 ± 4.27 and 70.67 ± 7.76 %, respectively). It reflects tendency to use both, ankle and hip strategy to maintain postural stability.

In non-athletes, the strategy score also decreased after exercise from 96.00 ± 1.99 to 93.56 ± 3.13 % in condition 2 and from 81.50 ± 9.34 to 75.71 ± 6.60 % in condition 5, however its post-exercise values were higher than in athletes, similarly as in case of equilibrium score.

Sensory analysis revealed that pre-exercise values of somatosensory, visual, vestibular, and visual preference ratios were similar in both group examined (Fig. 4). After exercise, the vestibular ratio significantly decreased from 81.57 ± 4.07 to 60.33 ± 8.09 %, whereas any changes in somatosensory one were observed (97.19 ± 1.85 and 96.20 ± 3.13 %, respectively), indicating that vestibular is more affected by exercise than somatosensory system.

However, it has been proved only in athletes. As post-exercise measurements of postural stability under condition 1, 3, 4, 6 in non-athletes were reduced, sensory ratios in this group could not be calculated. Also, absence results of equilibrium score in condition 3 and 4 after exercise in both groups did not allow calculating neither visual nor its preference ratio. Further studies are needed to obtain these information.

Discussion

Impairment of postural stability immediately after maximal exercise is very probably due to more marked ventilation as a means of respiratory compensation of lactate induced metabolic acidosis. Despite the fact that increased concentration of hydrogen ions is partly compensated by the buffer system, it also stimulates the respiratory center and increases ventilation. This may be documented by its higher values after such

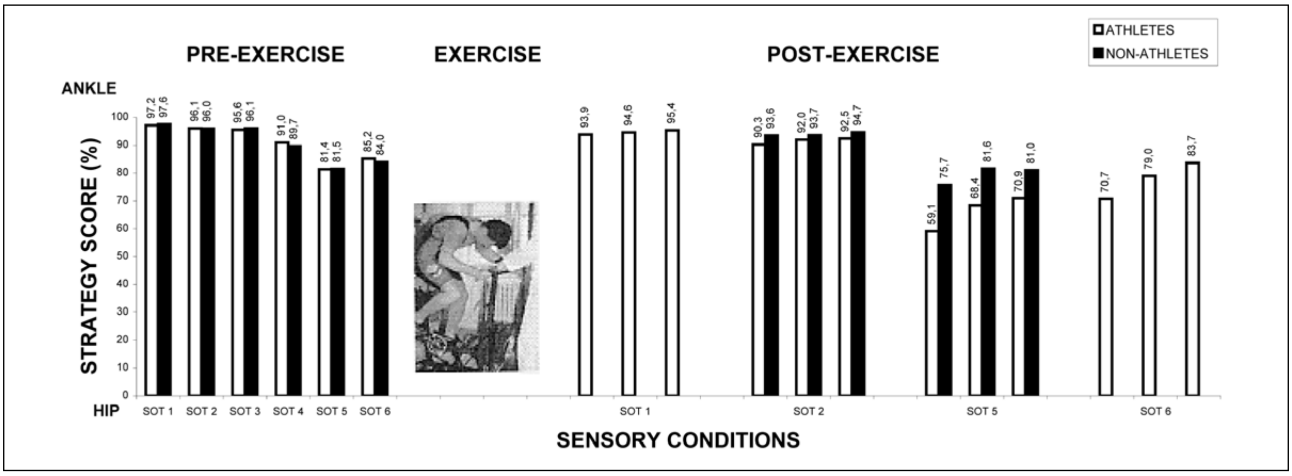

Fig. 3. *Strategy score in different SOT and HS SOT conditions prior to (an average of three 20 seconds trials) and after maximal exercise (a three 20 seconds trials) in athletes and non-athletes*

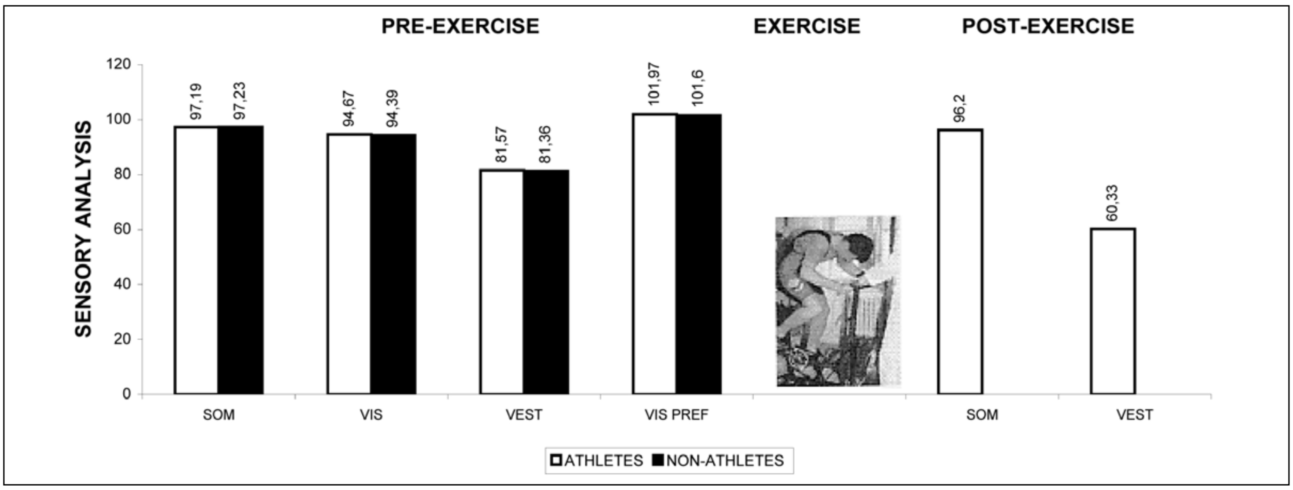

Fig. 4. *Sensory analysis prior to and after maximal exercise in athletes and non-athletes*

an exercise in comparison with baseline. In addition, ventilation remained temporarily elevated and only then started to decrease gradually back to the resting level. Similar trend was evident for heart rate.

Besides blood lactate increase, maximal exercise is also associated with increasing oxygen deficit. Its repayment during recovery also contributed to post-exercise elevation of ventilation and heart rate.

As balance is influenced by body recoil resulting from heart rate action and breathing (26), their exercise induced increase could have affected postural control system. However, in regard to heart rate, experiments with different exercise loads indicate that this factor and body sway does not correlate (3). Accordingly, cardiovascular response to exercise seems not to play essential role in maintenance of balance.

On the other hand, several reports (26-33) have shown that higher breathing rate significantly affect postural stability.

Besides higher respiration, also fatigue might partly impair postural stability. However, such an effect is usually a consequence of prolonged exercise, as shown by Lepers et al. (16) after 25 km running and 1 h 44 min cycling, respectively or Derave et al. (5) after 30 min of treadmill walking and running, respectively.

Therefore it may be assumed that impairment of postural stability after maximal exercise was mediated mainly by hyperventilation. This assumption may be corroborated by close correlation between the movement center of gravity and level of ventilation in recovery phase after such an exercise, similarly as has been shown in case of static balance after short-term abruptly instituted maximal exercise (4).

In sports dependent on post-exercise postural stability, re-adjustment of such an impaired balance is considered as an important ability. It is provided by muscle synergies, ankle and hip strategy (34). Most of the corrective movements take place in the ankle joints, to a lesser degree in the knees and hips (35). This process involves information from the brain based on the visual, somatosensory, and vestibular inputs. Consequently, factors such as hyperventilation or, in part, fatigue may affect several links of the postural control chain.

Results of sensory ratio indicate that inadequate vestibular feedback is the most significant sensory deficit contributing to the post-exercise postural instability. It may be ascribed to the hyperventilation, known to disrupt mainly mechanisms mediating vestibular compensation, and at least partly peripheral and central somatosensory signals from the lower limbs (32).

It is evident in decreased equilibrium score in condition 5 and 6, during which both the support surface and visual references are simultaneously altered. In such a case when as visual as proprioceptive information from lower limbs are reduced, postural control relies mostly on vestibular inputs (36,37) and hence may be preferentially affected by hyperventilation. Besides its exercise induced increase, also post-exercise rotation in the pitch plane might partly increase a respiratory frequency due to shortening of the interval between inspirations (38). Though this factor may contributed to the lowest equilibrium score recorded when subjects performed roll and pitch head motions while surface was moved relative to their body sway, in particular it is a consequence of disrupted function the otolith inputs by such a movement (39).

In addition, postural stability may deteriorate when not only vestibular, but also neck information is not properly coupled (40). It is known in case of neck fatigue producing anomalous proprioceptive input to the central nervous system and a lasting sense of instability (41). In fact, stimulation of the neck proprioceptors and the otolithic organs, both sensitive to linear head accelerations (42) as well as larger vertical head movement and its acceleration pattern are more evident during running than during cycling (16) or walking (5). However, the over-stimulation of the vestibular centre by excessive head oscillations not even after prolonged running does not significantly affect its sensitivity threshold and therefore this phenomenon does not play a key role in the post-exercise impairment of postural stability (43).

Similarly, visual input is less stimulated by the moving field of vision during cycling in comparison with other forms of locomotion, for example running (5,6,16). Because of reduced post-exercise measurements of postural stability in the present study, its contribution on balance impairment cannot be ascertained. Anyway, the grade of visual compensation for body balance may be evaluated by the ratio of sway velocity in eyes closed and eyes open conditions. Surprisingly, there were no significant differences in equilibrium score between eyes open and eyes closed neither prior to nor after exercise. Though it may be in part ascribed to the selection of athletes, very probably it reflects their training background, indicating that they were able to use the remaining sensory modalities to compensate the lack of vision to maintain balance after exercise. This finding is in agreement with the reports of several authors (10,44) who documented that visual contribution to postural stability is improved by training.

It appears that stimulation of vestibular, somatosensory, and visual inputs during cycling is relatively low as compared to other forms of exercise bouts and therefore one would not expect to be particularly affect postural control system, namely those concerning highly skilled athletes. In such a case, exercise induced hyperventilation and fatigue reflecting its intensity and duration take more essential place in balance impairment.

Both factors are probably responsible for decreased preference in ankle strategy after exercise in condition

5 including sway-referenced support and eyes closed. In part, shift to the hip (abductor/adductor) control reflecting medio-lateral balance (45), may be associated with hyperventilation known to increase sway more in sagittal than frontal plane (32). However, these changes in post-exercise postural strategies are very probably due to central (3) and in particular peripheral fatigue of the neuromuscular system (2). According to Lundin et al. (46) plantar flexor and dorsiflexor fatigue increase postural sway amplitude. As platform is moved proportional to the subject´s antero-posterior body sway (17) and in side-by-side stance antero-posterior balance is under ankle (plantar/dorsiflexor) control (45), decreased preference in ankle strategy after exercise is very probably due to by such a fatigue.

This finding is in accordance with several studies that documented higher increase in the medio-lateral than antero-posterior direction after exercise. It has been documented during aiming a rifle after an exercise bout simulating cross-country ski racing (47) or after specific tasks in acrobatic sports, such as gymnastics (10), rockenroll (11) and dance (48).

However, in the present study such a phenomenon has been found only in dynamic conditions. Despite strenuous exercise was applied, during standing on the fixed support surface as with eyes open as eyes closed any significant differences in sway variables were observed. It is accepted that there is certain degree of overlap or redundancy within postural control system in static conditions, and therefore one can suggests the static posturography not to be enough sensitive for the evaluation of exercise effect on balance, namely those concerning highly skilled athletes. In addition, such a slight detrimental effect of exercise on static balance has been found to be only short-lasting, similarly as documented by Nardone et al. (2) and Zemkova, Hamar (7) after cycling, Nardone et al. (2) after running or Nardone et al. (1) after uphill walking, all of them with intensity above anaerobic threshold.

Thus, assessment of postural sway response in dynamic conditions may be assumed as a more sensitive and hence more suitable method for elite athletes. Moreover, dynamic posturography provide additional useful information related to strategy preference and ability to use inputs from vestibular, somatosensory, and visual systems to maintain balance. In addition, cross sectional study of Diard et al. (49) revealed differences between athletes with different demand on balance abilities, indicating that such a method may be applied not only for assessment acute effect of exercise on postural stability but also for training control (50,51) and talent identification too (52,53).

Conclusion

The present study showed no differences between pre- and post-exercise values in equilibrium score, strategy score, and sensory ratios in static conditions. In contrast, these values significantly decreased in dynamic conditions, indicating that these more sensitive reflect changes in postural stability induced by exercise.

It is assumed that hyperventilation as a consequence of respiratory compensation of lactate induced metabolic acidosis caused by maximal exercise is responsible for impaired postural stability. Metabolic response to exercise, hence, plays an important role in maintenance of balance. This fact has to be taken in account in sports dependent on post-exercise postural stability, such as biathlon, gymnastics, rockenroll, figure skating, basketball and so forth.

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DIETARY HABITS AND PHYSICAL ACTIVITY IN YOUNG ADULTS WITH INAPPROPRIATELY HIGH BODY MASS INDEX – A CROSS-SECTIONAL STUDY IN MEDICAL STUDENTS

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Abstract

Krzych LJ. Dietary habits and physical activity in young adults with inappropriately high body mass index – a cross-sectional study in medical students. *Med Sport* 2007, 11(3): 78-83.

Introduction: An early detection of overweight and its basic risk factors in population studies increase the efficiency of preventive actions.

The aim of the study was to assess the determinants of the occurrence of inappropriately high BMI, according to dietary habits and physical activity patterns in young subjects.

Materials and methods: A cross-sectional study was conducted in 604 medical students, 298 males and 306 females, aged 20.6 ± 2.0. The participants were divided into two groups, according to their BMI value, the group of 106 students with BMI ≥ 25 kg/m^2 and the group of 498 subjects with BMI < 25 kg/m^2.

Results: Inappropriately high BMI was found in 17.4% students, more frequently concerning males than females (p<0.001). Persons with BMI ≥ 25 kg/m^2 more often reported the use of diet rich in fat (OR=2.21, 95% CI: 1.31, 3.73) as well as frequent alcohol drinking (OR=1.88, 95% CI: 0.93, 3.76). The adjustment to gender did not confirm the results.

Conclusions: The study confirms neither dietary habits nor physical activity influence on inappropriately high BMI. The role of methodological issue, including epidemiological concern and statistical analysis, should be taken into account in data interpreting.

Key words: *overweight, diet, BMI, questionnaire, epidemiology*

Introduction

It is estimated that overweight occurs in over 60% adults in Poland (1). In recent years in all age groups, an increasing trend towards the spread of obesity has been observed (2), however the prevalence differs depending on gender and age – it is the highest in males aged 45-49 and females aged 60-74, amounting to 17.5 and 23.5%, respectively (1). Although in children and youth aged 7-17 the percentage is lower (below 5%), one ought to mark that the sequelae of obesity usually appear only just in several years' time (2,3), particularly in the form of diabetes type 2 (4), hypertension (5), coronary heart disease (6), and arthritis (7).

An early detection of overweight and its basic risk factors in population studies increase the efficiency of preventive actions, both in primary and secondary prophylaxis (8-10). In the subject literature it is emphasized that improper diet and low physical activity are the factors that increase the risk of becoming overweight remarkably (4,11).

The aim of the study was to assess the determinants of overweight prevalence, according to dietary habits and physical activity patterns in young adults, medical students. Additionally, this article presents some important concerns regarding methodological problems in data interpretation in a cross-sectional study based on a questionnaire method.

Materials and Methods

An epidemiologic cross-sectional study was conducted in 2004/2005. The subjects were students at the Medical University of Silesia, Poland. The number of 604 volunteers from the group of 1000 invited students agreed to participate in the study (the participation rate 60.4%). All students were informed about the procedure and gave their informed consent. The study was approved by the local ethical committee.

The data describing dietary habits and physical activity were obtained by an author-designed questionnaire. Food patterns concerned the practice of eating dairy products, fruit and vegetables, sweets, food rich in fat or salt, and drinking coffee and alcohol. Physical activity was assessed according to the frequency of exercises and leisure-time physical activity, declared in a questionnaire. The prevalence of smoking habit was analyzed additionally. All questions were in the closeformat with all multiple questions with one choice. The choices in each question were scaled as follows: 'everyday', 'few times a week', 'few times a month', 'more rarely' and 'never'. When dichotomized answers were crucial for analysis, the category of 'regular' practice was defined. 'Regularity' was recognized when categories 'everyday' or 'few times a week' were reported. The questionnaire reliability had been assessed before by a validation procedure (12) in a random sample of 100 students. The results of inter-observer agreement ratio estimation (% of repeatability in test-retest) and Kappa statistic revealed very good repeatability of five key questions of the questionnaire (12,13).

The prevalence of overweight was determined basing on self-reported height and weight. Body mass index (BMI) was calculated as body weight divided by height squared. The participants were divided into two subjectively defined groups, according to students' BMI value; the group of 106 subjects with inappropriately high BMI and the group of 498 persons with proper BMI. Inappropriately high BMI was defined as BMI ≥ 25 kg/m^2, covering overweight and obesity, and proper BMI was found if BMI < 25 kg/m^2 (even if BMI < 18.5 kg/m^2).

The statistical analysis was performed with EpiInfo 6.0 procedures. Descriptive statistics are presented as percentages, means, and standard deviations. Student's t test and non-parametric Kruskal-Wallis test were used to calculate statistical differences between means. The chi-square test and Fisher's exact test were used to compare categorical variables. Additionally, Cochran-Mantel-Haenszel chi-square tests were used to examine the relationship between the prevalence of inappropriately high BMI and dietary habits, and physical activity, controlling for gender as a potential confounder. A 'p' value equal or less than 0.05 was considered to be statistically significant.

Results

The students participating in the study were 604 in number, 298 males (49.3%) and 306 females (50.7%). The mean age of the subjects was 20.6 ± 2.0 years. The characteristic of the subjects, considering the differences in gender and BMI status, is shown in Table 1 and 2. It has been revealed that inappropriately high BMI occurred in 17.4% students and was six times more frequent in males than females (p<0.001), with the difference in BMI mean values exceeding 3 kg/m^2. Overweight was documented in 16.6% and obesity – in 0.8% of the surveyed. It has been shown that persons with BMI ≥ 25 kg/m^2 were older than students with BMI < 25 kg/m^2 (p<0.01).

Table 1. *Demographic and anthropometric variables*

Variable	All	Females	Males
No of subjects (%)	604	306 (50.7)	298 (49.3)
Age (years)	21.2 ± 1.9	20.6 ± 1.2	21.8 ± 2.2
Height (cm)	173.7 ± 8.9	167.2 ± 5.7	180.3 ± 6.5*
Weight (kg)	66.6 ± 13.0	56.9 ± 6.6	76.4 ± 10.2*
Body mass index (kg/m^2)	21.8 ± 2.8	20.3 ± 2.1	23.4 ± 2.6*
BMI categories:*			
BMI < 18.5 kg/m^2 (%)	9.9	18.3	1.7
BMI 18.5 – 24.9 kg/m^2 (%)	72.7	76.8	68.5
BMI 25 – 29.9 kg/m^2 (%)	16.6	4.9	28.1
BMI ≥ 30 kg/m^2 (%)	0.8	0	1.7

BMI – body mass index; * p<0.05, males vs. females

Table 2. *Demographic and anthropometric variables, according to BMI status and gender*

Variable	Students with BMI ≥ 25 kg/m^2			Students with BMI < 25 kg/m^2		
	All	Females	Males	All	Females	Males
No of subjects (%)	106	15 (14.2)*	91 (85.8)	498	291 (58.4)	207 (41.6)
Age (years)	21.9 ± 2.8	20.5 ± 1.6*	22.2 ± 2.9	21.1 ± 1.6**	20.7 ± 1.3*	21.7 ± 1.9
Height (cm)	178.2 ± 8.8	166.0 ± 7.3*	180.2 ± 7.3	172.7 ± 8.7**	167.3 ± 5.7*	180.3 ± 6.1
Weight (kg)	83.7 ± 11.5	68.7 ± 8.3*	86.2 ± 10.0	62.9 ± 10.1**	56.3 ± 5.9*	72.2 ± 6.8
BMI (kg/m^2)	26.5 ± 2.0	25.6 ± 0.9	26.0 ± 2.1	20.9 ± 1.9**	20.0 ± 1.7	22.0 ± 1.4

BMI – body mass index; * p<0.05, males vs. females in subsequent groups; ** p<0.05, students with BMI ≥ 25 kg/m^2 vs. students with BMI < 25 kg/m^2

Table 3. Food patterns and physical activity of subjects

Variable	Females		Males		All	
	n	%	N	%	N	%
Regular food intake	175	58.1	157	53.0	332	55.6
Regular fruit and vegetables intake	277	91.4	261	88.5	538	90.0
Regular physical activity	150	49.5	181	61.4*	331	55.4
Physical activity as a way of spending leisure time	107	41.6	134	59.6*	225	46.6
Regular intake of diet rich in salt	85	28.1	106	35.9*	191	31.9
Regular intake of diet rich in fat	161	53.1	220	74.6*	381	63.7
Regular sweets intake	240	79.2	225	76.3	465	77.8
Regular coffee drinking	193	73.7	168	70.3	361	72.1
Regular alcohol drinking	10	3.9	43	15.7*	53	10.0
Smoking habit	62	20.5	88	29.8*	150	25.1

* p<0.05, males vs. females

Table 4. *Possible determinants of inappropriately high BMI occurrence in subjects*

Determinant		Students with BMI ≥ 25 kg/m²	Students with BMI < 25 kg/m²	OR (95%CI)
Male gender	Yes	91/298*	207/298	8.53 (4.64÷15.92)
	No	15/306	291/306	
Regular food intake	Yes	51/332	281/332	0.69 (0.44÷1.08)
	No	55/265	210/265	
Regular intake of diet rich in salt	Yes	39/191	152/191	1.30 (0.82÷2.07)
	No	67/407	340/407	
Regular intake of diet rich in fat	Yes	82/381*	299/381	2.21 (1.31÷3.73)
	No	24/217	193/217	
Regular coffee drinking	Yes	87/492	405/492	0.96 (0.54÷1.74)
	No	19/104	85/104	
Regular sweets intake	Yes	78/465	387/465	0.76 (0.45÷1.27)
	No	28/133	105/133	
Regular dairy intake	Yes	91/532	441/532	0.70 (0.36÷1.38)
	No	15/66	51/66	
Regular fruit and vegetables intake	Yes	96/538	442/538	1.09 (0.51÷2.39)
	No	10/60	50/60	
Regular alcohol drinking	Yes	15/53**	38/53	1.88 (0.93÷3.76)
	No	83/479	396/479	
Smoking habit	Yes	28/150	122/150	1.08 (0.83÷3.72)
	No	78/447	369/447	
Regular physical activity	Yes	60/303	243/303	1.19 (0.75÷1.9)
	No	41/239	198/239	
Physical activity as a way of spending leisure time	Yes	47/225	178/225	1.25 (0.77÷2.03)
	No	45/258	231/258	

OR – odds ratio; 95%CI – 95% confidence interval; * p<0.05, students with BMI ≥ 25kg/m² vs. students with BMI < 25kg/m²; ** p=0.05, students with BMI ≥ 25kg/m² vs. students with BMI < 25kg/m²

Table 3 shows the dietary habits and physical activity of the students, considering the differences in gender. Males, more often than females, reported regular intake of food rich in salt and fat, regular alcohol drinking and physical activity ($p<0.05$). The results of the nutrition patterns analysis revealed that persons with inappropriately high BMI, in comparison to the students with BMI < 25 kg/m², statistically significantly more often reported the use of diet rich in fat (OR=2.21, 95% CI: 1.31, 3.73, $p<0.05$) as well

Table 5. *Possible determinants of inappropriately high BMI occurrence, controlling for gender*

Determinant	Females	Males	'p'*
	OR (95%CI)	OR (95%CI)	
Regular food intake	1.47 (0.44-5.12)	0.63 (0.37-1.07)	0.2
Regular intake of diet rich in salt	1.30 (0.37-4.35)	1.09 (0.63-1.89)	0.7
Regular intake of diet rich in fat	3.37 (0.94-17.23)	1.20 (0.65-2.24)	0.1
Regular coffee drinking	1.15 (0.23-7.76)	1.13 (0.57-2.23)	0.7
Regular sweets intake	0.71 (0.20-2.78)	0.81 (0.44-1.50)	0.4
Regular dairy intake	0.25 (0.07-1.03)	1.11 (0.49-2.53)	0.6
Regular fruit and vegetables intake	**	1.08 (0.46-2.57)	0.6
Regular alcohol drinking	0 (0-11.99)	1.21 (0.57-2.54)	0.8
Smoking habit	0.58 (0.09-2.86)	0.92 (0.51-1.64)	0.6
Regular physical activity	1.42 (0.39-5.37)	0.87 (0.5-1.52)	0.4
Physical activity as a way of spending leisure time	1.05(0.24-4.4)	0.92 (0.52-1.63)	0.9

OR – odds ratio; 95%CI – 95% confidence interval; * 'p' value is for the Cochran-Mantel-Haenszel chi-square for general association, controlling for gender; ** OR not possibile to estimate because of '0' value

as frequent alcohol drinking (OR=1.88, 95% CI: 0.93, 3.76, p=0.05). No significant differences have been revealed as far as regular intake of food rich in salt, dairy products, sweets, vegetables and fruit, coffee drinking and smoking habit are concerned. The results of the observation are presented in Table 4. Because of revealed abovementioned differences between males and females, the analysis was also performed with adjustment to gender as a potential confounder. The results of Cochran-Mantel-Haenszel chi-square tests did not confirm the influence of the assessed dietary habits on inappropriately high BMI occurrence (Table 5). It should be mentioned that females with BMI ≥ 25 kg/m^2 less frequently reported regular dairy intake, in comparison to females with proper BMI (OR=0.25, 95% CI: 0.07, 1.03; p=0.05). It has also been revealed that persons with BMI ≥ 25 kg/m^2, more frequently than students with proper body mass index, reported practicing sport regularly, adequately: 57.5% vs. 54.8% (p=0.1). There were some differences between genders (59.3% in overweight males vs. 46.7% in overweight females; p<0.05). Furthermore, no differences have been shown in the frequency of choosing physical activity as a way of spending leisure time between the analyzed groups.

Discussion

The aim of the study was the assessment of the potential determinants of the occurrence of inappropriately high BMI in young adults in a cross-sectional study. Methodological impact on reliability of obtained results was also of great importance.

In the study, inappropriately high BMI, defined as BMI ≥ 25 kg/m^2, concerned nearly 17.6% of the students, more often males than females (p<0.05). Overweight was recognized in 16.6% participants and obesity in 0.8% of the surveyed. The results coincide with most data available in literature. Ali et al. (14) assess that overweight occurs in about 18.4% of females, aged 18-34. The results of the multi-center survey among the European countries students revealed that the frequency of overweight is 8%, however the percentage differed significantly between particular countries (15). Moreover, Janssen et al. (16) revealed that overweight most frequently concerns young adults in the countries of North America and South and West Europe. Data concerning Polish students say that the frequency of overweight is 13-16.7% (17,18). Taking the presented data into account, the results obtained in the survey can be considered reliable and reflecting the importance of the problem in the medical students.

The results of the analysis revealed no significant influence of improper diet on the occurrence of inappropriately high BMI, whereas, suggested that students with BMI ≥ 25 kg/m^2, more frequently than their peers with BMI < 25 kg/m^2, were physically active (57.5% vs. 54.8%), however the result was not statistically significant (p=0.1). Smoking habit appeared to be of no importance. In the light of literature data, there are plenty of discrepancies concerning the information about the influence of diet on overweight prevalence in young people. Despite the proven influence of excessive highly energetic products intake on obesity by Scali et al. (19), still in the multivariate analysis, the dietary habits determined merely 18.5% of the current BMI value in females and 14.6% in males. On the one hand, there is no doubt that inappropriate lifestyle in long-term dimension promotes overweight and obesity incidence in adults, which was confirmed in prospective epidemiologic surveys (20-23). On the other hand, as far as food patterns are concerned, the results are consistent with the investigations conducted among youth and adults by Grabauskas et al. (9), Kolarzyk et al. (17), Janssen et al. (24), Patrick et al. (25), Maffeis et al. (26), Oblacinska et al. (27) and Jeszka et al. (28). The latter are in agreement with the suggestions that the nutrition patterns have a merely weak, however positive effect on BMI (especially in overweight category), whereas obesity incidence is more complex and remarkably genetically determined (19). The comparisons are additionally blurred by geographical differences of possible overweight risk factors and their longitudinal trends (29).

The relationship between physical activity and overweight prevalence seems to be interesting. Although complete explanation of this effect is not possible, two major factors seem to influence the result remarkably. To begin with, it has been recorded that overweight persons more often attempt to be physically active (8). Socio-economical status of subjects (medical students) is also of great importance. People with higher education level and larger income tend to be more conscious as far as the need of overweight reduction is concerned, and are more liable to the physicians' suggestions concerning the increase of everyday physical activity (14,30). Although it is proven that behavioral changes in lifestyle play major role in the treatment of obesity, there is unquestionable evidence that longitudinal interventions are more effective than short-term ones (4). More to the point, both physical activity and diet are important and separate factors in weight loss. However a decrease in energy intake is generally more important for weight loss, while physical activity is generally more important for weight maintenance (4).

Finally, the methodological issue of the study has the crucial impact. The BMI value assessment on the basis of self-reported height and weight is generally used in population epidemiological studies. Firstly, the remarkable difference in overweight between men and women, and in fact the remarkably lean female population in general, raise a great concern on underreporting of the female participants (31,32). It becomes even more important given the fact that self-reported BMI is almost always lower then measured BMI (32). In addition, women generally underreport their actual weight making the BMI less accurate. This may explain the differences in the prevalence of overweight, and obesity between men and women. Although data obtained in the present study are believed to be reliable, this limitation in concluding should be taken into consideration. Secondly, not only the assessment of overweight prevalence, but also self-reported diet patterns and physical activity are frequently influenced by a measurement error (33). More to the point, a questionnaire method, that is also employed in this research, is likely to give imprecise and excessively generalized information which may result in regression dilution bias. These are present especially in relation to nutrition characteristics (e.g. lack of data about the frequency of the intake of several nutrition product groups that are important for obesity and overweight like grain products, meat, sweet drinks, different kinds of fat) and physical activity (e.g. lack of more detailed data concerning numbers of hours of exercises, additional or coming from the everyday activity, or other weight lose activities in overweight subject at present). Thirdly, two additional methodological concerns desire attention. The study design employed (a cross-sectional one) does not allow to observe new incidences of disease in population and identify risk factors utterly (as it takes place in cohort studies) (34). It seems to be important to conduct cohort studies to obtain the relationship between improper lifestyle and obesity properly, especially in young subjects. Additionally, the assessment of cause-and-effect relationship should take into account noise of possible confounders, as showed the results of Mantel-Haenszel analysis in the present study. Investigators should be encouraged to use some more advanced statistical techniques (e.g. stratification or multivariate analysis) to reduce the possibility of making misleading conclusions.

Conclusion

In conclusion, the presented data confirm neither dietary habits nor physical activity influence on overweight prevalence in young adults. The design of the survey employed constitutes the restriction of the concluding. The role of methodological issue, including epidemiological concern and statistical analysis, should be taken into account by investigators in data interpreting.

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SELF-ASSESSMENT OF THE STATE OF HEALTH AND PHYSICAL PROFICIENCY OF FEMALE STUDENTS, CONSIDERING BIOLOGICAL CONDITION AND SOCIAL AND ECONOMIC CIRCUMSTANCES

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Abstract

Wojtyna J, Rodziewicz-Gruhn J. Self-assessment of the state of health and physical proficiency of female students, considering biological condition and social and economic circumstances. *Med Sport* 2007, 11(3): 84-87.

Introduction: The results of the review of the literature on the subject show that self-assessment of the state of health and physical proficiencies can be influenced by: gender, age, life style and some elements of social and economic environment.

Aim of the study: The aim of this paper was to answer the question; whether selected somatic data plus social and economic circumstances can influence the self-assessment of the state of health and physical proficiency.

Methods: Research was carried out in the academic year 2005/2006 on a sample of 333 female students aged 20.24 ±0.96 years. It employs a method of diagnostic survey, in the form of an anonymous written questionnaire. The questionnaire included questions concerning place of residence, level of parents' education, size of families and subjective estimates of states of health and physical proficiency. Apart from this the height and body mass of the students was also taken, which was used to calculate the BMI.

Results: Over 58% of the sample lived in a town. Most of these were the daughters of parents with a secondary education. The tested students mainly came from families with 2-3 children (81.38%) and graded their state of health and physical proficiency generally as good – respectively 61.56% and 66.67%. Student's who's BMI was in the range of norm or mild thinness assessed their health and physical proficiency best, however the worst to asses their health and physical proficiency were woman of an overweight factor (accordingly $p<0.001$ and $p<0.05$). The best marks for health gave the daughters of fathers with secondary education and the worst, daughters of fathers with basic education ($p<0.001$). Similar differences ($p<0.05$) were noted in the relationship between grades for physical proficiency and the father's educational status.

Conclusion: The level of fathers education and BMI can significantly influence on the self-assessment of the state of health and physical proficiency.

Key words: *health, questionnaire, BMI, parents, education*

Introduction

The object of the health questionnaire is to research knowledge and feelings of respondents about their own personal health. WHO's experts attach big weight to subjective index of health. They believe that the subjective index characterizes the health of the whole population much better than the mortality and morbidity rates (1,2). Data published by the Polish Main Statistic Office (GUS) indicates that in the last decade the subjective state of health of Poles greatly improved. Out of persons aged 15 years and over – 12.8% evaluated their sate of health as very good, 40.5% as good and 31.3% as average. 12.3% of the probed population assessed their health as bad and only 2.6% as very bad (3). A large majority of students (high school and university) evaluated themselves as being healthy, physically proficient and satisfied from life and their own appearance (2-8). Males, inhabitants of big cities, wealthy persons with highest education and children of parents with higher education assessed themselves better than others. (1,3).

Aim of the study

The aim of this paper is to answer the question; whether selected somatic data plus social and economic circumstances can influence the self-assessment of the state of health and physical proficiency of female students starting university?

Material and methods

Research was carried out in the academic year 2005/2006 on a sample of 333 female students aged x=20.24 ±0.96 years, from the 1st year pedagogic faculty of JDA in Częstochowa. It employs a method of diagnostic survey, in the form of an anonymous written questionnaire. The questionnaire included questions concerning place of residence, level of parents' education, size of families and subjective estimates of states of health and physical proficiency. Apart from this the height and body mass of the students was also taken, which was used to calculate the BMI (weight/height^2 [kg/m^2]). The Chi-squared test was used in order to analyse the differences between the searched variables.

Results and discussion

Over 58% of the sample lived in a town. Most of these were the daughters of parents with a secondary education – respectively mothers: 50.45%, fathers: 43.54%. These students mainly came from families with 2-3 children – 81.38%. The average arithmetic height, body mass and BMI of the female students were as follows: $x=165.22 \pm 6.05$cm; $x=57.20 \pm 8.13$kg; $x=20.93 \pm 2.55$kg/m^2. In comparison to norms for female students of pedagogic universities (9) and WHO Report (10) standards, most girls were within average height (40.24%), body mass (42.64%) and BMI (81.38%). The tested students graded their state of health and physical proficiency mainly as good – respectively 61.56% and 66.67%.

Among the groups of somatic factors the biggest percentage of surveyed students who graded their own heath as very good were students of average height and average body mass (tab.1), conversely the students who evaluated their physical proficiency as best, were very tall and with big body mass (tab.2). However, differences in these groups of factors turned out to be statistically negligible. Student's who's BMI was in the range of norm or mild thinness assessed their health (fig.1) and physical proficiency (fig.2) best, however the worst to asses their health and physical proficiency were woman of an overweight factor and in this range the differences were statistically significant (accordingly $p<0.001$ and $p<0.05$).

In groups of social-economic factors results show that women living in cities graded their health as very good (32.1%) on the other hand for physical proficiency the very good notes were given by the students who live in rural areas (15.3%). Largeness of the family, which was another factor, produced results, which indicate that the girls who are an only child gave the best grades for their own health and physical proficiency. 36.7% of those girls marked their health as very good and 56.7% as good. The same girls graded their physical proficiency as follows: 13.3% very good and 70.0% as good notes. The worst marks for health (9.4% as average) and physical proficiency (21.9% as average) were given by girls from families with four or more children. In analysis of influence of parental educational status, 25.9% girls of mothers with higher education graded their health as very good and 70.7% as good. The biggest percentage (16.5%) of average marks for their own health was noted in the group of girls whose mothers have primary education level, however 20.8% of those girls graded their physical proficiency as very good and 62.5% as good. In the group influenced by the father's educational status the best marks for their health, gave the daughters of fathers with secondary education and the worst, daughters of fathers with basic education (fig.3). This

Table 1. *Self-assessment of the state of health in relationship to the selected somatic data in percentage of subjects indications*

Somatic data	Self-assessment of the state of health			
	Very good	Good	Average	Bad
Body height				
Very short	19.1	68.1	12.8	0.0
Short	27.1	64.6	6.3	2.1
Average	35.8	56.7	7.5	0.0
Tall	23.6	70.9	5.5	0.0
Very tall	36.7	55.1	8.2	0.0
Body mass				
Very small	25.0	55.6	19.4	0.0
Small	29.7	64.1	6.3	0.0
Average	33.8	57.7	8.5	0.0
Big	30.0	63.3	6.7	0.0
Very big	24.6	70.5	3.3	1.6

Table 2. *Self-assessment of the state of physical proficiency in relationship to the selected somatic data in percentage of subjects indications*

Somatic data	Self-assessment of the state of physical proficiency			
	Very good	Good	Average	Bad
Body height				
Very short	10.6	57.4	31.9	0.0
Short	14.6	66.7	18.8	0.0
Average	13.4	68.7	17.9	0.0
Tall	14.5	74.5	10.9	0.0
Very tall	20.4	61.2	18.4	0.0
Body mass				
Very small	16.7	61.1	22.2	0.0
Small	7.8	73.4	18.8	0.0
Average	14.8	67.6	17.6	0.0
Big	23.3	66.7	10.0	0.0
Very big	14.8	60.7	24.6	0.0

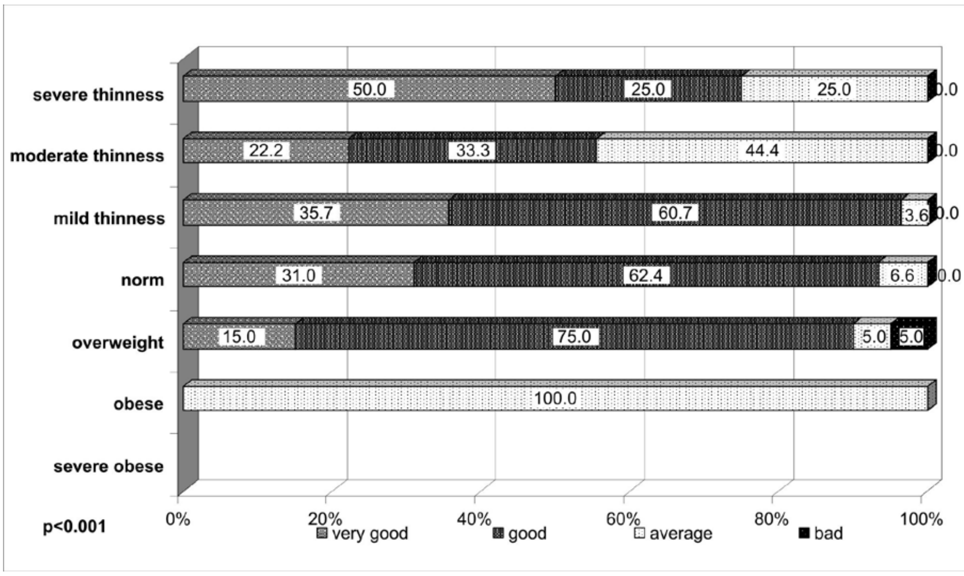

Fig.1. *Self-assessment of the state of health in relationship to the BMI in percentage of subjects indications*

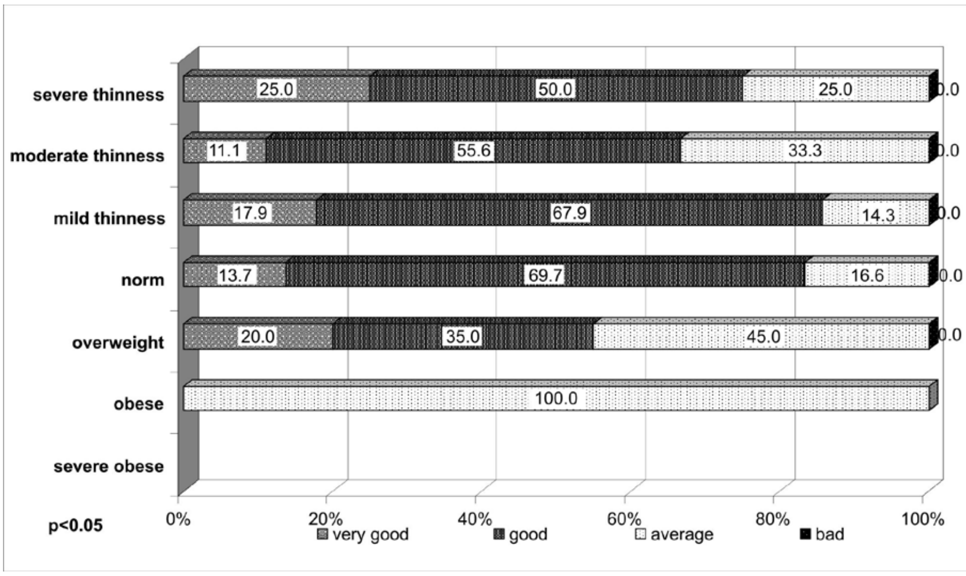

Fig.2. *Self-assessment of the state of physical proficiency in relationship to the BMI in percentage of subjects indications*

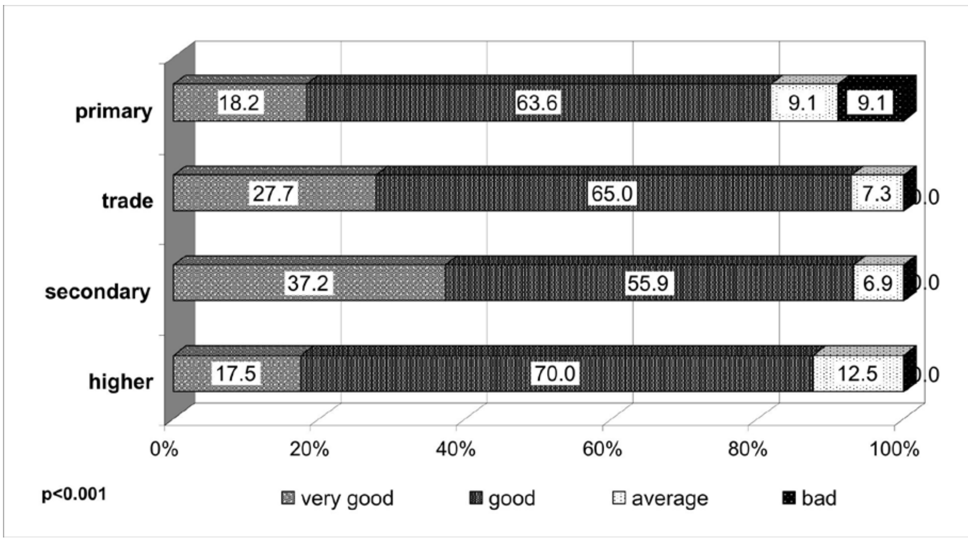

Fig.3. *Self-assessment of the state of health in relationship to the fathers education in percentage of subjects indications*

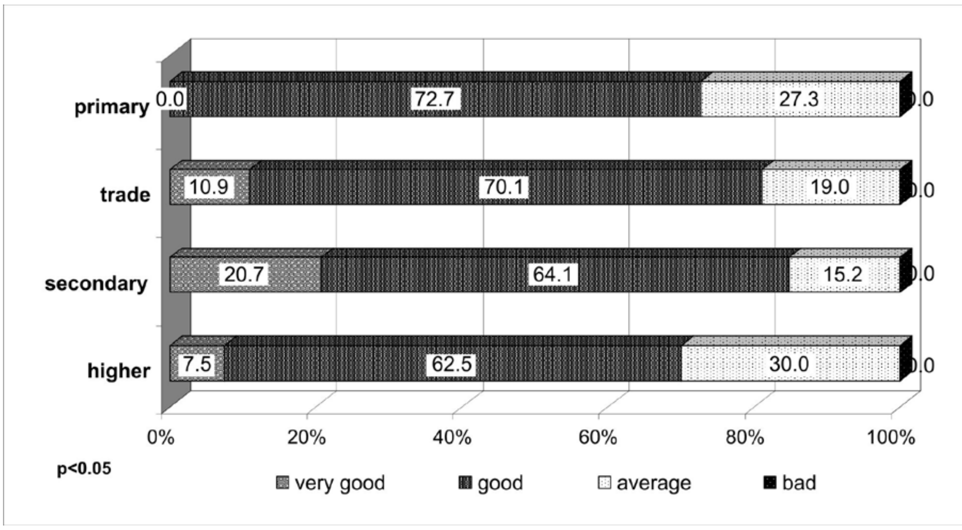

Fig.4. *Self-assessment of the state of physical proficiency in relationship to the fathers education in percentage of subjects indications*

group produced bad grades and differences in this range were statistically important ($p<0.001$). Similar important differences ($p<0.05$) were noted in the relationship between grades for physical proficiency and the father's educational status (fig.4)

Many authors indicate, that social variables like: residence, education of parents and largeness of families effect the biological form of children, youth and adults. They ascertain also, that inhabitants of town and children of parents with higher education, grade their health and physical proficiency better then others (2-6,8). However, results produced by this research do not univocally confirm these dependents.

Conclusion

Analysis of the collected investigative material allowed the formulation of the following conclusion: Only status of father's education of surveyed girls students and their BMI significantly effected their self-estimation of health and physical proficiency.

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F – Literature Search
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