OFFICIAL JOURNAL OF POLISH SOCIETY OF SPORTS MEDICINE

ISSN 1429-0022 from 1997 till 2004
Indexed in: SportDiscus; EMBASE/Excerpta Medica; Index Copernicus

Medicina Sportiva 2007 vol. 11 Issue 4
Copyright © 2007 Medicina Sportiva

**Shaping of physical endurance and front crawl swimming technique indices
in swimmers after half-year training period**

Marek Strzała, Aleksander Tyka

pp: 88-96
[Read article »](#)

**Effect of three months of serial mechanical proprioceptive stimulation
on parameters of balance in older women**

Erika Zemková, Dušan Hamar, Ľubica Böhmerová

pp: 97-101
[Read article »](#)

The causes of injuries in freestyle snowboarding

Monika Zygmuntowicz, Edward Czerwiński

pp: 102-104
[Read article »](#)

**Traumatic posterior dislocation of sternoclavicular joint in a young rugby player
presenting with minimal symptoms: A case report**

Vinay K Singh, Pankaj K Singh, Alka Mishra, Juhi Tomar

pp: 105-107
[Read article »](#)

Prevention of hearing impairment in sport shooters

Felicja Lwow, Paweł Józków, Wojciech Gawron, Marek Mędraś

pp: 108-112
[Read article »](#)

**Evaluation of ecological awareness among physically active people in the context
of their lifestyle**

Ewa Rembiałkowska, Renata Kazimierczak, Dominika Średnicka,
Angelika Jeżewska

pp: 113-118
[Read article »](#)

**Daily intake of macronutrients and selected minerals in physically active female students
in comparison with males of matched age and physical activity**

Grażyna Lutosławska, Marzena Malara, Krzysztof Mazurek, Anna Czajkowska

pp: 119-123
[Read article »](#)

SHAPING OF PHYSICAL ENDURANCE AND FRONT CRAWL SWIMMING TECHNIQUE INDICES IN SWIMMERS AFTER HALF-YEAR TRAINING PERIOD

Marek Strzała¹ (A,B,C,D,E,F,G), Aleksander Tyka² (A,B,C,D,E,F,G)

¹Department of Theory and Methodology of Water Sports, University School of Physical Education, Kraków, Poland

²Institute of Human Physiology, University of Physical Education, Kraków, Poland

Abstract

Marek Strzała, Aleksander Tyka. Shaping of physical endurance and front crawl swimming technique indices in swimmers after half-year training period. *Med Sport* 2007, 11(4): 88-96.

Introduction: For young swimmers, front crawl swimming technique shaping, parallel to physical endurance changes are dynamic processes. Improving swimmer's physical endurance should be related to main swimming speed perfecting, stroke length (SL), stroke rate (SR), and index of coordination (IdC).

Aim of the study: Examine the influence of somatic and functional factors and front crawl swimming technique indices on the results of 400-meter-long race in case of young swimmers, and determine how these factors changed after half-a-year training period.

Methods: In the two research series the same test set was conducted on 19 swimmers divided according to their age G1 (n=11, 16.0±0.89 years) and G2 (n=8, 14.4±0.52 years). All-out 400 m swimming parameters were recorded: SR, SL and IdC. On land: 60 s anaerobic endurance tests, and incremental until exhaustion, with arms (TWAR and VO₂maxAR) and legs (TWLG and VO₂maxLG) separately.

Results: The partial correlations between front crawl arm movements coordination (IdC) and V400 as well as between arm movement frequency (SR) and V400 were the strongest (r=0.63). Statistically significant relationships were also found between body total length (BTL) or arm span (AS) and V400. The second test series showed statistically significant increase in swimming speed in G1+G2 group, approximately from 1.43±0.06 to 1.44±0.05 m·s⁻¹. Statistically significant correlations were noted also between V400 and SR (r=0.64), upper extremities propulsion phases (PL+PS) (r=0.62) and IdC (r=0.49).

Conclusions: After six month training the obtained research results indicate that 400 meters front crawl swimming speed was mainly dependent on swimming technique parameters – stroke rate, arm coordination index and number of propulsion phases.

Key words: young swimmers, swimming speed, somatic factors, oxygen uptake, anaerobic threshold

Introduction

In swimmers' training shaping of physical endurance parameters is parallel to swimming technique modeling. The greatest reserves in scope of results improvement are mainly in method of training monitoring and optimization of training influence on swimmers' organism. Evolution in applying training workloads is recently observed. It is aimed at increasing swimmers' aerobic capacity. It is achieved by using higher intensity than Maximal Lactate Steady State (1) or Onset of Blood Lactate Accumulation (2). Research conducted by Wakayoshi et al. (3, 4), Dekerle et al. (5,6) indicate using higher, submaximal effort intensity with maximal aerobic metabolic track usage, without metabolic acidosis effect – Critical Swimming Speed. These results create possibility of non-invasive swimming speed estimating for middle- and long-distance swimmers (6).

For young swimmers, front crawl swimming technique shaping, parallel to physical endurance changes

are dynamic processes. Improving swimmer's physical endurance should be related to main swimming speed perfecting, stroke length (SL; distance which is covered by a swimmer during one upper extremities movement cycle) extension while preserving or increasing stroke rate (SR; upper extremities movement frequency) (7-10). Apart from these basic parameters, index of coordination (IdC) and propulsion and non-propulsion phase measurement are also introduced to assess front crawl swimming technique (11-15). IdC illustrates proportional occurrence of propulsion phases in movement cycle. Moreover, it shows correlation with SR, giving more information about swimming technique to researchers than for instance stroke index (SL · V) (16).

The aim of the experiment was to examine the effects of somatic and functional factors as well as technique parameters on 400 meter front crawl swimming scores of young swimmers and determine their susceptibility to training actions.

Materials and methods

There were examined 19 broadly trained swimmers (students of sports school) at the age of 16.0 ± 0.89 (group - G1) and 14.4 ± 0.52 (group-G2). They all represent high sports level – domestically and internationally.

There were only one swimmer specializing in sprint (50-100 meters distance) and no breaststrokes among them. G1 swimmers trained 25 hours per week and G2 – 22 hours on average. The two series of tests were conducted 10 days after the most important all-Poland competition of the winter and summer season respectively. All the sportsmen were volunteers, and signed a written informed consent. The research project obtained a consent of Bioethics Commission in Kraków. Both series included identical sets of tests, laboratory measurements and swimming races.

On the basis of the data collected during anthropometric measurements there were estimated such parameters as: somatotype, using method introduced by Carter-Heath (17), percentage of body fat (PF) and lean body mass (LBM) using the Slaughter et al. (18) formula. Total body length (BTL) was measured while the subjects were lying on their back with their upper extremities extended above the head, and ankles plantar-flexed. Arm span of abducted arms was measured between the right and left arm from fingertips on the back side of the body at the shoulders height. The arms tests ($\dot{V}O_{2\max}AR$ and TWAR) were performed by subjects in a sitting position, with the use of the 834E-Ergonomic ergometer, Monark (Sweden). The $\dot{V}O_{2\max}LG$ legs aerobic capacity test was performed on the ER 900 Jaeger ergometer (Germany), and the TWLG test on the 874E-Ergonomic cyclo ergometer, Monark (Sweden).

During the anaerobic endurance tests – 60s TWLG the ergometer breaking strength was set on 7.5% of BM, and during TWAR – 4.5% of BM (19,20). Graded exercise $\dot{V}O_{2\max}LG$ was preceded by a three-minute warm-up (WU) at intensity of about 45% of $\dot{V}O_{2\max}$, after which every three minutes the power was increased of 30W. The WU intensity at $\dot{V}O_{2\max}LG$ varied from 120W to 150W and for $\dot{V}O_{2\max}AR$ – 60W and 90W depending on the swimmers' age and physical endurance. During upper extremities tests the power increased successively every 3 minutes by 18W and 12W respectively. Pedaling rhythm amounted 70 rpm at $\dot{V}O_{2\max}LG$ and 60rpm at $\dot{V}O_{2\max}AR$. Breathing exchange parameters were measured using 919ER Medikro (Finland) apparatus. During the last 30 seconds of each segment of load in $\dot{V}O_{2\max}AR$ and $\dot{V}O_{2\max}LG$ a sample of capillary earlobe blood was taken to determine lactate concentration (La) using Minifotometer Plus Dr Lange (Germany). Research procedure adopted by the authors enabled to determine simultaneously anaerobic threshold (AT) using Dmax technique (21) and maximal oxygen capacity ($\dot{V}O_{2\max}AR$ and $\dot{V}O_{2\max}LG$).

The examination was conducted during 400 meter swimming beginning from water at the 50 meter long pool. The parameters used for assessing swimming technique were measured at the end of each 100 meter long segment of the distance (between 75m and 90m, excluding 5 meter zone before the turn). Duration of the race and the intermediate time of covering particular distances were measured using stopwatch with precision of 0.01s. Swimmers' movement was recorded with a rapid shutter speed GRV 9800 JVC (Japan) video camera at the frequency of 50 pictures per second, from side view about 1 meter below the water surface. Two complete upper extremities cycles were analyzed.

As the arms movements during front crawl swimming are cyclic, the cycles were separated and divided into phases in the recording. The identification of the intracyclic phases was conducted according to Chollet et al. method (12). Cycles were divided into phases according to characteristic events during hand and arm movement. For each phase there was specified its role in accelerating the swimmers' body (propulsion or non-propulsion phase). The first phase is the entry phase (*E – Entry*, non-propulsion) – from the entry of the hand into the water till the beginning of its backward movement. Then there comes the first propulsion phase (*PL – Pull*) – from the end of the entry phase till the moment when the arm is vertically raised above the humeral joint. Then the second propulsion phase (*PS – Push*) – from the vertical position of the arm till the arm release from the water. The cycle ends with the non-propulsion phase (*R – Recovery*) – from the hand's release from the water to its next entry into the water.

Following parameters were used to assess swimming technique on each separate 20m long passage ($i=1,2,3,4$):

- passage swimming speed: $V_i = 20m / \Delta t_i$
- stroke rate (SR_i), calculated as the reciprocal of the arithmetical average of duration of two analyzed swimming cycles: $SR_i = 1/T_i$
- stroke length (SL_i), calculated as the average speed to SR_i ratio: $SL_i = V_i / SR_i$

The swimming cycles of the both of arms are typically phase-shifted. Depending on the chosen extremities coordination method, such a shift results in the occurrence of periods without any propulsion (when none of the extremities is in the propulsion phase) or periods with double propulsion (when both extremities are in the propulsion phase). To assess the upper extremities cooperation in body propulsion a parameter called index of coordination (IdC_i) is used. It is given as percentage of cycle duration (Equation 1). IdC is a positive number when propulsion phases interfere, but it takes negative value when there is a pause between them.

$$IdC_i = \frac{t_R^{k1} - t_{PL}^{k2}}{T_i} * 100\% \quad (\text{Eq 1})$$

where: t_R^{k1} – beginning of R phase for the first arm, t_{PL}^{k2} – beginning of PL phase for the second arm, T_i – duration of swimming cycle

In 6 months period G1 athletes have swum 1588 km on average, while G2 – 1031 km. Training time has been 92h 1min and 70h 25min respectively. Training workloads were recorded using Maglischo method (22). For G1 and G2 swimmers aerobic exercise (basic, threshold endurance and recovery swimming) in water took 84.8% and 85.1% respectively and on land – 82.7% and 84.7%, anaerobic (overload, lactate tolerance, race-pace) in water – 14.2% and 14.1% and on land – 17.2% and 15.2%. Taper training (lactate production, power training) took only 1.0% and 0.8% in water and on land about 0.1% in both groups.

Statistical analysis

Standard statistical methods were used to calculate average values and standard deviations. To assess statistical significance of score changes between the first and the second test series there were used Student's *t*-tests for repeated measurements. The differences in the scores level between the two examined sportsmen groups (the younger and the older ones) were determined using Student's *t*-test for independent samples. Dependences between swimming speed at individual distances and somatic variables, physical endurance parameters and swimming technique among the 19 swimmers were calculated using partial correlations with examined subjects' age control. In swimming speed parameters V, SR, SL, IdC changes analysis in four segments of 400m distance in two athletes groups and in two research series 3-way ANOVA was conducted. These parameters changes dynamics was analyzed using variance analysis with repeated measurements. Character of examined variables distributions was checked, and it was found that they were close to Gauss-Laplace normal curve. The above-mentioned calculations were done using Statistica 6.0 (Statsoft Inc.). Differences between variances in both groups were found only in a few cases (Levene test). So parametric tests usage was justified. To extract anthropometric, physiological and swimming technique factors determining speed during swimming races there was conducted hierarchical regression analysis using SPSS 12 (SPSS Inc.). In hierarchical regression analysis with age control only the factors that were not correlated stronger than $r=0.6$ were taken into account in prediction.

Results

In the initial observation (1. research series) 6 subjects from G1 group had mesomorphic bodybuilding, 5 – ectomorphic, while in the G2 group 5 and

3 subjects respectively (according to Carter-Heath criterion). In the second series the somatotype of only one of the examined sportsmen in G1 group changed from meso- to ectomorphic. Significant diversities of body height (BH), total body length (BTL), arm span (AS) and body mass (BM) and its fatless component (LBM) were found among the swimmers from G1 and G2 group in both test series (Table 1). In leg tests (LG) and arm tests (AR) the maximal oxygen intake ($VO_2 \max$) was usually statistically significantly differentiated in the first and second test series. After six-months training period most of the analyzed indices underwent essential changes (Table 1).

In both test series swimmers' organism anaerobic efficiency, determined on the basis of workload in one-minute TWAR and TWLG tests was significantly higher in G1 than in G2.

After six-months training in G1 and G2 the workload done by the swimmers in TWAR test was not statistically significantly different, which was caused by the small number of subjects in the examined groups. When groups G1 and G2 were joined together, there were found statistically significant differences between above analyzed indice level in TWAR and TWLG tests. After laboratory anaerobic endurance tests the blood lactate concentration was regarded as anaerobic metabolic transformations participation index in those efforts. In the first test series in the group with longer swimming experience blood La concentration after one-minute tests were on the whole higher than in control group (Table 1). In the second test series in both groups La changes after the exercise tests were differentiated. In the second test series after 400-meter-long swimming test in G2 and G1+G2 groups blood La concentration was significantly higher than in the first series.

Swimming technique parameters have only slightly changed in the second test series. Statistically insignificant rise in SL index with simultaneous SR lowering were noted. These seemingly inconsiderable swimming technique changes contributed to essential improvement in swimming time results in G1 (from 276.2 to 273.2) and G1+G2 (from 280.7s to 277.8s) group swimmers (Table 2). Differences between mean IdC values in first and second research series in both groups were statistically insignificant because of their great diversity (Table 2).

In both research series in the successive 100 meters distance the swimming speed was usually significantly diverse in G1 and G2 (Fig. 1a and Table 3). Swimming speed distribution at successive 100-meter-long segments in first and second research series took square trend in G1 and G2 groups ($p<0.01$). The highest swimming speed was noted at the first 100 meters of the distance, then it dropped in the second and third segment, and finally raised again during the last 100

Table1. *Biometric, body structure and physical endurance indices for G1, G2, G1+G2 group swimmers*

Group Series	Group-G1 (n=11)		Group-G2 (n=8)		Group-G1+G2 (n=19)	
	I	II	I	II	I	II
Parameters	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$
Age [y]	16.0±0.89	17.0±0.89	14.4±0.52*	15.4±0.52**	15.3±1.11	16.3±1.11
BH [cm]	180.6±5.72	181.3±6.26	174.8±5.57*	176.2±4.74#*	178.2±6.23	179.2±6.10#
BTL [cm]	251.7±9.38	253.2±9.40#	241.8±9.50*	244.2±8.84#*	247.5±10.45	248.7±10.24#
AS [cm]	186.3±8.27	187.6±8.46#	178.3±8.03*	180.9±7.15#*	182.9±8.91	184.76±8.44#
BM [kg]	67.2±4.59	71.3±4.51#	60.6±7.14*	63.1±7.04#*	64.41±6.56	67.87±6.92#
LBM [kg]	60.8±3.81	63.5±4.13#	55.3±6.44*	57.0±6.08#*	58.5±5.67	60.8±5.89#
PF [%]	9.5±2.07	10.9±2.34#	8.7±1.6	9.6±2.70	9.1±1.87	10.4±2.52#
$\dot{V}O_{2maxAR}$ [l·min ⁻¹]	3.11±0.44	3.50±0.43#	2.75±0.31*	2.86±0.29*	2.96±0.42	3.23±0.50#
$\dot{V}O_{2maxLG}$ [l·min ⁻¹]	3.75±0.43	4.09±0.41#	3.54±0.29	3.74±0.30*	3.66±0.38	3.94±0.41#
WL _{LT} AR[W]	121.1±11.95	134.2±17.78#	99.0±12.42*	109.5±13.13*	111.8±16.27	123.8±20.42#
WL _{LT} LG[W]	204.5±26.22	207.3±32.50	161.3±22.32*	183.8±19.23#	186.3±32.53	197.4±30.52
TWAR [kJ]	307.5±29.94	323.1±30.34	246.5±37.96*	265.5±35.0*	281.8±44.88	298.8±43.50#
TWLG [kJ]	492.7±38.65	517.2±33.70#	428.9±61.75*	451.6±62.15#*	465.8±57.98	489.6±57.46#
LA -TWAR [mmol·l ⁻¹]	12.79±1.48	12.59±1.53	11.05±1.58*	12.73±2.27	12.06±1.72	12.65±1.82
LA -TWLG [mmol·l ⁻¹]	16.20±1.59	15.04±1.27	15.48±1.70	13.47±1.27#	15.90±1.63	14.38±1.47#

*p<0.05 Statistically significant differences between groups

p<0.05 Significant differences between approximate results in 1. and 2. research series

Table 2. *Speed and swimming technique parameters of examined athletes*

400 m	G1		G2		G1 + G2	
	I	II	I	II	I	II
Parameters	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$
V [m·s ⁻¹]	1.45±0.05	1.46±0.04#	1.39±0.05*	1.40±0.05*	1.43±0.06	1.44±0.05#
SR [ckl·min ⁻¹]	38.2±4.15	37.9±3.94	42.1±4.28*	41.4±4.50	39.9±4.55	39.4±4.43
SL [m]	2.21±0.25	2.23±0.21	2.02±0.17*	2.07±0.18*	2.13±0.23	2.16±0.21
IdC [%]	-8.1±8.88	-6.0±4.82	-1.1±5.54*	-4.9±8.84	-5.1±8.26	-5.6±6.61
LA - 400m [mmol·l ⁻¹]	10.43±2.35	11.77±2.33	9.03±11.77	11.16±1.84#	9.84±2.19	11.51±2.10#

*p<0.05 Statistically significant differences between groups

p<0.05 Significant differences between approximate results in 1. and 2. research series

Table 3. *3-way ANOVA analysis results, investigating differences in researched parameters V, SR, SL and IDC between: - two training groups G1 and G2, - two research series, - successive segments of 400m distance (Lap-100m)*

Effect	V		SR		SL		IdC	
	F	p	F	p	F	p	F	p
Training group	5.043	0.038	3.899	0.065	3.65	0.073	1.989	0.177
Research Series	4.129	0.058	1.368	0.258	1.395	0.254	0.259	0.617
Series · Group	0.180	0.676	0.120	0.733	0.401	0.535	2.688	0.119
Lap-100 m	100.800	<0.01	18.418	<0.01	31.013	<0.01	5.103	0.004
Lap-100 m · Group	0.577	0.633	1.014	0.394	0.497	0.686	0.317	0.813
Series · Lap-100 m	0.775	0.513	0.226	0.878	0.426	0.735	0.568	0.639
Series · Lap-100 m · Group	0.993	0.404	0.884	0.456	2.270	0.091	7.111	<0.001

Fig. 1. Swimming speed (a) and front crawl swimming technique indices (b, c, d) during individual segments of 400-meter distance

meters. In both groups stroke lengths at this distance was decreasing in linear trend both in first ($p < 0.01$) and second ($p < 0.02$) research series. Arm stroke rate increased statistically significantly in second part of the distance, in general with parallel linear decrease in SL. Furthermore, both parameters differentiated both groups (Table 3 and Fig. 1 a,b). In G1 in first research series SR changed in quadratic trend ($p < 0.01$) and in G2 it increased linearly ($p < 0.01$). In second research series SR took quadratic trend in both groups ($p < 0.01$). IdC differentiated swimmers' groups in successive 400m distance segments (Table 3, Fig. 1d)

Front crawl swimming technique parameters were correlated with swimming speed at the distance of 400 meters with sportsmen age control. It was found that stroke rate strongly influenced swimming speed (V400), (Table 4). Index of coordination (IdC) showed high and average interdependence on V400, but stroke length (SL) negatively (although statistically insignificantly) correlated with V400. As far as the biometric indices are concerned, significant correlations were noted only in the first test series between body total length (BTL), arm span (AS) and V400.

Hierarchical regression analysis (Table 5 and 6) enabled examining dependencies of chosen indices influencing swimming speed for all examined people ($n=19$), without age control impact on research results. Swimming speed was dependent on swimmers age in the first series in 36.2%, whereas in the second series in 28.7%. After introducing remaining chosen variables contained in Tables 1 and 2 the explained variance percentage increased statistically significantly to 68.1% in the first series and 68% in the second series.

Table 4. Chosen partial correlations with swimmers age control calculated between swimming speed at the distance of 400 meters and front crawl swimming technique indices, as well as swimmers organisms somatic and functional parameters

G1+G2 (n=19)		
SERIES	I	II
Parameters	V 400 [$\text{m}\cdot\text{s}^{-1}$]	
SR [$\text{ckl}\cdot\text{min}^{-1}$]	0.59*	0.64*
SL [m]	-0.30	-0.38
IdC [%]	0.63*	0.49*
PL+PS [%]	0.32	0.62*
E+R [%]	-0.32	-0.62*
BM [kg]	0.13	0.03
LBM [kg]	0.07	0.09
BTL [cm]	0.47*	0.34
AS [cm]	0.49*	0.32
TWAR [kJ]	0.18	-0.09
TWLG [kJ]	0.26	-0.09
WL _{tr} AR[W]	0.37	0.17
WL _{tr} LG[W]	-0.07	0.01
$\dot{V}\text{O}_2\text{maxAR}$ [$\text{l}\cdot\text{min}^{-1}$]	0.11	0.30
$\dot{V}\text{O}_2\text{maxLG}$ [$\text{l}\cdot\text{min}^{-1}$]	-0.18	-0.10

* $p < 0.05$

In 400 meters front crawl swimming in the first test series SR was the index that had the greatest influence on swimming speed. In the second series this impact was even greater (Table 6).

In the second test series V400 depended also on $\dot{V}\text{O}_2\text{maxAR}$ level (the correlation was on the edge of significance).

Table 5. Explained variance percentage from age factor and the most essential variables for swimming speed at the distance of 400 meters in G1+G2

G1+G2 (n=19)											
V [$\text{m}\cdot\text{s}^{-1}$] Age	Age	R		R ²		Change R ²		F For change		p	
	Other variables										
SERIES		I	II	I	II	I	II	I	II	I	II
V 400	Age	0.602	0.536	0.362	0.287	0.362	0.287	9.649	6.841	0.006	0.018
	Variables	0.825	0.824	0.681	0.680	0.319	0.393	4.664	5.716	0.018	0.009

Table 6. Predictors' regression factors for independent variables for 400 meters swimming speed in G1+G2

V400 G1+G2 (n=19)							
I series				II series			
	β	t	p<		β	t	p<
Constant	-	1.710	0.109	Constant	-	2.140	0.050
SR 400 [$\text{ckl}\cdot\text{min}^{-1}$]	0.523	2.695	0.017	SR 400 [$\text{ckl}\cdot\text{min}^{-1}$]	0.680	3.466	0.004
TWAR [kJ]	0.221	0.947	0.359	AR [$\text{l}\cdot\text{min}^{-1}$]	0.354	2.032	0.062
AS [cm]	0.268	1.187	0.255	BTL [cm]	-0.062	-0.282	0.782a

Discussion

Swimmers' bodies biometric indices observation in both test series allowed to determine changes in ontogenesis. In both swimmer groups it was found that after six-month swimming training AS, BTL, BM and LBM significantly increased. In G1 and G1+G2 there were also observed changes in PF, which increased more than 1%. In this research, excluding one case, in the control period no significant changes in somatotype (according to Carter-Heath typology) were found. Hawes et al. (23) observed in case of leading speed skaters and swimmers in four-year period essential changes in body building. It was manifested by increasing body structure ectomorphic component and systematic LBM increase, while observing body fatness fluctuations, with a tendency to its lowering. In the case of the examined swimmers (G1+G2) PF increased on average from $9.1 \pm 1.87\%$ to $10.4 \pm 2.52\%$ and it showed a higher level than in case of the swimmers examined by Krawczyk et al. (24) $8.54 \pm 1.26\%$.

Workload in anaerobic tests TWAR and TWLG was in general higher in the second series than in the first, but regarding small number of examined subjects in G1 and G2, statistically significant differences between these indices levels were noted for TWAR and TWLG tests for joined group (G1+G2). Blood lactate concentration (La) changes after anaerobic tests were usually similar. In G1 and G2 in the second series it was found that with increasing effort capacities (TWLG) La concentration significantly decreased. It may indicate lowering anaerobic metabolism contribution in this effort, on the other hand it may indicate increasing blood buffer efficiency. In second test series after TWAR test in G1+G2 7% increase in blood La concentration was noted, and after leg test – 9% decrease. Workload in TWAR test and post exercise blood La concentration significantly increased ($p < 0.05$) in the second test series (Table 1). Moreover, strong correlation between increase in these indices (ΔLa and $\Delta TWAR$) was also noted ($r = 0.78$, $p < 0.001$).

In case of professional swimmers during a 400 meters front crawl race the participation of physical endurance anaerobic component is high. According to Wakayoshi et al. (25) it reaches even 40% of organism energy requirement. Bonifazi et al. (26) and Petibois et al. (27) empirically proved that for the leading 400-meter-distance swimmers high anaerobic metabolism efficiency is convergent to quick La perfusion from skeletal muscle cells to blood. It was found that after several weeks training period, in case of swimmers specialized in 50 to 400 meters, there occurs a statistically significant dependence between increase in swimming speed (ΔV) and increase in lactate concentration (ΔLa). In these study changes of biochemical, physiological indices were not convergent to observations of above cited authors. In young swimmers

training organism anaerobic efficiency shaping tends to be peripheral. The main stress is put on technique modeling and physical endurance aerobic component improvement.

In both test series in WL_{LTAR} test anaerobic threshold power didn't show statistically significant correlation with V400. High swimming speed level on anaerobic threshold, beside maximal oxygen intake, is the basic factor determining sport results for medium and long-distance swimming (1,2,6,15,28). Body sizes in examined group played important role in 400 meters swimming speed, which was apparent in the first test series. Body length factors BTL and AS correlated above averagely with V400 ($r = 0.47$, $p < 0.5$ and $r = 0.49$, $p < 0.04$ respectively). However, hierarchical regression analysis calculations didn't show leading role of these parameters for the swimming results. Other research results (29,30) indicate important role of swimmers body size in propulsion generation, particularly in front crawl swimming at the distance of 400 meters. Authors' research only partially confirm these observations because crucial dependencies between AS, BTL and V400 was recorded only in the first test series. It may indicate that having high levels of these indices is one of the main determinants of high swimming efficiency. The main 400 meters front crawl swimming speed determinants include IdC and SR indices. For hierarchical regression analysis SR parameter was used, which correlated more strongly with V400. Authors' research results, confirmed by other scientists' observations (12,13,31) show that arm movement coordination, closer to so called opposing and showing smaller lag between arms propulsion phases "opposition", enabled to reach higher swimming speed. It happens because movement cycle swimming speed decrease is caused by smaller propulsion force generation in E and PL phases than in PS phase and lag time ($IdC\% > 0$) occurring in arm propulsion generation, the bigger the lower stroke rate is. Shaping of optimal arm movement coordination requires that the swimmer takes into consideration the distance length. In the case of examined sportsmen at the 400 meters race it would demand reducing stroke length as well as the recovery and entry phases.

Generally, a smaller IdC is observed when swimmers have a higher SL, that could be due to greater force and power out-put used in pull and push by one arm what gives opposite arm greater time spent to glide with reducing active drag (i.e. in entry and catch phase) (31). Longer non-propulsion gliding phase achieved by quicker arm recovery, overall characteristic for elite front crawl swimmers (12), is hydrodynamically favorable. However, if gliding elongation means push phase extension, which may cause stroke length extension, SR decrease and, consequently, quicker tiredness growth (8,15,32). Upsweep phase at the end of push

is less propulsively efficient, comparing to insweep phase. Its elongation with greater elbow extension doesn't seem relevant in 400m front crawl swimming, because it causes higher water resistance and skeletal muscle bioelectric activity in this movement phase, which intensifies effort energy expense (33). In the second test series in G1 group SL and SR indices averaged 2.23 ± 0.21 m and 37.9 ± 3.94 cyclemin⁻¹. They varied comparing to European Championship in 2006 in Budapest finalists ("elite" swimmers). SL was shorter by 0.02 m, SR slower by 7 cycles per minute. Partial correlations between V400 and SR showed dependency on the level of $r=0.59$, $p<0.05$ in the first and 0.64, $p<0.05$ in the second test series. It indicates that some swimmers in the first and the second test series were able to execute higher stroke length and therefore they swam faster. In the second series average swimming speed (1.44 ± 0.05 m s⁻¹) increased statistically significantly in G1+G2, mainly because of increasing SL, not SR. Perhaps in case of young swimmers front crawl swimming technique shaping should take into account long movement cycle training. Examined by Petibois et al. (27) 19.1±1.8-years-old swimmers reached in successive 400 meters front crawl swimming distance segments longer arm cycles of 3.7, 3.8, 6.9 and 4.0% than G1 group swimmers. 400 meters swimming speed was also higher of 0.1 m s⁻¹ than in G1 group, but they executed also higher stroke rate of 13.1, 5.8, 5.8 and 3.1% respectively. According to Yanai (34) a sportsman can swim faster on a given day mainly thanks to increasing stroke rate. But in longer term swimming speed improvement takes place mainly because of increasing stroke length. Such implications cause that in long term a sportsman swimming with a given speed reduces stroke rate. On the other hand, Maglisho (22) notes that improving swimming technique consists in movement's correction and automatization at the beginning of each training season. Others like Sidney et al. (35) point unfavorable technique modification by outer factors task used in swimming training. It concerns long-term using swimming paddles, which increasing propulsion area cause coordination training with increased entry and "catch up" phase.

After six month training the obtained research results indicate that 400 meters front crawl swimming speed was mainly dependent on swimming technique parameters – stroke rate, arm coordination index and number of propulsion phases. Somatic indices and aerobic endurance didn't have deciding influence on 400 meters front crawl swimming results.

References

1. Beneke R. Anaerobic threshold, individual anaerobic threshold, and maximal lactate steady state in rowing. *Med Sci Sports Exerc* 1995; 27: 863-7.
2. Sjödin B, Jacobs I. Onset of blood lactate accumulation and marathon performance. *Int J Sports Med* 1981; 2: 23-6.
3. Wakayoshi K, Yoshida T, Udo M, et al. A simple method for determining critical speed as swimming fatigue threshold in competitive swimming. *Int J Sports Med* 1992; 13: 367-71.
4. Wakayoshi K, Ikuta K, Yoshida T, et al. Determination and validity of critical velocity as an index of swimming performance in the competitive swimmer. *Eur J Appl Physiol* 1992; 64: 153-7.
5. Wakayoshi K, Yoshida T, Udo M, et al. Does critical swimming velocity represent exercise intensity at maximal lactate steady state? *Eur J Appl Physiol* 1993; 66: 90-5.
6. Dekerle J, Nesi X, Lefevre T, et al. Strokings parameters in front crawl swimming and maximal lactate steady state speed. *Int J Sports Med* 2005a; 25: 53-8.
7. Dekerle J, Pelayo P, Clipet B., et al. Critical swimming speed does not represent the speed at maximal lactate steady state. *Int J Sports Med* 2005b; 26: 524-30.
8. Craig AB., Pendergast DR., Relationships of stroke rate, distance per stroke, and velocity in competitive swimming. *Med Sci in Sports* 1979; 11: 278-83.
9. Craig AB, Shekan PL, Pawelczyk JA., et al. Velocity, stroke rate, and distance per stroke during elite swimming competition. *Med Sci Sports Exerc* 1985; 17: 625-34.
10. Keskinen KL, Komi PV. Strokings Characteristics of front Crawl Swimming During Exercise. *J Appl Biomech* 1993; 9: 219-26.
11. Keskinen KL, Lauri J, Komi PV. Maximum velocity swimming: Interrelationships of stroking characteristics, force production and anthropometric variables. *Scand J Sports Sci* 1989; 11: 87-92.
12. Chollet D, Chaliès S, Chatard JC. A new index of coordination for the crawl: description and usefulness. *Int J Sports Med* 2000; 21: 54-9.
13. Millet GP, Chollet D, Chaliès S, et al. Coordination in front crawl in elite triathletes and elite swimmers. *Int J Sports Med* 2002; 23: 99 – 104.
14. Seifert L, Chollet D, Bardy BG. Effect of swimming velocity on arm coordination in the front crawl. *J Sports Sci* 2004; 22: 651 – 60.
15. Strzała M, Tyka A, Krężałek P. Crucial swimming velocity parameters in 2000 meters front crawl performance. *Human Movement* 2007; 8: 15-20.
16. Costill DL, Kovaleski J, Porter D., et al. Energy Expenditure during front crawl swimming: predicting success in middle-distance events. *Int J Sports Med* 1985; 6: 266-70.
17. Carter JE, Heath BH. Somatotyping development and applications. Cambridge Studies in Biological Anthropology. Cambridge University Press, New York 1990.
18. Slaughter MH, Lohman TG, Boileau RA, et al. Skinfold equations of body fatness in children and youth. *Human Biology. Hum Biol*, Wayne State University Press 1988, 60: 709-23.
19. Bar-Or O. Wingate anaerobic test. An update on methodology, reliability and validity. *Sports Medicine* 1987; 4: 381-94.
20. Lutosławska G, Hübner-Woźniak E, Sitkowski D. Plasma glucose and blood lactate response to incremental cycling until exhaustion in active young men with different maximal oxygen uptake. *Biology of Sport* 1995; 12: 137-43.
21. Cheng B, Kuipers H, Snyder AC, et al. New approach for the determination of ventilatory and lactate thresholds. *Int J Sports Med* 1992; 13: 518-22.
22. Maglisho EW. Swimming fastest. *Human Kinetics*. 2003. p 558.
23. Hawes MR, Sovak D. Morphological prototypes, assessment and change in elite athletes. *J Sports Sci* 1994; 12: 235-42.
24. Krawczyk B, Skład M, Majle B. Body components of male and female athletes representing various sports. *Biology of Sport* 1995; 12: 243-50.
25. Wakayoshi K, Yoshida T, Ikuta Y, et al. Adaptations to six months aerobic swim training. Changes in velocity, stroke rate, stroke length and blood lactate. *Int J Sports Med* 1993; 14: 368-72.
26. Bonifazi M, Sardella F, Lupo C. Preparatory versus main competitions: differences in performances, lactate responses and pre-competition plasma cortisol concentrations in elite male swimmers. *Eur J Appl Physiol* 2000; 82: 368-73.

27. Petibois C, Deleris G. Fourier-Transform infrared spectrometry determination of the metabolic changes during a maximal 400-meter swimming test. *Int J Sports Med* 2003; 24: 313-9.
28. Holmer I. Physiology of swimming man. *Acta Physiol Scand*, 1974, 407, (Suppl.), 1-55.
29. Jürimäe J, Haljaste K, Cicchella A, et. al. Analysis of swimming performance from physical, physiological, and biomechanical parameters in young swimmers. *Pediatr Exerc Sci*. 2007; 19: 70-81.
30. Grimston SK, Hay JG. Relationships among anthropometric and stroking characteristics of college swimmers. *Med Sci Sports Exerc* 1986; 18: 60-8.
31. Seifert L, Chollet D, Rouard A. Swimming constraints and arm coordination. *Human Movement Science* 2005; 24: 234-56.
32. Pelayo P, Sidney M, Kherif T, et.al. Stroking characteristics in freestyle swimming and relationships with anthropometric characteristics. *J Appl Biomech* 1996; 12: 197-206.
33. Rouard AH, Billat RP. Influences of sex and level performance on freestyle stroke: an electromyography and kinematic study. *Int J Sports Med* 1990; 11: 150-5.
34. Yanai T. Stroke frequency in front crawl: its mechanical link to the fluid forces required in non-propulsive directions. *J Biomech* 2003; 36: 53-62.
35. Sidney M, Paillette S, Hespel JM, et al. Effect of swim paddles on the intra-cyclic velocity variations and arm coordination of front crawl stroke. In J. R. Blackwell & R. H. Sanders (Eds.), XIX international symposium on biomechanics in sports 2001: (s 39-42). San Francisco: ISBS.

Received: September 30, 2007

Accepted: November 16, 2007

Published: December 03, 2007

Address for correspondence:

Marek Strzala

Zakład Teorii i Metodyki Sportów Wodnych

Akademia Wychowania Fizycznego

Ul. Rogozińskiego 12, 31-559 Kraków, Poland

tel. +48 12 648 52 22

e-mail: marekstrzala@o2.pl

Author's contribution

A – Study Design

B – Data Collection

C – Statistical Analysis

D – Data Interpretation

E – Manuscript Preparation

F – Literature Search

G – Funds Collection

EFFECT OF THREE MONTHS OF SERIAL MECHANICAL PROPRIOCEPTIVE STIMULATION ON PARAMETERS OF BALANCE IN OLDER WOMEN

Erika Zemková^(A,B,C,D,E,F), Dušan Hamar^(A,D,E,G), Ľubica Bóhmerová^(B)

Faculty of Physical Education and Sport, Comenius University, Bratislava, Slovakia

Abstract

Zemková E, Hamar D, Bóhmerová L. Effect of three months of serial mechanical proprioceptive stimulation on parameters of balance in older women. *Med Sport* 2007, 11(4): 97-101.

Introduction: Although several studies were carried out on effects of vibration exposure on strength, there are scarce of those concerning its influence on balance.

Aim of the study: The study examines changes of postural sway in older women after 3-month of proprioceptive stimulation training applied to lower extremities.

Methods: Altogether thirty-two older women, randomly divided into experimental and control group, participated in the study. They underwent two different forms of exercise during vibrations, either stood with slightly flexed knees or performed semi-squats. The intensity of exercise in the first case increased by lengthening the time of vibrations, whereas in the second by additional load. Vibrations were applied by means of special strength exercise device producing short-term counter movements at the frequency of 10 Hz and amplitude 3 mm. Stabilographic parameter (mean velocity of the centre of pressure) was registered at 100 Hz by means of the stabilography system FITRO Sway check based on dynamometric platform.

Results: Results showed a significant ($p < 0.01$) decrease in velocity of the centre of pressure from 11.2 ± 2.5 to 8.9 ± 2.0 mm/s. In addition, such an improvement of postural stability was more efficient after training in which semi-squats were performed as compared to those when subjects stood in semi-squat position on the vibrating platform (28.8 and 27.0 %, respectively). On the other hand, no significant changes in control group were observed (12.6 ± 2.4 and 11.9 ± 1.8 mm/s, respectively).

Conclusion: It may be concluded that long-term proprioceptive stimulation training applied to lower extremities improve postural stability in older people. Such a positive change may be ascribed to the enhancement of neuroregulatory functions, namely increased rate of motoneuron firing and better synchronisation of motor units activation.

Key words: elderly, postural sway, proprioceptive stimulation, training

Introduction

Accidents related to falls have been recognized as a primary risk factor of injuries in elderly population (1). These consequently lead to fear of further falling, known as a “postfall syndrome”, activity restriction, loss of independence and decreasing quality of life.

A major contributor to falls is an impaired capacity for proper neuromuscular response in controlling postural sway, a function substantially depending on muscle proprioceptors (e.g., 2, 3).

Recently developed method of serial mechanical stimulation has been found to influence proprioceptive feedback mechanisms and specific neural components with subsequent enhancement of neuromuscular performance (4).

Up to date longitudinal studies have documented an increase of the height and mechanical power in 5-s continuous jumping test in well-trained handball players (5), the isometric and dynamic knee-extensor strength and counter-movement jump height in untrained females (6), jump performance and isome-

tric limb extension strength in sedentary subjects (7), rate of the force development in physical education students (8), and 18 % gain in chair-rising time in elderly (9) after vibrating training.

On the other hand, there are only scarce reports (7, 10) studying the adaptive changes in postural stability due to systematic proprioceptive stimulation training, namely in elderly population.

As decreased balance goes hand in hand with aging and potential risk of falls, its improvement by such novel, more efficient and lower-risk means than traditional aerobic and strength are, should be considered as an integral part of healthy orientated exercise program. Although results of preliminary studies related to utilization of vibrations for this purpose (11-13) seem to be promising, there is still lack of information whether such a positive effect should not be even more enhanced by adding resistance exercise while exposure vibrations.

Indeed, a significant increase in strength has been proved when squats, deep squats, wide-stance squats,

Stabilographic parameter of the velocity of the centre of pressure (mean and in antero-posterior and medio-lateral directions) was registered at 100 Hz by means of the posturography system FiTRO Sway check based on dynamometric platform (Fig. 3). The average of 2 min measurement was used as the test score. Subjects were asked to stand still as quiet as possible.

Fig. 3. A computer based posturography system FiTRO Sway check

Statistical analysis

A paired Wilcoxon test was employed to determine the statistical significance of differences between velocity of the center of pressure prior to and after first, second, and third month, $p < 0.05$ was considered significant. Values (mean $\pm$ SD) obtained in the last test were expressed as percentages of the baseline value and presented for control and both experimental groups.

Results

The results showed (Fig. 4) that after first month of the training during which all subjects were standing in semi-squat position on the vibrating platform the velocity of the centre of pressure decreased from 12.4 ± 2.5 to 10.0 ± 2.4 mm/s.

Afterwards, they were randomly divided into two groups, in which different training program was carried out.

Following second month the velocity of the centre of pressure decreased more profoundly in group standing 30 sec on vibrating platform as compared to those performing semi-squats (9.1 ± 1.5 and 9.7 ± 2.4 mm/s, respectively). Light squats in average duration of 15 sec likely provided insufficient stimulus and therefore their benefit was neglected.

However, after third month further changes in velocity of the centre of pressure in group standing 45 sec in semi-squat position were not observed (8.9 ± 1.8 mm/s), mostly due to not enough intensive exercise. On the other hand, its values even decreased in group performing semi-squats with additional load (8.9 ± 2.2 mm/s).

To sum up, 3-month of proprioceptive stimulation training led to a significant ($p < 0.01$) improvement of static balance in older women. This effect was more evident in group performing light squats than in those standing with slightly flexed knees (28.8 and 27.0 %, respectively).

In contrast, in control group no differences in the velocity of the centre of pressure in mentioned period were found (12.6 ± 2.4 and 11.9 ± 1.8 mm/s, respectively).

In addition, in all groups a predominant shift of the velocity of the centre of pressure in medio-lateral than antero-posterior direction was registered (Table 1). However, in the end of training its values showed a slight tendency to decrease from more than 60 % to about 55 % in X direction and vice versa in Y.

Fig. 4. Changes in velocity of the centre of pressure during 3-month of proprioceptive stimulation training applied to lower extremities in two different conditions, either standing with slightly flexed knees or performing semi-squats, in comparison with no training

Table 1. Changes in velocity of the centre of pressure during 3-month of proprioceptive stimulation training applied to lower extremities in antero-posterior (Y) and medio-lateral (X) directions in all groups examined

Sway variables	Pre- -training	Post-training (months)		
Sway velocity - x (mm/s)		1	2	3
Control group	7.4 ± 1.2	–	–	7.1 ± 0.9
Experimental group 1	7.2 ± 0.8	6.3 ± 1.3	5.7 ± 0.6	5.2 ± 0.6
Experimental group 2	7.6 ± 1.4	6.4 ± 0.9	5.1 ± 0.5	4.9 ± 0.6
Sway velocity - y (mm/s)		1	2	3
Control group	4.9 ± 0.6	–	–	4.9 ± 0.8
Experimental group 1	4.6 ± 0.8	3.9 ± 0.5	3.7 ± 0.7	3.9 ± 0.4
Experimental group 2	4.5 ± 0.6	3.7 ± 0.6	4.0 ± 0.9	3.9 ± 0.5

Discussion

Improvement of postural stability in older women following 3-month of proprioceptive stimulation training applied to lower extremities may be ascribed to the improvement of neuromuscular functions, namely increased rate of motoneuron firing and better synchronization of motor unit activation.

As close correlation between strength and balance performance has been found (15), such a positive changes in postural sway are very probably similar and occur via similar pathways as those by resistance training induced.

It is known that within an initial two to three months such a training the specific neural components and their proprioceptive feedback mechanisms are influenced. During standing on the vibrating platform proprioceptive afferent inflow from the ankle region and afferent impulses from the sole are strongly stimulated. The vibratory stimulus activate the sensory receptors that results in reflexive muscle contraction. Long-term extensive sensory stimulation might thus lead to more efficient use of the positive proprioceptive feedback loop in the adjustment of postural sway.

It is particularly important for elderly people. They tend to shift the corrective movements necessary for properly postural adjustments from the ankle joints to the knees or the hips. A reflex contraction of the ankle dorsiflexors is, however, more appropriate in relation to the overall goal of maintaining stability. Hence, improvement the ability to produce required output at the ankle joint and enhancement the efficiency of proprioceptive pathways is of special importance in these people.

Besides this, tonic vibration reflex elicited by vibrations has been suggested to cause an increase in recruitment of the motor units (16). It supports also recent view, according which the vibration training has been found to increase the number of active motor units and their firing frequency (17).

Since a decreased ability to develop force rapidly in elderly is associated with a lower capacity for neuromuscular response in controlling postural sway (15), an increase of force production at the onset muscle contraction may contribute to the speed of balance adjustment, e.g., on an unexpectedly moving surface.

In addition, vibrations are thought to inhibit the activation of antagonist muscles via Ia inhibitory interneurons (18), thus increasing the co-contraction of synergists. An important consequence of such a muscle groups arrangement is an improvement of age-impaired coordination.

In light of the above reports is evident that exercise performed under influence of proprioceptive stimulation represents strong stimulus to the sensory-motor pathways resulting in more rapid compensatory responses to stabilize posture and to prevent falling.

It is related to mainly those known to be delay in elderly people, such as an immediate muscle stiffness, activation of a long-latency stretch reflex, vestibular activation, and myotatic stretch reflex.

Mechanism of such an adaptation depends also on the body position and target muscles stimulated as well as the specificity of training. Escamilla et al. (19) has found the semi-squat position on the vibrating platform as an optimal for triggering vastus lateralis stimulation. It may be ascribed to the fact that sensitivity to vibrations increases when the target muscles are stretched (18, 20). Recent evidence also suggests that vibrations are more effective on improving force-generating capacity when applied during concentric rather than isometric or isokinetic activations (21).

Based on these findings it may be assumed that as standing in semi-squat position as performing lower limbs resistance exercise on the vibrating platform may be considered as an effective and suitable means for enhancement of neuromuscular performance with subsequent improvement of balance in elderly population.

Moreover, an enormous increase in neural activity during vibration, up to more than twice the baseline values (21), indicate that this type of treatment is able to stimulate the neuromuscular system more than others used to improve neuromuscular performance.

The potential risk of vibration exercises is for elderly negligible. It may be corroborated by study of Rittweger et al. (23) who has shown the mild effect of exercises performed on vibrating platform to cardiovascular system.

It is also in agreement with results of the present study and experience gained. Proprioceptive stimulation training has been found not to be exhausting for previously untrained subjects and the effect can be achieved within a relative short time. Hence, if carried out properly the exercises performed under influence of vibrations of appropriate frequency and amplitude may be safe physical activity with great potential also in a therapeutic context for patient who are not able to perform standard training programs.

Conclusion

It may be concluded that 3-month of proprioceptive stimulation training applied to lower extremities improve postural stability in older people. Its effect is more evident when during vibrations the resistance exercises, e.i., semi-squats are performed.

Such a positive change may be ascribed to the improvement of neuroregulatory functions, namely increased rate of motoneuron firing and better synchronisation of motor units activation. This, together with improvement of proprioceptive functions and neuromuscular coordination enables more rapid postural sway adjustments in altered surface conditions.

It has a practical impact on decrease a risk of falling with subsequent reduction of complications affecting namely elderly population.

Acknowledgment

This project was supported through a Scientific Grant Agency of the Ministry of Education of Slovak Republic and the Slovak Academy of Sciences (No. 1/9192/02).

References

- Runge M. Gehstörungen, Stürze, Hüftfrakturen. Darmstadt: Steinkopff-Verlag, 1998.
- Pyykkö I, Aalto H, Hytönen M, et al. Effect of age on postural control. In: Amblard B, Berthoz A, Clarac F, ed. Posture and Gait: Development, Adaptation and Modulation. Amsterdam: Elsevier, 1988: 95-104.
- Di Fabio RP, Badke MB, McEvoy A, Breunig A. Influence of local sensory afference in the calibration of human balance responses. *Exp Brain Res* 1990; 80: 591-9.
- Bosco C, Iacovelli M, Tsarpela O, et al. Hormonal responses to whole-body vibration in men. *Eur J Appl Physiol* 2000; 81(6): 449-54.
- Bosco C, Cardinale M, Colli R, et al. The influence of whole body vibration on jumping ability. *Biol Sport* 1998; 15(3): 157-164.
- Delecluse C, Roelants M, Verschueren S. Strength increase after whole-body vibration compared with resistance training. *Med Sci Sports Exerc* 2003; 35(6): 1033-41.
- Torvinen S, Kannus P, Sievänen H, et al. Effect of four-month vertical whole body vibration on performance and balance. *Med Sci Sports Exerc* 2002; 34(9): 1523-8.
- Hamar D, Schickhofer P, Kampmiller T, Vanderka M. Effect of proprioceptive stimulation on the parameters of maximal isometric contraction. *Official Journal of the American College of Sports Medicine* 2003; 35(5 Suppl): 390.
- Runge M, Rehfeld G, Resnick E. Balance training and exercise in geriatric patients. *J Musculoskelet Neuron Interact* 2000; 1: 61-5.
- Torvinen S, Kannus P, Sievänen H, et al. Effect of 8-month vertical whole body vibration on bone, muscle performance, and body balance: a randomized controlled study. *J Bone Miner Res* 2003; 18(5): 876-84.
- Wierzbicka MM, Gilhodes JC, Roll JP. Vibration-induced postural posteffects. *J Neurophysiol* 1998; 79: 143-50.
- Priplata AA, Niemi JB, Harry JD, et al. Vibrating insoles and balance control in elderly people. *Lancet* 2003; 362: 1123-4.
- Verschueren SMP, Roelants M, Delecluse CH, et al. Effect of 6-month whole body vibration training on hip density, muscle strength, and postural control in postmenopausal women: a randomised controlled pilot study. *J Bone Miner Res* 2004; 19: 352-9.
- De Ruiter CJ, Van Raak SM, Schilperoort JV, et al. The effects of 11 weeks of whole body vibration training on jump height, contractile properties and activation of human knee extensors. *Eur J Appl Physiol* 2003; 16.
- Izquierdo M, Aguado X, Gonzales R, et al. Maximal and explosive force production capacity and balance performance in men of different ages. *Eur J Appl Physiol* 1999; 79: 260-7.
- De Gail P, Lance JW, Neilson PD. Differential effects on tonic and phasic reflex mechanisms produced by vibration of muscles in man. *J Neurol Neurosurg Psych* 1966; 29: 1-11.
- Clark FJ, Matthews PB, Muir RB. Motor unit firing and its relation to tremor in the tonic vibration reflex of the decerebrate cat. *J Physiol* 1981; 313: 317-34.
- Eklund G, Hagbarth KE. Normal variability of tonic vibration reflexes in man. *Exp Neurol* 1966; 16: 80-92.
- Escamilla RF, Fleisig GS, Zheng N, et al. Biomechanics of the knee during closed kinetic chain and open kinetics chain exercises. *Med Sci Sports Exerc* 1998; 30: 556-69.
- Nordin M, Hagbarth KE. Effects of preceding movements and contractions on the tonic vibration reflex of human finger extensor muscles. *Acta Physiol Scand* 1996; 156(4): 435-40.
- Warman G, Humphries B, Purton J. The effects of timing and application of vibrations on muscular contractions. *Aviat Space Environ Med* 2002; 73: 119-27.
- Bosco C, Cardinale M, Tsarpela O. Influence of vibration on mechanical power and electromyogram activity in human arm flexor muscles. *Eur J Appl Physiol Occup Physiol* 1999; 79(4): 306-11.
- Rittweger J, Beller G, Felsenberg D. Acute physiological effects of exhaustive whole-body vibration exercise in man. *Clin Physiol* 2000; 20(2): 134-42.

Received: September 12, 2007

Accepted: November 16, 2007

Published: December, 2007

Address for correspondence:

Erika Zemková, Ph.D.

Faculty of Physical Education and Sport

Comenius University

Svobodovo nábrežie 9

814 69 Bratislava

Slovakia

Tel: 00421-2-54411624

E-mail: zemkova@yahoo.com

Author's contribution

A – Study Design

B – Data Collection

C – Statistical Analysis

D – Data Interpretation

E – Manuscript Preparation

F – Literature Search

G – Funds Collection

THE CAUSES OF INJURIES IN FREESTYLE SNOWBOARDING

Monika Zygmuntowicz^(A, B, C, D, E, F), Edward Czerwiński^(A, C, D, E)

Department of Bone and Joint Diseases Jagiellonian University Medical College

Abstract

Zygmuntowicz M, Czerwiński W. The causes of injuries in freestyle snowboarding. *Med Sport* 2007, 11(4): 102-104.

Introduction: Freestyle is the most popular and common style of snowboarding. This style includes jumps, tricks, rail slides and halfpipe.

Aim of the study: The aim of the present study was to estimate the causes of injuries in freestyle snowboarding.

Material and Methods: The research was carried out on 211 persons (42 women and 169 men) in age from 16 to 21 years; average age for both sexes was 19, 3 years. The questionnaire was used as a research method.

Results: The most common reasons for injuries were technical mistakes (n=89, 81%), tiredness (n=15, 14%), icy slope (n= 14, 13%), other peoples' mistakes (n=4, 4%) and faulty equipment (n=1, 1%). Falls were the injury mechanism in 77%, collisions account for less than 12% of snowboarding injuries. Most collisions involving snowboarders occur with a stationary object.

Conclusions: Individual snowboarding errors were the most common cause of injury in other study. Falls were the most common mechanism of injury in snowboarding.

Key words: freestyle snowboarding, causes of injuries, injury, mechanism

Introduction

Snowboard is the most frequently practised sport discipline. It is assessed that almost 3, 4 million people snowboard in the USA. The National Sporting Goods Association estimates that since 1988 the number of snowboarders has risen by 70% whereas the number of skiers has gone down by 25% (1). The frequency of injuries is estimated on the basis of the number of days spent on skiing / snowboarding. In case of professional snowboarders it is 7 injuries per 1000 days, in case of people who snowboard for recreation – 4 per 1000 days. In case of amateur skiers the it is 2-3 per 1000 days. In freestyle competition: big air it is 15.9 per 1000 days and halfpipe – 12.7 per 1000 days (2).

Freestyle is the most popular snowboard style. It involves performing jumps and 'aerobatics' on a specially prepared jumps, obstacles (3) which can be found in snowparks.

Snowpark is a slope, or its part, on which different constructions are arranged (rails, boxes, half pipes, tapezes, corners, jumps) enabling the snowboarders to perform various aerobatics.

One of the freestyle disciplines is big air. Snowboarders need a big jump to practise it. This style entails contusions; therefore it is important to learn about the causes for the injuries in order to prevent them. The aim of the thesis was the assessment of the causes for the injuries of freestyle snowboarders.

Materials and Methods

The research was conducted among sportsmen belonging to snowboard clubs and associations as well as snowparks in Cieszyn, Szczyrk, Ustroń and Wisła.

211 people (169 men and 42 women) participated in the research. They were from 16 to 21 years old, and they have been practising snowboard for 2 – 12 years. (3,49 years on average).

The research was based on a specially prepared questionnaire consisting in 32 questions. The questions concerned personal data, technical data, the reasons for injuries (technical mistakes, faulty equipment, other peoples' mistakes, tiredness, other), the mechanisms of injuries (fall, collision: with another person on the slope, with natural/ artificial objects on the slope, other) as well as atmospheric and snow conditions. Respondents could choose more than one answer from a list of options.

The research was conducted in winter season 2006/2007 among 211 people, 109 were injured during snowboarding in freestyle competitions. Only 19 % of respondents said they wore a helmet and 38 % used protectors.

Results

The reasons of injury

The questionnaire was completed by all respondents. The most frequent reasons for injuries were technical mistakes (n=89, 81%), tiredness (n=15, 14%), icy slope (n= 14, 13%), other peoples' mistakes (n=4, 4%) and faulty equipment (n=1, 1%). The research didn't show the influence of atmospheric conditions (rainfalls, snowfalls, fog) on the occurrence of injuries. Nevertheless they were influenced by snow condition. The assessment of snow condition involved the kind of snow (soft snow, fake snow, wet frozen ice) and it was claimed that the frost on the slope caused injuries in case of 13% of all respondents.

Fig. 1. The reasons of injury

The results indicate that contusions of the snowboarders practising freestyle are due to technical mistakes (losing control, catching the edge, recklessness, taking risks), both in case of people with long and short experience (4). The respondents claimed to have made mistakes more often when learning new stunts, than when perfecting the already known ones. Injuries caused by tiredness occurred usually in the evenings. Determined causes for injuries are illustrated in figure 1.

The mechanism of injury

The research showed that the most frequent injury mechanism was the fall during landing after the jump ($n=92,77\%$). Rarely, the cause for injuries was the collision with another person on the slope ($n=4,3\%$) or with natural or artificial objects on the slope (tree, pillar, snow cannon) ($n=11, 9\%$) (4).

During snowboarding in snowparks, the most frequent falling mechanism was one that occurred on rails and boxes ($n=13, 11\%$) during which snowboarders were most frequently injured on the head (fig. 2).

Discussion

The results presented in the dissertation confirm the results published by Hagel (5), who claims that the main cause for snowboarders' injuries are technical errors and the major injury mechanism is a fall. The research carried out by Bjornstig and Hagel prove that the main reason for injuries is the loss of balance during the performance of stunts. In freestyle competitions like big air and halfpipe the risk of contusion is greater than in other competitions (like slalom) or recreational forms of this sport discipline (2).

Torjussen and Bahr conducted similar research among professional snowboarders. They stated that injuries occurring during halfpipe and big air competitions result from falls, which constituted 93% and 100% (2).

Despite the results presented by Young, which show that 4-8% of the respondents were injured during using ski lifts, our research presents no such results (1).

In order to lessen the number of technical errors, and what follows – the number of injuries – a proper preparation for the snowboarding season is necessary. Exercising and jumping on a trampoline will help to

Fig. 2. The mechanism of injury

prepare for jumps and stunts. Special training will enable to improve motor abilities, movement coordination and balance (6).

Conclusions

On the basis of the conducted research the following conclusions can be drawn:

- 1) Snowboarders taking part in freestyle competitions suffer from injuries because of technical errors (loss of control, catching the edge, carelessness, taking risks).
- 2) Atmospheric conditions have no influence on the occurrence of injuries, whereas the frost on the slopes does.
- 3) The most frequent injury mechanism is a fall (77%).
- 4) Collisions constituted 12 % of all injury mechanisms. Most frequently, the sportsmen collided with natural or artificial objects (tree, pillar, snow cannon).

References

1. Young C, Niedfeldt M. Snowboarding injuries. *Am Fam Physician* 1999; 59(1): 131-41.
2. Torjussen J, Bahr R. Injuries among elite snowboarders (FIS Snowboard World Cup). *Br J Sports Med* 2006; 40: 230-4.
3. Dunn K. What are the health hazards of snowboarding? *West J Med* 2001; 174(2): 128-30.
4. Bridges E, White N. Snowboarding injuries. Position Statement. *Canadian Academy of Sport Medicine*, 2006; 1-10.
5. Hagel B. Skiing and snowboarding injuries. *Med Sport Sci* 2005; 48: 74-119.
6. Bjornstig J, Bjornstig U. Snowboarding injuries can be prevented. *Nord Med* 1996; 111(1): 7-9.

Received: August 28, 2007

Accepted: November 16, 2007

Published: December 10, 2007

Address for correspondence:

Monika Zygmuntowicz

ul. Kopernika 32

31-501 Krakow

Tel. 012 4303209

Fax 012 4303217

e-mail : mzygmuntowicz@o2.pl

Author's contribution

A – Study Design

B – Data Collection

C – Statistical Analysis

D – Data Interpretation

E – Manuscript Preparation

F – Literature Search

G – Funds Collection

TRAUMATIC POSTERIOR DISLOCATION OF STERNOCLAVICULAR JOINT IN A YOUNG RUGBY PLAYER PRESENTING WITH MINIMAL SYMPTOMS: A CASE REPORT

Vinay K Singh^{1 (A,B,E,F)}, Pankaj K Singh^{2 (D,E,F)}, Alka Mishra^{1(E,F)}, Juhi Tomar^{3(E,F)}

¹James Paget University Hospital, UK

²Royal Hallamshire Hospital, UK

³Northern General Hospital, UK

Abstract

Singh Vinay K, Singh Pankaj K, Mishra A, Tomar J. Traumatic posterior dislocation of sternoclavicular joint in a young rugby player presenting with minimal symptoms: a case report. *Med Sport* 2007, 11(4): 105-107.

Injury to sternoclavicular joint is uncommon but may be life threatening if the diagnosis is not made acutely. Posterior sternoclavicular joint dislocation is associated with a number of complications including tracheal tear and trauma to the great vessels. Diagnosis by conventional radiography is difficult. Even experienced examiners may miss the diagnosis unless a high index of suspicion is kept and the appropriate imaging studies are ordered. We report a case of traumatic dislocation of sternoclavicular joint in an 11-year-old boy post rugby injury, successfully treated by closed reduction.

Key words: sternoclavicular joint; dislocation; child; rugby; sports injury

Introduction

Sternoclavicular joint (SCJ) is a synovial diarthrodial joint that links upper extremity to torso. It provides the enough freedom to clavicle enabling it to participate in all the movements of upper extremity. In spite of being a gliding joint, it competes with a ball and socket joint in terms of range of movements. Stability of this joint is vital to enable forward thrust at the arm and shoulder. Articular surface of clavicle is much larger than articular surface of sternum hence only 50% of the medial end of clavicle articulates with sternum. SCJ has little inherent stability; most of the strength and stability originates from the joint capsule and supporting ligaments. The capsule surrounding the joint is weakest inferiorly, while it is reinforced on the superior, anterior and posterior aspects by the various ligaments. These include the interclavicular, anterior and posterior sternoclavicular and costoclavicular ligaments. SCJ dislocations are rare injuries (1,2) accounting for <1% of all traumatic joint dislocations. It was first described in 1824 by Cooper (3) and since then only around 120 cases of posterior dislocation of SCJ have been reported in literature. Anterior dislocation is more common (4) than posterior dislocation (9:1). Most of these injuries have been described in adults. We report a case of asymptomatic traumatic posterior dislocation of sternoclavicular joint in an 11-year-old child post sporting injury.

Case report

An 11-year-old enthusiastic rugby player was injured while playing rugby. He was involved in a bad tackle and fell awkwardly on his right shoulder and another player fell on top of his opposite shoulder. He had to discontinue playing because of pain. Physical trainer assessed him at scene and advised to visit casualty.

In casualty the child was comfortable with minimal pain but restricted range of right upper limb movements. He had swelling, minimal tenderness and a subtle palpable dip in right sternoclavicular area. He had no other symptoms suggestive of tracheal involvement or pneumothorax and was neurovascularly intact. Child was sent for a chest X-ray to look for possible sternoclavicular dislocation, which was inconclusive (fig. 1). Specialist opinion was sought because of clinical suspicion. Child was admitted under the care of orthopedic team for observation and CT scan to rule out dislocation. A CT scan was performed next day, which revealed posterior dislocation of right sternoclavicular joint (fig. 2). Once the diagnosis was confirmed he was urgently taken to theatre. A successful closed reduction was performed under general anesthetic using fluoroscopic guidance (fig. 3). Symptoms resolved post manipulation and he was subsequently discharged home. Follow up in the clinic in 6 weeks time showed normal examination and complete resolution of the symptoms.

Fig. 1. The X-ray, taken in A&E, immediately after admission. The radiograph is unable to reveal any abnormality and was reported normal by radiologist

Fig. 2. The high resolution CT scan with 3- dimensional reconstruction of thoracic cage. The scan reveals the separation of right clavicle from sternal attachment with posterior displacement (arrow)

Fig. 3. The intra-operative image showing the satisfactory reduction

Discussion

Injuries to the sternoclavicular joint are uncommon, but can be life-threatening if not diagnosed and treated adequately. Nearly 25% of patients with SCJ dislocation have associated injuries (5) such as pneumothorax, injury to brachial plexus, laceration of the superior vena cava, occlusion of the subclavian artery or vein and disruption of the trachea. All of these complications can cause significant disability and even death. Prompt diagnosis and treatment is necessary to avoid complications. Osteomyelitis of clavicular head or esophageal fistula may be the late sequel (5).

High index of suspicion is required in cases of high velocity road traffic injuries or high impact sporting injuries. Children playing contact sports are particularly at risk. Chest X-ray may help in diagnosis but should not be used to rule out SCJ dislocations. Specific views of SCJ such as Rockwood (serendipity), Hobb, Kattan (6) and Heinig views may be requested to help diagnosis but CT scan is the imaging modality of choice. It is imperative to make the diagnosis early, as delay may be life threatening and the closed reduction is best accomplished during the first 48 hours. Contrasted CT scan may be especially helpful in diagnosing an underlying vascular injury (5).

When diagnosis is not clear patient should be admitted for adjunctive imaging (CT scan) to rule out the condition. Reduction of posterior dislocation must only be done in theatre under general anesthetic (7) in view of the possibility of compression of mediastinal structures (8) with cardiothoracic team on standby. However in the rare event of life threatening tracheal compression immediate reduction is necessary in emergency department itself using the towel clips (5).

References

1. Cope R, Riddervold HO, Shore JL, et al. Dislocation of the sternoclavicular joint: anatomic basis, etiologies, and radiologic diagnosis. *Orthop Trauma* 1991; 5(3): 379–84.
2. Denham RH, Jr., Dingley AF, Jr. Epiphyseal separation of the medial end of the clavicle. *J Bone J Surg* 1967, 49-A: 1179–83.
3. Cooper A. A Treatise on Dislocations and on Fractures of the Joints. Ed 3, p 559. London, Longman, 1824.
4. Rockwood CA, Wirth MA. Injuries to the sternoclavicular joints. In: Rockwood CA, Green DP, Bucholtz RW, Heckman JD., ed. *Fractures in adults*, 4th ed. Philadelphia: Lippincott-Raven, 1996: 1415–71.
5. Mirza AH, Alam K, Ali A. Posterior sternoclavicular dislocation in a rugby player as a cause of silent vascular compromise: a case report. *Br J Sports Med* 2005; 39(5): e28.
6. Kattan KR. Modified view for use in roentgen examination of the sternoclavicular joints. *Radiology* 1973; 108(1): 8.
7. Selesnick FH, Jablon M, Frank C, et al. Retrosternal dislocation of the clavicle: report of four cases. *J Bone Joint Surg* 1984; 66A: 287–91.
8. Sanders JO, Lyons FA, Rockwood CA. Management of dislocations of both ends of the clavicle. *J Bone Joint Surg* 1990; 72A: 399–402.

Received: November 05, 2007

Accepted: December 14, 2007

Published: December 20, 2007

Address for correspondence:

Vinay K Singh, MBBS, D Orth, MRCS

Department of Trauma & Orthopedics Surgery,

James Paget University Hospital,

Great Yarmouth,

U.K. NR31 6LA

Phone: 00 44 1493 452452

Fax: 00 44 1493 452451

Mobile: 00 44 7963636753

E-mail: we.publish@googlegmail.com

Author's contribution

A – Study Design

B – Data Collection

C – Statistical Analysis

D – Data Interpretation

E – Manuscript Preparation

F – Literature Search

G – Funds Collection

PREVENTION OF HEARING IMPAIRMENT IN SPORT SHOOTERS

Felicja Lwow^{1(A,B,C,D,E,F,G)}, Paweł Józków^{1(C,D,E,F)}, Wojciech Gawron^{2(D,E,F)}, Marek Mędraś^{1(D)}

¹Department of Sports Medicine, University School of Physical Education, Wrocław, Poland

²Department of Otolaryngology, Wrocław Medical University, Wrocław, Poland

Abstract

Lwow F, Józków P, Gawron W, Mędraś M. Prevention of hearing impairment in sport shooters. *Med Sport* 2007, 11(4): 108-112.

Background: Noise associated with training and competition poses a serious risk on sport shooters. Hearing trauma is one of the most important health hazards in this group of sportspersons.

Aim of the study: We assessed measures undertaken by individuals to prevent hearing trauma and searched for associations between parameters of noise exposure and health disturbances.

Material and methods: We surveyed 197 sport shooters (104 women and 93 men) aged 12-56, who represented 18 sport clubs from within one European country (Poland). Their level of performance varied from III sport class to champion class (Olympic champions). The length of exposure to shooting-noise was from under 1 year to more than 12 years.

Results: We have found that between 32-53% of women shooters and 39-48% of men shooters did not use any kind of hearing protection during training/competition. It was striking that though hearing disturbances were present in more than 20% of shooters only 36% of women and 53% of men underwent an audiometric examination during their careers.

Conclusions: Sport shooters are not sufficiently protected against hearing trauma and they do not undergo proper audiological screening. Preventive measures such as careful otolaryngological observation and wearing hearing protectors need further dissemination and application in this group of sportspersons.

Key words: firearms, sports, noise-induced hearing loss, prevention, protective devices

Introduction

Sport shooters are exposed to a specific acoustic environment of impulse character. During training and competition they receive an uncommonly high number of acoustic stimuli that derive from their own and other competitors' weapon.

Specific hearing trauma linked to exposure to impulse noise has been well documented (1-8). Audiometric evaluation in sport shooters typically reveals chronic hearing loss at 4 and 6 kHz (9-11).

Weapon-associated hearing loss is strongly dependent on individual predispositions (9). However the risk posed on the hearing organ may be substantially decreased by wearing individual hearing protection, performing regular hearing tests as well as through proper scheduling of shooting training/competition.

In an observational, cross-sectional study we wanted to assess measures undertaken by individual sport shooters to prevent hearing impairment. We also searched for associations between: the length of noise exposure, sport class, shooters' age and application of hearing protectors and hearing/health disturbances.

Material and methods

We surveyed 104 women (aged 12-30) and 93 men (aged 13-56) who participated in national shooting championships. They were members of 18 sport

clubs from different parts of Poland. Studied subjects represented international champion class/champion master (Olympic champions), I, II or at least III sport class. The length of their exposure to noise varied from under 1 year to more than 12 years.

Every sportsperson was asked to reveal any chronic diseases (and time of their diagnosis) and list medications received actually or in the past. Individuals with chronic conditions diagnosed prior the start of shooting training and ones that used potentially ototoxic agents were not included in the present investigation. Characteristics of the study group are presented in Figures 1-3.

Fig. 1. Age and sex of surveyed shooters

Fig. 2. Length of exposure to impulse noise (according to Dieroff et al. (12))

Fig. 3. Sport class of surveyed subjects

In a self-applied questionnaire surveyed subjects answered following questions.

1. Do you wear individual hearing protectors during training sessions: yes/no?
2. Do you wear individual hearing protectors during competitions: yes/no?
3. What kind of hearing protection do you use – note the brand and the type name?
4. Do you use hearing protectors designed specially against impulse noise: yes/no?
5. If you do not wear hearing protectors please give reasons why.

6. Do you undergo audiometric testing: yes/no?
7. Have you experienced any kind of transient/permanent hearing deterioration, recurrent otitis media or tinnitus: yes/no?
8. Can you see any effects of noise exposure on your daily life (e.g. headaches, somnolence, increased irritability/increased apathy in daily life, reduced stress tolerance, a habit of loud speaking): yes/no?
9. Who should control noise exposure in shooters (in your personal view)?

We assigned studied shooters to four phases of acoustic trauma according to classification by Dieroff (12):

1. habit phase, up to one year of exposition, with a considerable transient threshold shift,
2. compensation phase, from 2 to 4 years of exposition, adaptation to noise is most effective,
3. collapse phase, from 5 to 12 years of exposition, fastest dynamics of hearing impairment, saturation phase, hearing deterioration starts to slow down (Figure 2).

All statistical analyses were performed with use of Statistica 5.1 (1998, StatSoft, USA). Associations between variables were assessed by means of Chi-squared test. The level of statistical significance was determined at $p < 0.05$ and $p < 0.01$.

Results

During competition 48% of women and 61% of men declared to wear individual hearing protectors. During training these numbers were 68% and 52% respectively (Figure 4).

Fig. 4. Percentage of shooters wearing individual hearing protectors during training (I) and during competition (II), undergoing audiometric control (III), reporting hearing impairment (IV) or other health complications (V)

Fourteen percent of studied sportspersons revealed that the only reason to wear hearing protectors were competition regulations.

Women often used soft aural inserts (earplugs) that easily fit into external auditory canal. Among them

were: Insta-Hold, AMPW Silence, Ear-Classic. Men were more likely to use earmuffs (earphones) such as: Peltor H-9, Peltor H-7, Bilsom 727, Silencio KPA 84, Opta-OS-5N. Cotton wool by Bilsom was used only by men shooters (Figure 5).

Fig. 5. Types of individual hearing protectors used by studied shooters

Wearing hearing protectors during training, but not during competition, was positively associated with the length of exposure to shooting noise and age in men shooters (Table 1). Among women situation was opposite. Application of hearing protection during competition was positively associated with the length of exposure and age (Table 1).

Table 1. Associations between the length of shooting-noise exposure, sport class, age and application of hearing protectors

	Hearing protectors during training		Hearing protectors during competition	
	Men	Women	Men	Women
Length of exposure	8.56*	4.91	1.47	8.26*
Sport class	3.3	2.85	3.54	3.14
Age	8.9*	2.84	5.92	3.96*

Chi-squared test; * $p < 0.05$

Health problems were reported by 77% of women and 56% of men (Figure 4). Tinnitus, recurrent otitis media, transient hearing threshold shift or chronic hearing loss were present in 32% male and 23% female shooters (Figure 4). We have found a strong correlation between above conditions and sport class in men. Associations of hearing impairment with the length of exposure and age were less pronounced in studied subjects (Table 2).

Table 2. Associations between length of shooting-noise exposition, sport class, age and hearing impairment/health complications

	Hearing impairment		Other health complications	
	Men	Women	Men	Women
Length of exposure	8.5*	1.7	9.11*	0.44
Sport class	16.54**	0.125	5.49	8.07*
Age	8.33*	8.25*	13.33**	3.99

Chi-squared test; * $p < 0.05$; ** $p < 0.01$

In studied women, noise-induced hearing disturbances were associated with age, while symptoms such as headache, somnolence, increased irritability/apathy in daily life, reduced stress tolerance, habit of loud speaking correlated with sport class (Table 2).

Audiological tests are part of hearing impairment prevention programs. In our study group pure tone audiometry was performed more often in men (53%) than in women (36%) (Figure 4).

Discussion

Lack of individual hearing protection during shooting may result in transient or permanent hearing disturbances and a range of other health complications. A simple way to prevent such undesirable effects is to suppress acoustic stimuli before they reach shooter's ears.

In our observation a considerable group of shooters did not use any kind of hearing protection neither during training (32% of women and 48% of men) nor during competition (52% of women and 39% of men). However we have not noticed any consistent associations between application of hearing protectors and: length of exposure, sport class and age in the whole studied group (both genders considered).

Hearing organ evaluation in shooters usually reveals significant hearing loss in the frequency range 4-6 kHz. Alterations are also found at lower frequencies. Hearing disturbances induced by impulse noise initially reveal as alterations at frequencies exceeding 8 kHz (3,13,14).

We have found that in spite of the fact that hearing impairment and other health problems were frequent in shooters of both genders, audiometric control was not performed in 64% of women and 47% of men.

Pure tone audiometry testing allows detection of early stages of hearing loss if performed systematically. Some authors recommend combined screening that should consist of conventional-range pure tone audiometry and high frequency audiometry. It is reasonable to perform pure tone audiometry in the first phase of training and temporary threshold shift evaluation just after training. Such measures let evaluate changes of the threshold values and time needed to achieve the pre-training status. In this way the length and the intensity of training can be optimized. Exposure to impulse noise in the phase of physiological fatigue may lead to pathological fatigue and a permanent threshold shift. Shooters should be also well-informed on potential ototoxicity of drugs such as aminoglycosydes, diuretics or chinine (13).

Impulse noise may not only cause mechanical lesions to the middle ear but also to the cochlear hair cells localized close to the cochlear base (they are responsible for reception of impulses of frequencies higher than 8 kHz). It is a common finding that cochlear hair cells impairment does not correspond with the low frequency hearing loss in pure tone audiometry (2,3,14,15). Impairment of cochlear hair cells may be monitored with the use of otoacoustic emissions (13,16,17).

Impedance audiometry enables assessment of acoustic energy suppression proximally to the perceptive part of the cochlea (9,13). Impedance value assessment is crucial in the first year of training as it is the time of greatest dynamics of hearing deterioration. The same testing should be repeated after 5 years of exposure when substantial acceleration of hearing loss generation is observed (12,18).

Evaluation of hearing protectors' effectiveness is performed by application of acoustic signals of defined, constant character. However many authors point to high inertia and non-linear response of the suppressive system to acoustic signals (4,7,10,19). Impulse noise in sport shooting is characterized by high values of acoustic pressure (that exceed occupational noise exposure limits), short periods of signals' power increases and evolution of power spectrum density (10,20-22).

Suppressive effects of passive hearing protectors that are designed for protection against constant noise have not been confirmed in impulse noise environment (4,7,15,22). Among many reasons of such situation is lack of unitary criteria in methodology of acoustic tests. Nevertheless benefits of passive hearing protection, as compared with no protection, were shown in studies applying pure tone audiometry and

otoacoustic emissions. Subjects who wore protectors did not have any hearing threshold shift or otoacoustic emissions alterations (16,21).

In subjects studied by us a considerable group did not use hearing protectors because of physical discomfort (earmuffs) or skin allergic reactions (earplugs). Others reported difficulties in communication with colleagues or trainers. Several individuals indicated that hearing protectors negatively influenced their concentration. A few pointed to economical limitations as their individual expenses were not reimbursed by sport clubs.

In a number of studies proper fitting of hearing protectors has been emphasized. Training in earplugs insertion is important for good attenuation of impulse noise (15). Sufficient low-frequency attenuation may be achieved with combination of earmuffs and earplugs (5,6,23,24).

Individual preferences of shooters and matching acoustic environment with acoustic parameters of chosen protection (average sound suppression SNR, critical values levels for high, medium and low frequencies) are most important for fitting the protector (25-28). Hearing protectors attenuate noise by 10-30 dB, depending on the frequency (22). Their effectiveness against impulse noise is due to high frequency components of impulses (7). In rifle shooting the attenuation of earplugs (16 dB) and small-volume earmuffs (17dB) is not sufficient. In this discipline large-volume earmuffs are recommended. Any kinds of earmuffs are effective against impulses from large-caliber weapons with energy components at low frequencies. Also pistol and shotgun impulses are well attenuated by earmuffs. Especially effective against impulse noise of low frequency are earmuffs with regulation of suppression (7,20,28).

We can conclude that a thorough examination of the hearing organ should precede commencement of any long-term shooting training. It is advisable to perform audiological screening every 6 months during the first year of training and continue it annually. Otolaryngologists should decide on most appropriate diagnostic tests (pure tone audiometry, impedance audiometry and otoacoustic emissions).

At the same time combined use of earplugs and earmuffs is recommended for majority of impulse noise sources. Sport shooters are not sufficiently informed and not fully aware of benefits of using hearing protectors during training and competition.

Conclusions

1. Application of individual hearing protectors in sport shooters is insufficient.
2. Individual hearing protectors should be adjusted to specific impulse noise exposure and preferences of individual competitors.

3. Both men and women shooters do not have proper audiological screening though they often suffer from noise-related health disturbances.
4. Laryngological/audiological evaluation is necessary not only before commencement of training, but in regular intervals during sport career as well.

References

1. Hamernik RP, Ahroon WA, Hsueh KD. The energy spectrum of an impulse: its relation to hearing loss. *J Acoust Soc Am* 1991; 90: 197-204.
2. Counter SA, Borg E, Olofsson A. Oto-traumatic effects of computer simulated magnetic coil impulse noise: analysis of mechanisms. *Acta Otolaryngol (Stockh)* 1993; 113: 699-705.
3. Henselman LW, Henderson D, Subramaniam M, et al. The effect of 'conditioning' exposures on hearing loss from impulse noise. *Hear Res* 1994; 78:1-10.
4. Price GR. Hazard from impulse noise: Problem and prospects. *J Acoust Soc Am* 1994; 95: 2861-2.
5. Lusk SL. Noise exposures. Effects on hearing and prevention of noise induced hearing loss. *AAOHN J* 1997; 45: 397-408.
6. Prince MM, Gilbert SJ, Smith RJ, et al. Evaluation of the risk of noise-induced hearing loss among unscreened male industrial workers. *J Acoust Soc Am* 2003; 113: 871-80.
7. Starck J, Toppila E, Pyrkko I. Impulse noise and risk criteria. *Noise Health* 2003; 5: 63-73.
8. Tambs K, Hoffman HJ, Borchgrevink HM, et al. Hearing loss induced by noise, ear infections, and head injuries: results from the Nord-Trondelag Hearing Loss Study. *Int J Audiol* 2003; 42: 89-105.
9. Mc Bride DJ, Wiliam S. Audiometric notch as a sign of noise induced hearing loss. *Occup Environ Med* 2001; 58: 45-51.
10. Pekkarinen J, Iki M, Starck J, et al. Hearing loss risk from exposure to shooting impulses in workers exposed to occupational noise. *Br J Audiol* 1993; 27: 175-82.
11. Tambs K, Hoffman HJ, Borchgrevink HM, et al. Hearing loss induced by occupational and impulse noise: results on threshold shifts by frequencies, age and gender from the Nord-Trondelag Hearing Loss Study. *Int J Audiol* 2006; 45: 309-17.
12. Dieroff H. Larmschwerhörigkeit. Leipzig: Barth JA, 1976: 1-190.
13. Fausti SA, Wilmington DJ, Helt PV, et al. Hearing health and care: The need for improved hearing loss prevention and hearing conservation practices. *J Rehabil Res Dev* 2005; 42: 45-62.
14. Turkkahraman S, Gok U, Karlidag T, et al. Findings of standard and high-frequency audiometry in workers exposed to occupational noise for long durations. *Kulak Burun Bogaz Ihtis Derg* 2003; 10: 137-42.
15. Toivonen M, Paakkonen R, Savolainen S, et al. Noise attenuation and proper insertion of earplugs into ear canals. *Ann Occup Hyg* 2002; 46: 527-30.
16. Harding GW, Bohne BA, Ahmad M. DPOAE level shifts and ABR threshold shifts compared to detailed analysis of histopathological damage from noise. *Hear Res* 2002; 174: 158-71.
17. Hotz MA, Probst R, Harris FP, et al. Monitoring the effects of noise exposure using transiently evoked otoacoustic emissions. *Acta Otolaryngol* 1993; 113: 478-82.
18. McNamee R, Burgess G, Dippnall WM, et al. Predictive validity of a retrospective measure of noise exposure. *Occup Environ Med* 2006; 63: 808-12. Epub 2006 Jun 6.
19. Henderson D, Subramaniam M, Gratton MA, et al. Impact noise: the importance of level, duration, and repetition rate. *J Acoust Soc Am* 1991; 89: 1350-7.
20. Ylikoski M, Pekkarinen JO, Starck JP, et al. Physical characteristics of gunfire impulse noise and its attenuation by hearing protectors. *Scand Audiol* 1995; 24: 3-11.
21. Pawlaczyk-Luszczynska M, Dudarewicz A, Bak M, et al. Temporary changes in hearing after exposure to shooting noise. *Int J Occup Med Environ Health* 2004; 17: 285-93.
22. Paakkonen R, Lehtomaki K. Protection efficiency of hearing protectors against military noise from handheld weapons and vehicles. *Noise Health* 2005; 7:11-20.
23. Abel SM, Odell P. Sound attenuation from earmuffs and earplugs in combination: maximum benefits vs. missed information. *Aviat Space Environ Med* 2006; 77: 899-904.
24. Daniell WE, Swan SS, McDaniel MM, et al. Noise exposure and hearing loss prevention programs after 20 years of regulations in the United States. *Occup Environ Med* 2006; 63: 343-51. Epub 2006 Mar 21. Erratum in: *Occup Environ Med* 2006; 63: 436.
25. Paakkonen R, Lehtomaki K, Savolainen S, et al. Noise attenuation of hearing protectors against heavy weapon noise. *Mil Med* 2000; 165: 678-82.
26. Paakkonen R, Lehtomaki K, Myllyniemi J, et al. Ear plug fit and attenuation - an experimental study. *Acta Acustica united with Acustica* 2000; 86: 481-4.
27. Paakkonen R, Savolainen S, Myllyniemi J, et al. Noise attenuation of hearing protectors in human ear - a method description. *Acta Acustica united with Acustica* 2000; 86: 477-80.
28. Zera J. The measurement of impulse noise protection by earmuffs with the use of various sound sources. *J Acoust Soc Am* 2000; 108: 2621.

Received: October 02, 2007

Accepted: December 24, 2007

Published: December 31, 2007

Address for correspondence:

Felicja Lwow MSc, PhD

Department of Sports Medicine

University School of Physical Education

ul. Witelona 25 A, 51-612 Wrocław, Poland

e-mail: felicitas1@wp.pl

tel. (+48 071) 347 31 91, 347 31 20

Author's contribution

A – Study Design

B – Data Collection

C – Statistical Analysis

D – Data Interpretation

E – Manuscript Preparation

F – Literature Search

G – Funds Collection

EVALUATION OF ECOLOGICAL AWARENESS AMONG PHYSICALLY ACTIVE PEOPLE IN THE CONTEXT OF THEIR LIFESTYLE

Ewa Rembiałkowska^(A,D,E), Renata Kazimierczak^(D,E), Dominika Średnicka^(D,E,F), Angelika Jeżewska^(A,B,D,F)

Division of Organic Foodstuffs, Warsaw University of Life Sciences – SGGW, Warsaw, Poland

Abstract

Rembiałkowska E, Kazimierczak R, Średnicka D, Jeżewska A. Evaluation of ecological awareness among physically active people in the context of their lifestyle. *Med Sport* 2007, 11(4): 113-118.

Aim of the study: The main aim of the research was to evaluate and to compare the ecological awareness of people representing three groups: amateurs, competitors and trainers in the context of their physical activity and lifestyle.

Methods: Questionnaire survey concerning the ecological awareness covered 150 respondents living in Warsaw and representing different levels of physical activity: 1/3 of respondents represented amateurs, 1/3 – competitors and 1/3 – trainers. Sport status was a basal criterion for respondents' selection, while age and gender were not considered.

Results: The results show lack of education in the area of environmental problems, environmental protection and interactions between human and nature in all analyzed groups. Amateurs present relatively highest level of ecological awareness, however the level is still very low in all the groups. Moreover, there is a difference between theoretical knowledge and declarations of respondents and their real behaviors towards environment.

Conclusion: Promotion of healthy lifestyle based on physical activity should be connected with dissemination of environmental knowledge in order to sensitize people to relations between the nature, health and the quality of life.

Key words: ecological awareness, environment, lifestyle, amateurs, competitors, trainers.

Introduction

Human is an integral part of nature, therefore should try to coexist harmoniously with its particular elements. Rapid development of civilization in last centuries and rapid growth of world population cause dangerous shrinking of natural resources. Decreasing resources of drinking water, polluted air, tons of non-recyclable waste, massive deforestations – these are only few effects of modern lifestyle. Only full awareness of close relations between humans and nature can stop these and other destructive actions. That kind of awareness, defined through the triad of interdependent elements, such as ecological knowledge, system of pro-environmental attitudes and pro-environmental actions, is called ecological awareness.

Evaluation of the ecological awareness in different social groups enables to define populations that need education first of all and to find the most effective methods of education. Physically active people, amateurs as well as competitors or trainers, are often perceived as a pattern of healthy lifestyle. Evaluation of their ecological awareness' level enables to say if they are really examples to be followed. It also enables to say whether taking care over their health goes hand in hand with taking care over natural environment, therefore, if their behaviors are pro-environmental.

Materials and Methods

The research was conducted by a survey method. Questionnaire survey covered 150 respondents living in Warsaw and representing different levels of physical activity. 1/3 of respondents represented amateurs, 1/3 – competitors and 1/3 – trainers. Sport status was a basal criterion for respondents' selection, while age and gender were not considered.

Amateurs were defined as people, who practice sport for pleasure and for whom physical activity isn't a source of income. Second group (competitors) consisted of members of various organizations and sport clubs, mostly with education and professional preparation in the field of practiced sport discipline. People with required education and professional powers in some discipline, professionally active, were numbered among the trainers.

Respondents were found in several fitness clubs and in The Jozef Pilsudski University of Physical Education in Warsaw. Everyone was asked to fill up an anonymous survey composed of 18 thematic questions concerning ecological awareness, environmental knowledge and practical adaptation of this knowledge in everyday life.

The results were analyzed in order to evaluate and to compare the level of ecological awareness of respondents from all the groups.

Results

The results concerning ecological awareness level of analyzed groups have been formatted into tables and figures (using percentage values). Table 1 presents respondents' attitudes toward environmental issues.

Amateurs took undoubtedly the keenest interest in environmental problems in comparison to the other analyzed groups. They also read more environmental magazines and are more worried about the actual condition of the environment. At the same time only few from among competitors and trainers declare taking a keen interest in environmental issues. They also read ecological papers very rarely. What is more, condition of natural environment doesn't inspire their fears. Lack of people declaring total lack of interest in environmental problems in all analyzed groups can be taken as a positive result. Moreover, almost all respondents are aware of problems regarding pollution of the environment in Poland. The result obtained shows, that environmental protection isn't marginal problem any more. Most of people are fully aware that the problem exists and this awareness can facilitate conscious commitment of people in pro-environmental actions in the future.

Respondents taking a keen interest in environmental problems were additionally asked about the sources of their knowledge. Television and radio were the most often mentioned sources of information. The second place took press and literature. Only few respondents mentioned family home and school as a source of their environmental knowledge. This result shows that the importance of school education in enhancing ecological awareness is still very small.

To explain this issue respondents were asked if the subjects of ecology and environmental protection were taken up during their school education. Fig. 1 presents the results of the analysis.

Respondents giving positive answers were additionally asked about the quality and the quantity of received information. 24% of amateurs, 37% of competitors and 54% of trainers found the information quantitatively sufficient. At the same time 76% of amateurs, 63% of competitors and 46% of trainers admitted that this information contributed something new to their way of thinking.

Respondents were also asked about their opinion concerning the most sufficient ways of environmental protection. Table 2 presents results of the analysis.

Table 1. *Attitudes toward environmental problems*

Question/Issue	Answer	Amateurs n = 50 [%]	Competitors n = 50 [%]	Trainers n = 50 [%]
Attitude toward environmental issues	Take a keen interest	54	10	18
	Interested on occasion	46	90	82
	Lack of interest	0	0	0
Do You read environmental/ ecological newspapers/ magazines?	Yes	44	8	22
	No	56	92	78
Do You think that environment in Poland is polluted?	Yes	96	100	84
	No	4	0	16
To what degree the actual condition of environment inspires Your fear?	Very high	24	22	10
	High	64	44	68
	Low	12	34	22
	No	0	0	0

Table 2. *Opinions concerning effectiveness of factors which can be used in order to protect environment*

Factors	Amateurs n = 50 [%]	Competitors n = 50 [%]	Trainers n = 50 [%]
Strict environmental law	10	25	20
Consequent enforcing of the rules	32	35	20
Strong pressure of the Government on environmental issues	5	10	0
Financial situation of the state and citizens	0	5	10
Increase of local authorities' activity	5	0	0
Active help of individuals (all of us)	26	10	20
Wider range of environmental education	22	15	30

Fig 1. Presence of environmental issues in the program of school education

32% of amateurs and 35% of competitors admitted that consequent enforcing of the rules is unquestionably the best way of effective environmental protection. At the same time 30% of trainers gave weight to wider environmental education. Strict environmental law and active help of individuals were also found as important factors.

Next question in the survey involved the ranking of environmental elements in respect of necessity of it's protection (scale from 1 – for the element which needs the strongest and fastest protection to 6 – for the least important element). Possible answers were: clean air, drinking water, rare species of animals and plants, uncontaminated food, cleanliness of watering places,

beauty of the nature. The results, presented in table 3, were the same for all analyzed groups:

In opinion of respondents from all analyzed groups drinking water was the most important element to protect. The second place took clean air, then successively: uncontaminated food, rare species of animals and plants, beauty of the nature and cleanliness of watering places.

In the survey there were also some questions with the object of environmental knowledge evaluation. Respondents were asked about the names of Polish National Parks, about some protected species of plants and animals. Results are presented in table 4.

On the basis of this part of the survey it is possible to say, that the level of environmental knowledge isn't

Table 3. The ranking of environmental elements in respect of necessity of it's protection (scale from 1 – for the element which needs the strongest and fastest protection to 6 – for the least important element)

Environmental element to protect	Amateurs n = 50	Competitors n = 50	Trainers n = 50
Drinking water	1.5	1.2	1.8
Clean air	1.9	2.5	2.2
Uncontaminated food	2.8	3.1	2.9
Rare species of animals and plants	4.1	3.8	4.3
Beauty of the nature	5.2	4.9	5.2
Cleanliness of watering places	5.8	5.6	5.5

Table 4. Environmental knowledge (knowledge of Polish National Parks, protected animals and plants)

Question	Number of correct answers	Amateurs n = 50 [%]	Competitors n = 50 [%]	Trainers n = 50 [%]
Knowledge of National Parks in Poland	0	10	0	14
	1-3	40	52	50
	4	50	48	36
Knowledge of protected animals	0	10	8	6
	1-3	70	58	74
	4	20	34	20
Knowledge of protected plants	0	34	42	50
	1-3	56	58	50
	4	10	0	0

Table 5. Means of transport usually used in everyday life (percentage share)

Mean of transport	Amateurs n = 50 [%]	Competitors n = 50 [%]	Trainers n = 50 [%]
Bicycle	6%	16%	24%
Metro	36%	70%	64%
Tram	6%	0%	0%
On foot	0%	0%	4%
Car	42%	0%	6%
Bus	10%	14%	2%

Table 6. Classification of the means of transport from the most dangerous (1) to the least dangerous (6) for the environment

Mean of transport	Amateurs n = 50	Competitors n = 50	Trainers n = 50
Bus	1.4	1.2	1.4
Car	1.8	1.6	1.6
Tram	2.9	3.0	3.4
Metro	3.5	3.8	3.6
Bike	5.1	5.2	5.1
Going on foot	5.8	5.9	5.8

satisfactory in all analyzed groups. Less than half of respondents were able to name correctly 4 from among 23 National Parks existing in Poland, while 10% of amateurs and 14% of trainers weren't able to give even one correct answer. The most often appearing answers were Tatra National Park, Kampinos National Park and Białowieża National Park. The results regarding knowledge of protected animals and plants are also alarming. Only a fifth of respondents was able to name correctly 4 protected animals. Moreover, only few respondents were able to give 4 correct names of protected plants, while nearly half of them weren't able to name correctly even one. European bison, brown bear, sea eagle, beaver and lynx were often appearing names of animals, whereas lily of the valley, edelweiss and crocus were the most often mentioned protected plants.

Respondents were also asked to classify the means of transport (bicycle, metro, tram, going on foot, car, bus) in respect of the frequency of its use in everyday life. They were asked to estimate approximate percentage share of each used mean of transport. The answers are presented in table 5.

The results show that the most popular means of transport among respondents are metro, bus and car (together nearly 80%), whereas definitely less popular are trams, bikes and going on foot (about 20%). Choice of the form of communication is often limited due to the work place localization or due to limited availability of some means of transport. However, the strongest motivations of this choice are time saving (76%) and comfort (20%). Only 4% of respondents choose the mean of transport thinking of environmental consequences.

The next task for the respondents was classification of the means of transport (bike, going on foot, metro, tram, bus, car) from the most dangerous (1) to the least dangerous (6) for the environment. Respondents from all analyzed groups established the same order. The results are presented in table 6.

In opinion of all groups of respondents bus is definitely a mean of transport the most dangerous for the environment. At the same time car takes the second place. Then are successively: tram, metro, bike and going on foot. It is necessary to notice, that if we take into consideration scale of pollution counted per 1 passenger, car is definitely the most polluting mean of transport. However, respondents don't realize this fact.

In the next part of the survey respondents were asked, if they can, in their opinion, influence the environment as individuals. Fig. 2 presents the results of this analysis.

The majority of respondents are aware of their individual influence on the environment and its protection. They use to mention the care of natural environment near work- and living places and active popularization of ecological knowledge and pro-environmental attitudes as the most effective individual activities in the field of environmental protection. Participation in environmental movements and ecological organizations isn't very effective in their opinion. There is still quite numerous groups of respondents (especially among the trainers) who consider that individual activities has no meaning in environmental issues. First of all they motivate their opinion with the lack of influence on government's decisions.

The last analyzed issues regarded respondents' individual behaviors in their households in the context

Fig. 2. Awareness of individual influence on the environment

Table 7. Individual behaviours of respondents in their households in the context of environmental effects

Question	Answer	Amateurs n = 50 [%]	Competitors n = 50 [%]	Trainers n = 50 [%]
Do You save water in Your household?	Yes	42	72	62
	No	10	20	0
	Sometimes	48	8	38
Do You save energy in Your household?	Yes	52	64	90
	No	10	0	0
	Sometimes	38	36	10
Do You buy drinks in returnable packaging?	Yes	14	12	0
	No	76	18	42
	Sometimes	10	70	58
Do You use multiply use bags?	Yes	12	42	40
	No	56	38	38
	Sometimes	32	20	22
Do You choose detergents with environmentally friendly composition?	Yes	8	10	0
	No	68	44	70
	Sometimes	24	46	30

of its environmental effects. Questions concerned especially water and energy saving problems, choice of returnable packaging, multiply use bags, and the choice of detergents. The results are presented in table 7.

The results in table 7 presenting the real state of respondents' practical involvement in the environmental protection are quite pessimistic. Water and energy saving is generally determined by economic reasons. Care of the environment isn't strong motivation for the respondents in this issue. Pro-environmental activities, such as choice of multiply use bags or choice of environmentally friendly detergents are generally ignored, because of the lack of economic reasons.

Discussion

According to performed analysis, amateurs present relatively highest level of ecological awareness, however the level is still very low in all the groups.

Environmental knowledge is also extremely low among respondents. Moreover, there is a noticeable difference between respondents' awareness and their real behaviors towards environment. This considerable inconsistency between general environmental attitudes and behaviors confirms observations of other authors (1).

Strict environmental law, it's consequent enforcing, and economic motivation of pro-environmental behaviors can be effective factors enhancing ecological awareness. However, observed interest of respondents in environmental issues proves that well planned educational actions can be the best way to achieve desired results (2). Education can effectively enhance ecological awareness and consequently improve the condition of the environment. Therefore it is necessary to put emphasis on spreading ecological education on each level of human education (3).

It is very important to spread ecological knowledge among children in kindergartens and primary schools (4). Children absorb knowledge easily and easily adopt presented attitudes. In a consequence they instill this knowledge into family members and effectively influence older generations (5). However, education of adults is much more difficult. However, the mass media play a huge role in this process (6). Many results show that television, radio and press are the most effective media. Local authorities and various environmental organizations should take part in dissemination of information. After Główna ecological education should be available for general public, regardless of the age and social group and should be lead constantly (7).

According to the conducted survey, 93% of respondents think that the environment in Poland is polluted and that inspires serious fears of 77% respondents. According to the analysis made by Wiśniewski (8) in 1994, 85% of respondents noticed that Polish environment is polluted. Observed difference shows visible increase of interest in environmental problems in Poland for last 13 years. However, conducted survey shows necessity for ecological education in order to enhance ecological awareness of general public.

Conclusions

1. Amateurs present relatively highest level of ecological awareness, however the level is still very low in all the groups;
2. Respondents often declare interests in environmental issues, but their everyday behaviors usually don't confirm these declarations;
3. It is necessary to put emphasis on spreading ecological education on each level of human education.

References

1. Diekmann A, Preisendörfer P. Environmental behavior. *Rationality and Society* 1998; 10(1): 79-102.
2. Newerli-Guz JI. Organic food in the awareness of Polish producers and consumers (in Polish). PhD Thesis. Gdynia: Gdynia Maritime University. Faculty of Business Administration, 2005.
3. Cichy D. Youth organizations and shaping of ecological awareness (in Polish). In: Cichy D, ed. Shaping of ecological awareness among Polish young generation. I Seminar of Youth Ecological Movement. Warszawa: Institute of Youth Problems Research, 1988.
4. Cohen S, ed. Promoting ecological awareness in children. *Childhood education* 1992; 68(5): 258-60.
5. Parlak M. Ecological education in the process of early education (in Polish). Kielce: Pedagogic Publishing House ZNP, 2007.
6. Poskrobko B. Social factors of environmental protection (in Polish). In: Górka K, Poskrobko B, Radecki W, ed. Environmental protection: social, economical and legislative problems. Warszawa: PWE, 1995.
7. Główna M. Ecological education in practice. Education of adults. Educational notebooks (in Polish). Warszawa: The Institute of Educational Research. 1998; 23: 175-7.
8. Wiśniewski A. Ecological awareness of Polish consumers. Summary (in Polish). Warszawa: Quality Institute, 1995.

Received: November 02, 2007

Accepted: December 24, 2007

Published: December 31, 2007

Address for correspondence:

Ewa Rembialkowska

Headmaster of the Division of Organic Foodstuffs

Warsaw University of Life Sciences – SGGW

Warsaw 02-776, Nowoursynowska 159 c

tel. 48 22 59 37 0 38

fax. 48 22 59 37 0 36

e-mail: ewa_rembialkowska@sggw.pl

Author's contribution

A – Study Design

B – Data Collection

C – Statistical Analysis

D – Data Interpretation

E – Manuscript Preparation

F – Literature Search

G – Funds Collection

DAILY INTAKE OF MACRONUTRIENTS AND SELECTED MINERALS IN PHYSICALLY ACTIVE FEMALE STUDENTS IN COMPARISON WITH MALES OF MATCHED AGE AND PHYSICAL ACTIVITY

Grażyna Lutosławska^{1(A,C,D,E,G)}, Marzena Malara^{1(B,C,D,E)}, Krzysztof Mazurek^{2(A,G)}, Anna Czajkowska^{2(B,C,D)}

¹ Department of Biochemistry, ² Department of Physiology, University of Physical Education, Warsaw, Poland

Abstract

Lutosławska G, Malara M, Mazurek K, Czajkowska A. Daily intake of macronutrients and selected minerals in physically active female students in comparison with males of matched age and physical activity. *Med Sport* 2007, 11(4): 119-123.

Introduction: Many female sportsmen have sub optimal energy and nutrient intakes and are at risk on compromised nutritional status. Physical education female students are highly active due to study program, which includes different sports (gymnastics, swimming, track and field). In addition, at least some of them are engaged in specific sports at the club level. However, their dietary habits were not studied.

Aim of the study: This study was undertaken to analyze daily intakes of energy, macronutrients and selected micronutrients (iron, copper and zinc) in male and female physical education students of matched physical activity.

Methods: In all subjects daily intake of energy, macronutrients, iron, copper and zinc was briefly assessed from 24 h food records taken over 4 days (2 week days and weekend) and analyzed using a computer program FOOD 2.

Results: In 84.5% of females and in 67.5% of males inadequate energy intake was noted. In females 52.3% of all participants were at risk of iron deficiency, 94.4 % were at risk of copper deficiency and 25.7% were characterized by inadequate zinc daily intake. The respective values in males were 0.8%, 69.9 % and 12.2% of all subjects.

Conclusions: High percent of females in our study were characterized by inadequate total energy intake vs. recommended for highly active women. The percent of males consuming inadequate amount of energy was lower than females. In consequence the risk of iron, copper and zinc deficiency in active females was higher than in males. However, high risk of copper deficit in the diet was noted in both sexes.

Key words: males, females, physical activity, diet, minerals

Introduction

It is well documented that nutritional demands of the body are determined by age, sex and physical activity (1). At present there is no doubts that dietary habits may affect performance and numerous studies have focused on dietary needs of elite sportsmen engaged in exhausting, high volume training and competition (2,3).

On the other hand, there is a wealth of data indicating that female athletes due to pressure to lose weight practice unhealthy weight-control methods, mainly restricted food intake, but also diet pills or appetite suppressant (4). In consequence, many female sportsmen, particularly those who participate in sports that emphasize leanness (distance running, figure skating, gymnastics), have suboptimal energy and nutrient intakes and are at risk of compromised nutritional status (5-7). This unhealthy eating practices result in low body fat content, but also bring about menstrual disturbances, decreased bone mineral density and impaired immune function (8-10).

However, even in sports, which do not focus on low body fat energy intake in female athletes, failed to meet the recommendation (11-13).

According to Torsveit and Sundgot-Borgen (14) disordered eating habits, low bone mineral density and menstrual dysfunction are observed in 12.4-15.2% of young normally active females, but are more frequent (up to 26.9 % of all participants) in high-performance female athletes.

As a result of inadequate energy intake females frequently face the deficiency of minerals. It is well documented that the prevalence of iron deficit is likely to be higher in athletic groups, especially in young female athletes, than in healthy sedentary individuals (15,16).

However, it should be stressed that limited energy intake results also in inadequate other minerals supply. Lukaski et al. (17,18) have indicated that the mean copper intake in female club level swimmers covered only 52% of the safe intake level. Similarly low daily copper intake has been reported in females engaged in different endurance sports at international and national level (12). In addition, in the cited studies copper to zinc ratio in the diet was high (8.0-8.7) suggesting depressed copper absorption (19).

Taking into account substantial role of copper in iron absorption it seems likely that low copper intake

concomitantly with unfavorable zinc to copper ratio even further disturb iron homeostasis (20).

On the other hand, despite energy and minerals deficiency in the diet micronutrient status in female athletes appeared relatively unaffected, probably due to their regular use of supplements (21). In contrast, about 20% of young sedentary females not taking supplements were recognized iron deficient without anemia (22). The percent of iron deficiency was even higher (36% of all participants) in recreationally active young women (23).

It is worthy to note that the above-mentioned hazardous dietary habits and its consequences are not limited to female athletes. Excessive dieting is common among young females who do not accept their body and are aimed at leanness (24-26).

Physical education students are highly active due to study program, which includes different sports (gymnastics, swimming, track and field). In addition, at least some of them are engaged in specific sports at the club level. However, their dietary habits were not studied.

Thus, this study was undertaken to analyze daily energy, macronutrients and selected micronutrients intake (iron, copper and zinc) in female and male physical education students of matched physical activity.

Materials and Methods

Subjects

A total of 232 subjects (123 males and 109 females) volunteered to participate in the study. All the subjects were healthy physical education students engaged in different sports (swimming, track and field, games). None of the participants were taking mineral supplements on the regular basis. All the women participating in the study reported regular menses and were not taking hormonal contraceptives. The subjects were informed about experimental procedure and gave their written consent prior to the participation. Study protocol was approved by the Ethics Commission in the University of Physical Education.

Dietary records

In all subjects daily intake of energy, macronutrients, iron, copper and zinc was briefly assessed from 24 h food records taken over 4 days (2 week days and weekend) and analyzed using a computer program FOOD 2 purchased from the Institute of Food and Nutrition in Warsaw. A set of pictures of meals and foods were shown to the subjects by an experienced interviewer. The household measures of food intake were converted into gram weights. An interviewer assigned codes to the food reported by the participants and performed computer analysis. The mean daily intake of micronutrients in males and females were compared with the respective safe intake levels.

Individual data of the daily intakes were compared with 2/3 of the respective safe intake levels. Subjects consuming daily less than 2/3 of the safe intake levels were recognized as being at risk of deficiency (27).

Statistical analysis

Data distribution was tested using Shapiro-Wilk test. Normally distributed data were compared using unpaired Student t-test. Data that did not fit to normal distribution were compared using nonparametric Mann-Whitney test. The significance was set at $p < 0.05$. Data are presented as mean $\pm$ SD. All the calculations were performed using Statistica v. 7.1 (StatSoft, USA).

Results

Male and female subjects did not differ with respect to age and weekly physical activity (Table 1). The mean energy intake in females covered 71.9% and in males 88.4% of recommended intake for subjects with high physical activity (Table 2). The percent of energy derived from protein did not differ in male and female students. In contrast, the percent of energy derived from fat in males was significantly higher ($p < 0.005$), but percent of energy derived from carbohydrates was significantly lower ($p < 0.004$) than in female participants. In females the mean daily iron intake covered 67.8%, in males - 135 % of the safe intake level. The mean copper intake covered 40.0 % and 56.0 % of the safe intake level in females and males, respectively. In female participants the mean zinc daily intake covered 83.0%, in males 96.4% of the safe intake level. Zinc to copper ratio in the diet in males was markedly higher than in females ($p < 0.001$). In female group 52.3% of participants were at risk of iron deficiency, 94.4 % were at risk of copper deficiency and 25.7% were characterized by inadequate zinc daily intake (Table 3). The respective values in males were 0.8%, 69.9 % and 12.2% . Nutritional density of iron and copper in males was lower than in females ($p < 0.001$). No between sex differences were noted with respect to zinc nutritional density (Table 4).

Table 1. *Subjects characteristics (mean $\pm$ SD)*

	Females (n=109)	Males (n=123)
Age (years)	20.5 $\pm$ 1.4	21.1 $\pm$ 1.6
Body mass (kg)	60.4 $\pm$ 9.5	78.7 $\pm$ 10.9
Body height (cm)	168.6 $\pm$ 6.6	180.8 $\pm$ 6.0
BMI	21.2 $\pm$ 3.0	24.1 $\pm$ 2.7
Activity (h/week)	10.2 $\pm$ 3.8	9.0 $\pm$ 2.1

Table 2. Daily intake of energy, macronutrients and minerals in male and female subjects (mean $\pm$ SD)

	Females (n=109)	Males (n=123)
Energy (kcal)	1763 $\pm$ 568 (71.9)*	2961 $\pm$ 769 (88.4)*
Protein (g)	60.7 $\pm$ 17.8 (14.5 $\pm$ 2.7)**	103.9 $\pm$ 30.8 (14.5 $\pm$ 8.3)**
Fat (g)	68.0 $\pm$ 29.5 (33.5 $\pm$ 7.0)**	120.3 $\pm$ 39.2 (36.0 $\pm$ 6.0)** a
Carbohydrates (g)	240.6 $\pm$ 77.3 (52.0 $\pm$ 7.0)**	383.6 $\pm$ 110.4 (49.5 $\pm$ 6.1)** b
Iron (mg)	9.5 $\pm$ 2.8 (67.8)^	14.8 $\pm$ 4.7 (135)^
Copper (mg)	1.0 $\pm$ 0.3 (40.0)^	1.4 $\pm$ 0.4 (56.0)^
Zinc (mg)	8.3 $\pm$ 2.6 (83.0)^	13.5 $\pm$ 4.0 (96.4)^
Zn/Cu	8.8 $\pm$ 1.8	10.1 $\pm$ 1.9 ^c

* percent of recommended intake; ** percent of energy derived from the respective macronutrient; ^ - percent of the safe intake level;

^a p<0.005 – significantly higher vs. females; ^b p<0.004 – significantly lower vs. females; ^c p<0.001 – significantly higher vs. females

Table 3. Percent of subjects at risk of micronutrient deficiency

	Females (n=109)	Males (n=123)
Iron	52.3 (57)*	0.8 (1)
Copper	94.4 (103)	69.9 (86)
Zinc	25.7 (28)	12.2 (15)

*- in brackets – number of subjects

Table 4. Nutritional density (mg/1000 kcal) of iron, copper and zinc in the diet of male and female subjects (mean $\pm$ SD)

	Females (n=109)	Males (n=123)
Iron	5.5 $\pm$ 1.2	5.0 $\pm$ 0.9 ^a
Copper	0.6 $\pm$ 0.1	0.5 $\pm$ 0.1 ^a
Zinc	4.9 $\pm$ 1.0	4.6 $\pm$ 0.9

^a p<0,001 – significantly lower vs. females

Discussion

Our study indicated that both female and male subjects consumed excess of protein providing 14,4 – 15,3 % of energy against recommended 10-11% (28). This is in agreement with others data which indicated too high protein intake in Polish adolescents and students (29,30). In addition, diet of our subjects contained

too much fat providing more than 30% of total energy (31). It is worthy to note that similar fat intake have been found by Gilis-Januszewska et al. (32) in male and female Cracow residents aged 45- 64 years.

However, in the present study dietary habits of females were more favorable since the percent of energy from fat was slightly, but significantly lower and percent of energy from carbohydrates – slightly but significantly higher than in males.

It should be stressed that the percent of energy derived from carbohydrates in males of our study (less than 50%) was similar to that reported by Pardo et al. (33) for Warsaw residents aged 35-64 years. However, in both male and female subjects were lower than recommended (34).

Thus, it could be postulated that dietary habits of our subjects were typical for Polish population with excess of protein and fat and inadequate carbohydrate consumption.

The mean iron intake in females of the present study covered 67.8% of the safe intake level (14 mg/day) and was by 17% lower than reported in female adolescents and by 47% lower than in female medical students (35,36). However, the mean daily intake of iron in our females were similar to that reported by Poprzęcki et al. (37) in female endurance athletes with high incidence (62.5% of all subjects) of iron deficiency.

Taking into account high physical activity of our participants and their low daily iron intake it could be postulated that they are at risk of depleted iron stores in the body. This assumption was strengthened by the analysis of individual iron daily intake of our females indicating that 52.3% of all females were at risk of iron deficiency consuming daily less than 2/3 of the safe intake level. It is worthy to note that only one male subject consumed inadequate amount of iron in the diet (i.e. less than 2/3 of the safe intake level - 11 mg/day).

Both female and male participants were characterized by low copper intake since it covered only 40% and 56% of the safe intake level (2.5 mg/day) in females and males, respectively and was lower than reported by others in Polish students and adolescents (35,36), however was similar to that reported by Grooper et al. (38) in sedentary young females.

The risk of copper deficiency in females (94.4% of all women) was much higher than in males (69.9% of all men). On the other, hand it should be pointed out that in both males and females high zinc to copper ratio (>6.0) in the diet could adversely affect copper absorption contributing to the depletion of its stores in the body (19,39,40).

Moreover, potential copper deficiency due to inadequate intake in the diet and adverse effect of zinc excess may be detrimental for iron homeostasis.

It is well documented that in copper-deficient mice and rats pronounced disturbances in iron absorption was noted due to depressed activity of copper containing ferroxidases – ceruloplasmin and hephaestin (41,42).

The mean zinc intake in female students covered 83% of the safe intake level (10 mg/day), in males covered 96.4% of the safe intake level (14 mg/day) and was similar to that reported by Ball and Ackland (43) in young men and women. In consequence, the risk of zinc deficiency was observed in 25.7% of female and only in 12.2% of male participants consuming less than 2/3 of the respective safe intake level.

The above data indicated that physically active females are at greater risk of iron, copper and zinc deficiency in comparison with males of matched physical activity. However, it is worthy to note that nutritional density of iron and copper in females was greater than in males indicating that females consumed more of these elements per each 1000 kcal than their male counterparts. Thus, diet quality in females was more favorable than in males.

On the other hand, high percent of females in our study (84.5%) were characterized by inadequate total energy intake recommended for highly active women (2450 kcal/day) (1). Therefore it could not be excluded that they were on low caloric diets.

It should be stressed that among young Polish women aged 18.5–23.0 years about 60% are on low caloric diets to reduce body mass (44) and the same could not be excluded in female subjects of the present study.

Taking into account high physical activity of our subjects caloric restriction in active women may be hazardous for their health possibly resulting in the deficiency of essential micronutrients.

The frequency of too low caloric intake (less than recommended 3350 kcal/day) in male subjects of the present study was less than in females (67.5%) and in consequence they were characterized by lower risk of micronutrients deficit. However, both sex were at high risk of copper deficiency.

Acknowledgment

This study was supported by the grant DS-77 and DS-108 from the University of Physical Education in Warsaw

References

1. Gertig H, Przysławski J. Bromatology. Principles in food and nutrition. PZWŁ, Warsaw, 2007 (in Polish).
2. Economos CHD, Bortz S, Nelson ME. Nutritional practices of elite athletes. *Sports Med* 1993; 16: 381-99.
3. Maughan RJ, Burke LM. Nutrition for sports performance. Kraków: Medicina Sportiva, 2000 (in Polish).
4. Sundgot-Borgen J. Eating disorders, energy intake, training volume, and menstrual function in high-level modern rhythmic gymnasts. *Int J Sport Nutr* 1996; 6: 100-9.
5. Benson JE, Engelbert-Fenton KA, Eiseman PA. Nutritional aspects of amenorrhea in the female athlete triad. *Int J Sport Nutr* 1996; 6: 134-45.
6. Ziegler P, Nelson JA, Barrat-Fornell A. et al. Energy and macronutrient intakes of elite figure skaters. *J Am Diet Assoc* 2001; 101: 319-25.
7. Ziegler P, Sharp R, Hughes V. et al. Nutritional status of teenage female competitive figure skaters. *J Am Diet Assoc* 2002; 102: 374-9.
8. Kraiserauer S, Snyder AC, Sleeper M. et al. Nutritional, physiological, and menstrual status of distance runners. *Med Sci Sports Exerc* 1989; 21: 120-5.
9. Montero A, López-Vaela S, Nova E. et al. The implication of the binomial nutrition-immunity on sportswomen's health. *Eur J Clin Nutr* 2002; 56 (Suppl 3): 538-41.
10. Birch K. Female athlete triad. *Br Med J* 2005; 330: 244-6.
11. Felder JM, Burke LM, Lowdon BJ. et al. Nutritional practices of elite female surfers during training and competition. *Int J Sport Nutr* 1998; 8: 36-48.
12. Raczyńska B, Szczepańska B, Siwińska D. et al. Zinc and copper content and their interrelations in daily food rations of the endurance athletes. *Biol Sport* 1999; 16: 179-89.
13. Volek JS, Forsythe CE, Kraemer WJ. Nutritional aspects of women strength athletes. *Br J Sports Med* 2006; 40: 742-8.
14. Torsveit MK, Sundgot-Borgen J. The female athlete triad exists in both elite athletes and controls. *Med Sci Sports Exerc* 2005; 37: 1449-59.
15. Beard J, Tobin B. Iron status and exercise. *Am J Clin Nutr* 2000; 72 (suppl): 594S-7S.
16. Akabas SH, Dolins KR. Micronutrient requirements of physically active women: what can we learn from iron? *Am J Clin Nutr* 2005; 81(suppl): 1246S-51S.
17. Lukaski HC, Hoverson BS, Gallagher SK. et al. Physical training and copper, iron and zinc status of swimmers. *Am J Clin Nutr* 1990; 51: 1093-9.
18. Lukaski HC, Siders WA, Hoverson BS. et al. Iron, copper, magnesium and zinc status as predictors of swimming performance. *Int J Sports Med* 1996; 17: 535-540.
19. Prasad AS, Brewer GJ, Schoomaker EB. et al. Hypocupremia induced by zinc therapy in adults. *JAMA* 1978; 240: 2166-8.
20. Linder MC, Hazegh-Azam M. Copper biochemistry and molecular biology. *Am J Clin Nutr* 1996; 63: 797S- 811S.
21. Beals KA, Manore MM. Nutritional status of female athletes with subclinical eating disorders. *J Am Diet Assoc* 1998; 98: 419-25.
22. Pynaert I, Delanghe J, Temmerman M. et al. Iron intake in relation to diet and iron status of young adult women. *Ann Nutr Metab* 2007; 51: 172-181.
23. Sinclair LM, Hinton PS. Prevalence of iron deficiency with and without anemia in recreationally active men and women. *J Am Diet Assoc* 2005; 105: 975-978.
24. McCargar LJ, McBurney RF. The chronic dieting syndrome: metabolic and behavioural characteristics. *Can J Diet Pract Res* 1999; 60: 227-30.
25. Akande A. Sex differences in preferences for ideal female body shape. *Health Car Women Int* 1993; 14: 249-59.
26. Grover VP, Keel PK, Mitchell JP. Gender differences in implicit weight identity. *Int J Eating Dis* 2003; 34: 125-35.
27. Ziemiański Ś. Interpretation of dietary recommended allowances – at present and in the future. In: Dietary allowances in men. Physiological basis. Ziemiański Ś, ed. Warszawa: PWZŁ, 2001: 17-34. (in Polish)
28. Bułhak-Jachymczyk B. Human energy requirements. In: Dietary allowances in men. Physiological basis. Ziemiański Ś, ed. Warszawa: PWZŁ, 2001: 35-57. (in Polish)
29. Ostrowska L, Czapska D, Karczewski J. Evaluation of protein, fat and carbohydrates content in daily dietary allowances of students with overweight and obesity in the Medical Academy of Białystok. *Roczn PZH* 2001; 52: 247-56. (in Polish).
30. Ustymowicz-Farbiszevska J, Smorczewska-Czupryńska B, Karczewski J. et al. Qualitative and quantitative evaluation of dietary habits of youth from Białystok and suburbia. *Wiad Lek* 2002; 50 (suppl 1): 550-5. (in Polish)
31. Ziemiański Ś. Dietary fat recommendation. In: Dietary allowances in men. Physiological basis. Ziemiański Ś, ed. Warszawa: PWZŁ, 2001: 78-114. (in Polish)

32. Gilis-Januszewska A, Topór-Mądry R, Pająk A. Education and the quality of diet in women and men at age 45-64, residents of Cracow. *Przegląd Lekarski* 2001; 60: 675-81 (in Polish).
33. Pardo B, Sygnowska E, Waśkiewicz A. et al. Fat consumption in daily food rations of Warsaw residents. *Pol Tyg Lek* 1992; 57: 22-23. (in Polish)
34. Ziemiański Ś. Dietary carbohydrate recommendation. Dietary allowances in men. Physiological basis. Ziemiański Ś, ed. Warszawa PWZL, 2001: 58-77. (in Polish)
35. Augustyniak U, Brzozowska A. Nutrient intake of the adolescents in Poland on the basis of literature from last ten years (1990-2000). *Roczn PZH* 2002; 53: 399-406. (in Polish).
36. Charkiewicz WJ, Charkiewicz AE, Markiewicz R. et al. Realization of recommended dietary allowances for selected minerals and vitamins in daily diets of students from Medical University of Białystok. *Żyw Człow Metab* 2007; 34: 128-31. (in Polish)
37. Poprzęcki S, Żebrowska A, Pokora I, Zając A. Iron status in female endurance athletes. *Żyw Człow Metab* 2007; 34: 434-9. (in Polish)
38. Grooper SS, Sorrells LM, Blessing D. Copper status of collegiate female athletes involved in different sports. *Int J Sport Nutr Exerc Metab* 2003; 13: 43-57.
39. Fischer PWF, Giroux A, L'Abbé MR. Effect of zinc on copper status in adult men. *Am J Clin Nutr* 1984; 40: 743-746.
40. Reeves 1998PG, Briske-Anderson M, Johnson L. Physiologic concentration of zinc affect the kinetics of copper uptake and transport in the human intestinal cell model, Caco-2. *J Nutr* 1998; 128: 1794-1801.
41. Reeves PG, DeMars LCS, Johnson T. et al. Dietary copper deficiency reduces iron absorption and duodenal enterocyte hephaestin protein in male and female rats. *J Nutr* 2005; 135: 92-8.
42. Chen H, Huang G, Su T. et al. Decreased hephaestin activity in the intestine of copper-deficient mice causes systemic iron deficiency. *J Nutr* 2006; 136: 1236-41.
43. Ball MJ, Ackland ML. Zinc intake and status in Australian vegetarians. *Br J Nutr* 2000; 83: 27-33..
44. Kolarzyk E, Skop-Lewandowska A. The characteristics of chosen dietary behaviour of Cracow medical students and pupils. *Żyw Człow Metab* 2007; 34: 188-93. (in Polish).

Received: November 08, 2007

Accepted: December 24 , 2007

Published: December 31, 2007

Address for correspondence:

Grażyna Lutosławska

Department of Biochemistry

University of Physical Education

00-968 Warsaw 45

PO box 55

E-mail: grazyna.lutoslawska@awf.edu.pl

Author's contribution

A – Study Design

B – Data Collection

C – Statistical Analysis

D – Data Interpretation

E – Manuscript Preparation

F – Literature Search

G – Funds Collection