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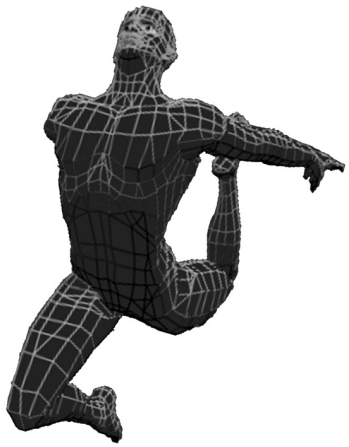
HUMAN MOVEMENT



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EDITORIAL

The 10th Anniversary of *Human Movement*

Ten years ago the Senate of the University School of Physical Education in Wrocław decided to launch a scientific journal *Człowiek i Ruch*. According to its first Editor-in-Chief, Dr hab. nauk med. Jan Łazowski, its main objective was to "publish original papers meeting the highest scientific standards, review papers, meta-analyses and conceptual reports" in the area of physical culture sciences. The first article published in *Człowiek i Ruch* was a review paper entitled "Co ma wspólnego kultura fizyczna z kulturą?" ("What does physical culture have in common with culture?") by Professor Henryk Grabowski.

The subsequent Editor-in-Chief, Prof. dr hab. Artur Jaskólski invited a great number of renowned scholars and scientists from all over the world to join the expanding journal's Advisory Board. Many of them are still working with us. Under Prof. Jaskólski's editorship the journal started to be published in English under the title of *Human Movement.*

Between 2006 and 2008 the *Human Movement* Editor-in-Chief was Prof. dr hab. Ryszard Panfil. During his tenure the journal entered an agreement with Versita to publish online on a MetaPress platform.

At present *Human Movement* is published jointly by the University School of Physical Education in Wrocław, University School of Physical Education in Poznań and University School of Physical Education in Kraków. In recent years there has been a growing interest in our journal from many contributors from Poland and abroad. The journal has received 6 points in the Polish Ministry of Science and Higher Education (MNiSzW) scoring for edition in 2010. From 2011 on we intend to publish *Human Movement* on a quarterly basis.

On behalf of the Editorial Board I would like to express my sincere thanks to all those who have been working with *Human Movement* from the very beginning, members of the Editorial Board and Advisory Board, translators, editors and – first and foremost – reviewers and contributors. I hope *Human Movement* will maintain its position as a top-level journal of exchange of ideas among physical culture scientists and scholars.

New member of the Advisory Board

It is our great pleasure to welcome Prof. dr hab. Andrzej Pawłucki as a new member of the *Human Movement* Advisory Board. His scholarly achievements, extensive professional knowledge and relations with the international scientific community constitute a great endorsement to our journal and will surely increase its scientific quality.

Retraction notice

We regret to inform that the article "The study of lung flow limitations in aerobically trained children" by Mohsen Ghanbarzadeh, Abdolhamid Habibi, Masoud Nikbakhat, Gholamhosain Ebadi, Hossein Poursoltani published in the last volume of *Human Movement*, 2009, 10 (2), 96–108, is a case of plagiarism. The above-mentioned authors gave their names to the article "Exercise flow-volume loops in prepubescent aerobically trained children" by Cedric Nourry, Fabien Deruelle, Claudine Fabre, Georges Baquet, Frederic Bart, Jean-Marie Grosbois, Serge Berthoin, and Patrick Mucci published in *Journal of Applied Physiology*, 2005, 99, 1912–1921. This is an unethical act in disregard of the principles of authorship as well as a breach of copyright and the Berne Convention for the Protection of Literary and Artistic Works.

Despite all our procedures (authors submitting manuscripts for publication in *Human Movement* should include a written statement that the work has not been published previously or submitted elsewhere for review) we failed to disclose this reprehensible misdeed in the editorial process. We apologize to the authors of the original article, publishers of *Journal of Applied Physiology* and readers of both journals.

The article has been retracted at the request of the authors and the American Physiological Society (APS) which drew the matter to our attention.

HUMAN MOVEMENT
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WHAT INFLUENCES RACE PERFORMANCE IN MALE OPEN-WATER ULTRA-ENDURANCE SWIMMERS: ANTHROPOMETRY OR TRAINING?

DOI: 10.2478/v10038-009-0021-3

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ABSTRACT

Purpose. We investigated the relationship between selected variables of anthropometry and training with race performance during a 26.4 km open-water ultra-endurance swim at 23°C in male master ultra-swimmers. **Basic procedures.** Fifteen non-professional male open-water ultra-endurance swimmers who were (mean ± SD) 40.0 (8.2) years of age with 83.7 (10.3) kg body mass, 1.80 (0.08) m body height and a BMI of 25.5 (2.5) kg/m^2 finished the race within the time limit. Body mass, percent body fat, thickness of 7 skin folds, body height, length of arm, and length of leg were measured prior to race. The number of years as active swimmer, average weekly training volume in hours and kilometres and average speed in training were recorded. The variables were then correlated to total race time. **Main findings.** Study participants had mean finish times of 551 (100) min and an average speed of 3.0 (0.5) km/h. Speed in swimming during training was the only variable related to total race time ($r = -0.66$, $p = 0.0037$) whereas none of the other investigated variables showed an association. **Conclusions.** We conclude that anthropometry was not related to race performance in these male ultra-endurance swimmers whereas speed in training showed a moderate association with total race time.

Keywords: ultra-endurance, skin-fold thickness, anthropometry, percent body fat

Introduction

Different factors are known to have an influence on endurance performance. Apart from several physiological parameters, a variety of anthropometric variables show a relationship with endurance performance. Body height [1], body fat [2, 3], upper extremity length [4], and skin-fold thickness [5] have been shown to be related to performance in competitive swimmers.

Apart from anthropometry, training variables [5–11] are also of importance. In competitive swimmers, Anderson et al. [5] could demonstrate that a combination of fitness and technique factors were important for competitive performance. According to Costill et al. [7], training intensity might be of greater importance than training volume in swimmers. In contrast, Stewart and Hopkins [8] found that better performance in swimmers over 50 m to 400 m was significantly associated with greater weekly training mileage. In a very recent study, Faude et al. [9] demonstrated that high-training volumes had no advantage in performance when compared to high-intensity training of lower volume. However, too intensive a training is counter productive. Raglin et al. [10] found in a training study of swimmers that peak training of 8.3 km per day led to a reduction in anaerobic swimming power.

Regarding open-water swimmers, Van Heest et al. [11] reported that elite open-water swimmers were smaller and lighter than competitive pool swimmers. It is probable that swimmers with more body fat are able to endure longer time periods in cold water [12] since swimmers with less subcutaneous fat get out of the water after significantly less time during a swim in water of 9.4°C compared to 11.0°C [13]. However, in a study of male pool-swimmers in a 12 hour swim, no correlation of anthropometric variables such as body fat to race performance was found [14].

The aim of the study was to investigate the relationship of anthropometric and training variables with total race time in male open-water ultra-endurance swimmers. The variables we included as potential anthropometric predictors were body mass, percent body fat, thickness of 7 skin folds, body height and length of arm and leg, while training factors included average speed in training and average weekly training volume. These variables are considered to be related to performance in

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short-distance pool-swimmers. Since open-water swimmers, in contrast to pool-swimmers, have to swim in rather cold water [12], we expected that body fat would show an association with race performance. Our working hypothesis was that ultra-swimmers with a high percentage of body fat would be faster than swimmers with a low percentage.

Material and methods

Subjects

The organiser of the 'Marathon Swim' in Lake Zurich 2008 contacted all participants upon inscription to the race by a separate newsletter and informed them about the planned investigation. A total of 26 male solo swimmers started in the race. Fifteen male swimmers participated in our study. The study was approved by the Institutional Review Board of St. Gallen, Switzerland, for use of human subjects and the athletes gave their informed written consent. The anthropometric data and training variables of the athletes are presented in Tab. 1. All the swimmers were trained and experienced open-water swimmers. Three of the swimmers had already swum across the English Channel between Dover (England) and Calais (France).

The race

The 21st edition of the 'Marathon Swim' in Lake Zurich, Switzerland, took place on 3 August 2008. Ultra-swimmers from all over the world started in this race, the longest open-water ultra-swimming contest in Europe. The idea of this race with its first edition in 1977 was the opportunity for open-water swimmers to prepare for the Channel swim. Several swimmers preparing to cross the Channel from Dover to Calais were using this competition as practice. The swimmers started in the morning at 07:00 a.m. in Rapperswil and had to swim to Zurich; covering a total distance of 26.4 km within a time limit of 14 h (840 min). Athletes were followed by a personal support boat with a crew providing nutrition and fluids. The weather was moderate during the whole day, for details see Tab. 2.

Measurements and calculations

Before the start of the race, body mass, length of extremities, body height and skin-fold thicknesses at 7 sites were measured. Body mass was determined using a commercial scale (Beurer BF 15, Beurer GmbH, Ulm, Germany) to the nearest 0.1 kg. Body height was measured using a stadiometer to the nearest 1 cm. Percentage of

Table 1. The association of anthropometric and training variables for the 15 swimmers with race time

Variable		*r*	*p*
Body mass (kg)	83.7 (10.3)	–0.07	n.s.
Body height (m)	1.80 (0.08)	–0.29	n.s.
BMI (kg/m^2)	25.5 (2.5)	0.40	n.s.
Length of arm (cm)	81.1 (3.0)	0.34	n.s.
Length of leg (cm)	86.2 (4.7)	–0.42	n.s.
Percent body fat (%)	17.9 (4.8)	0.28	n.s.
Sum of 7 skin folds (mm)	90.0 (36.4)	–0.30	n.s.
Number of years as active swimmer	17.6 (16.1)	0.33	n.s.
Average number of kilometres swum per week	15.8 (6.9)	0.01	n.s.
Average number of hours swum per week	6.7 (3.8)	0.27	n.s.
Average speed in training (km/h)	3.4 (0.5)	–0.66	0.0037

p-value is shown after Bonferroni correction

Table 2. General weather conditions during the race

	Start at 07:00	12:00	Finish at 19:00
Air temperature (°C)	20.4	24.5	28.1
Water temperature (°C)	23.1	23.3	24.1
Relative humidity (%)	73	55	42
Wind (m/s)	3.1	5.5	4.7
Direction of the wind (°)	178	281	292

Data were generously provided by the Sea Police Zurich

body fat was calculated using the following anthropometric formula: Percent body fat = 0.465 + 0.180(Σ7SF) – 0.0002406(Σ7SF)^2 + 0.0661(age), where Σ7SF = sum of skin-fold thickness of chest, midaxillary, triceps, subscapular, abdomen, suprailiac and thigh mean, according to Ball et al. [15]. This formula was evaluated using 160 men aged 18–62 years and cross-validated using DXA (dual energy X-ray absorptiometry). The mean differences between DXA percent body fat and calculated percent body fat ranged from 3.0% to 3.2%. Significant ($p < 0.01$) and high ($r > 0.90$) correlations existed between the anthropometric prediction equations and DXA. Skin-fold data were obtained using a skin-fold calliper (GPM-Hautfaltenmessgerät, Siber & Hegner, Zurich, Switzerland) and recorded to the nearest 0.2 mm. One trained investigator took all measurements since inter-tester variability is a major source of error in skin-fold measurements. An intra-tester reliability check was conducted prior to this testing on 27 male runners. No significant difference between the 2 trials, measuring the sum of 7 skin folds, was observed ($p > 0.05$). The intra-class correlation was high at $r = 0.99$. The same investigator was also compared to another trained investigator to determine objectivity. No significant difference existed between testers ($p > 0.05$). The skin-fold measurements were taken once for the entire 7 skin folds and then repeated 2 times by the same investigator; the mean of the 3 times was then used for the analyses. The timing of taking the skin-fold measurements was standardised to ensure reliability. According to Becque et al. [16], readings were performed 4 s after applying the calliper. The length of the right arm was measured from *acromion* to the tip of the third finger; the length of the right leg from *trochanter major* to *malleolus lateralis*. In addition to the determination of the anthropometric variables, athletes were asked about their average weekly training volume in hours, plus the kilometres swum, in preparation for the race. Each athlete maintained a comprehensive training diary consisting of daily workouts showing distance and duration. The training diary started upon inscription to the race. The average value in volume (kilometres and hours) and intensity (km/h) were calculated. The number of years as active and competitive swimmer was also obtained. Three participants were competitive triathletes.

Statistical analysis

Results are presented as mean (SD). The coefficient of variation (CV% = 100 × SD/mean) of total race time was calculated. The Pearson correlation analysis was applied to the variables body mass, body height, BMI, length of arm, length of leg, percent body fat, sum of 7 skin folds, years as active swimmer, average number of kilometres and hours swum per week and average speed in training. The Spearman correlation analysis was applied when the data were non-normally distributed. Bonferroni corrections were applied and a statistical significance was reported with $p < 0.0045$ (11 variables).

Results

The 26 athletes of the field finished the 26.4 km in a mean time of 551.5 (91.3) min. The fastest swimmer arrived after 377 min, setting a new course record in the master category. The slowest competitor finished after 710 min. All 15 study participants finished the race on average in 550.9 (99.5) min (CV% = 18) swimming at an average speed of 3.0 (0.5) km/h. None of the anthropometric variables investigated were associated with race performance (Tab. 1), whereas speed in swimming during training was significantly related to total race time ($r = –0.66$, $p = 0.0037$) (Fig. 1).

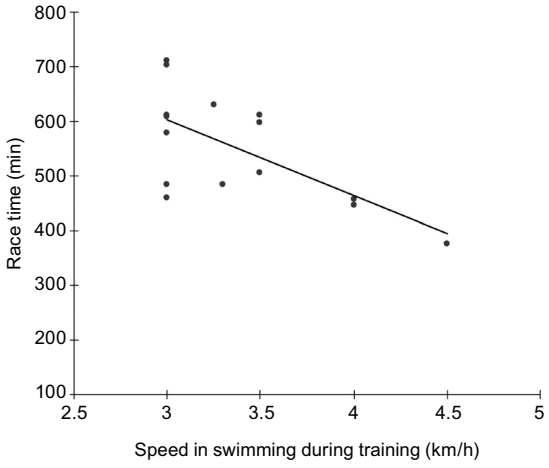

Figure 1. Speed in training was significantly associated with total race time ($r = –0.66$, $p = 0.0037$) for the 15 swimmers. Three athletes finished the race within the same minute, and 2 of them had an identical speed in training, we therefore see only 14 dots

Discussion

In contrast to the literature regarding short distance swimmers, we found no association between performance and known anthropometric factors in swimmers

such as fat mass [3], upper extremity length [4] and body height [4, 6] in this group of male open-water ultra-endurance swimmers.

Training intensity

In contrast to our presumption that body fat would be related to performance, we found that average speed in training was significantly associated with total race time (Fig. 1). It seems that athletes with a high training pace performed better in this ultra-endurance swim.

In the literature, neither high volume nor high intensity seem to be related to swimming performance in pool swimmers. Costill et al. [7] found in a training study of male swimmers that a high training volume did not enhance swim performance. In contrast, after a taper period, performance was improved. In another training study of competitive swimmers, a 4-week training period of both high volume and low intensity, or low volume and high intensity led to an improvement in performance [9]. Probably the incorporation of resistance training into a training programme enhances swim performance. Girold et al. [17] found in a training study of swimmers that programmes either combining swimming with dry-land strength training or with in-water resistance- and assisted-sprint exercise led to a similar gain in sprint performance, which was better than traditional training methods.

Training volume

Because of the low training volume we assumed that our subjects cannot be considered as successful athletes, but when observing the fact that they all finished the race within the time limit we cannot deduce that these athletes are not serious swimmers.

The swimmers in this sample trained, on average, a total distance of 15.8 km per week. This is very little, and suggests that these swimmers were not serious athletes, particularly for an aerobically demanding, high-endurance sport such as marathon-swimming. This point is also reflected in the average number of 6.7 hours of training per week. In comparison, the average elite competitive swimmer easily trains 3 to 4 times this distance each week. For comparison, athletes in the study of Van Heest et al. [11] swam on average just over 12 km per day during a 1 week training camp. This daily distance is almost equivalent to the average total distance swum by the participants in this study in an entire week. Swimming 26.4 km without a break at an average speed of 3 km per hour requires trained athletes. Since the average age of those swimmers is 40 years, and competitive swimmers are about 20 years younger [18, 19], we might assume that those swimmers had a long story of competitive swimming. This is reflected by the fact that these athletes had been training for 17.6 (16.1) years varying between 2 to 46 years. In addition, at least 2 athletes were former competitive swimmers at the national level in their country and at least 3 athletes were elite long-distance triathletes investing more time in cycling and running training than swimming. Presumably an older or senior competitive swimmer is able to maintain a high speed during training at low volumes for years and is therefore able to compete fast in ultra-endurance swimming.

Body height and length of extremities

We found no association between any of the anthropometric variables investigated and total race time. In contrast to our findings, in studies of pool swimmers, body mass, length of extremities and body height showed a relationship with swim performance.

Geladas et al. [4] could demonstrate in boys and girls aged 12 to 14 years that upper extremity length was, in addition to horizontal jump and grip strength, a significant predictor variable of 100 m freestyle performance in boys. In girls, body height, upper extremity and hand length were significantly related to 100 m freestyle times. Jagomagi and Jurimae [6] found in 125 female breaststroke swimmers that body height was the most important anthropometrical parameter, explaining 11.1% of the 100 m breaststroke results. The association of body weight with swim performance is probably related to gender. Sekulić et al. [20] could demonstrate that body height was related to performance in male swimmers over 50 m freestyle. Probably the length of the swim distance was the reason that we could not detect a correlation with total race time. We also found no relationship of body height to race performance, as Jagomagi and Jurimae [6] did.

Body mass and body fat

Sekulić et al. [20] showed that body mass was related to swim performance in female swimmers over 400 m freestyle and Siders et al. [2] found in female swimmers that body mass was correlated to swimming performance. Our athletes with a race distance of 26.4 km had to swim a considerably longer distance compared to

pool swimmers. We expected that high body fat would be beneficial for race performance in an open-water swim; however, fat mass showed no association with total race time. Swimmers crossing the English Channel face temperatures of about 15°C [12]. For ultra-swimmers in open-water competitions, such as the Channel, fat is a better insulator than human muscle [21]. Keatinge et al. [13] could show that swimmers with less thick subcutaneous fat made significantly shorter swims than those with thicker fat layers in water of 9.4°C to 11°C. The water temperature in Lake Zurich was constant at 23°C, so that the water temperature obviously was not a problem for those swimmers. They all finished successfully within the time limit.

In the Channel between Dover and Calais of over 32.2 km, swimmers commonly need about 12 hours, but some up to 20 hours [12] depending upon the circumstances. The finding that high fat mass seems to be advantageous for swimming performance is probably again dependent on the gender. However, also in female swimmers, a high fat mass may impair swim performance. Tuuri et al. [3] showed in female swimmers that greater fat mass is strongly related to lower levels of exercise. Siders et al. [2] could demonstrate that percent body fat was correlated to swimming performance over 100 yards in females.

Gender

Probably gender was the reason that we could not find a relationship between anthropometric variables and race performance. According to Siders et al. [2], the anthropometric variables: body height, body mass, percent body fat and fat-free mass have an effect on swimming performance in female swimmers, but not in males. Over a 100-yard swim of each swimmer's major competitive stroke, these 4 parameters showed an effect on performance. Interestingly, these 4 variables only showed an effect on performance in the female competitive swimmers, and not in the men. In contrast to these results, Geladas et al. [4] found that upper extremity length, hand length, and body height were significantly related to 100 m freestyle time, but the degree of association was markedly lower in girls than in boys.

Conclusions

This investigation suggests that anthropometric variables such as body fat, body height and length of extremities show no relationship to race time in male ultra-endurance swimmers in an open-water ultra-swimming contest as has been shown in pool-swimmers over shorter distances. In this group of ultra-swimmers, speed in training appears to have a modest association with race performance in a 26.4 km open-water ultra-swim. Further investigation is warranted in a larger sample of athletes to clarify why speed in training is important for performance in open-water ultra-endurance swimmers and not body fat. Especially the intensity of training should be determined using parameters such as heart rate or blood lactate. Furthermore, differences between genders should be investigated.

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BIOELECTRICAL IMPEDANCE ANALYSIS OF BODY COMPOSITION AND MUSCLE MASS DISTRIBUTION IN ADVANCED KAYAKERS

DOI: 10.2478/v10038-010-0008-0

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ABSTRACT
Purpose. The study aims at assessment of body composition and muscle mass distribution in advanced kayakers. Kayak paddlers should be characterized by large body mass with a significant percentage of muscle mass, especially in the trunk region. **Basic procedures.** The sample consisted of 26 kayakers. The body composition and muscle mass distribution were determined based on bioelectrical impedance analysis. **Main findings.** The subjects had large muscle mass and average fat mass. The percentage of body fat mass in the kayakers was observed to increase with age, whereas the muscle mass percentage decreased, with the exception of the limbs. **Conclusions.** BIA of body composition and distribution of muscle mass should be a standard diagnostic method to collect data on proper adaptation of kayakers to their training programs.

Key words: body composition, anthropometry, muscle mass, kayak, bioelectric impedance

Introduction

The body build of athletes is one of the key subjects of physical education and sport sciences. On the basis of the body build profile of athletes the most desirable body parameters for a particular sport can be determined that would ensure attainment of the highest sports results.

Numerous studies [1–7] have isolated the most significant morphological traits characteristic of kayakers. These traits include large body mass, strong muscles and solid skeleton. The upper body build in kayakers is commonly recognized as one of the most important parameters affecting their sports results [2, 7, 8]. They should also be taller than average. Both male and female kayak paddlers have a low percentage of adipose tissue: 13% ± 2.5 and 22.2% ± 4.6, respectively [9]. Similar observations were made by Van Someren and Palmer [10] in their study of U.S. Olympic kayakers and Akca and Muniroglu [11] in their study of the Turkish Olympic team. A similar body build profile was noted in boy and girl kayak paddlers at all training and competition stages [7].

Body build parameters indicative of training effectiveness and athlete selection in kayaking include body composition and muscle mass distribution. There have been a number studies examining somatotypes and basic anthropometric profiles in elite kayakers [2, 7, 10–13]. However, no results of muscle mass measurement using bioelectrical impedance analysis (BIA) or segmental analysis have been published so far. Neither data on changes in body components or assessment of regional body composition are available.

The present study was aimed to assess the basic body components of kayakers with the use of BIA and profiles of regional muscle mass distribution. In particular, the study focused on the assessment of the age-related range and direction of changes in somatic build and muscle mass distribution in kayak paddlers.

It was assumed that changes in kayakers' body build are indicative of the athletes' proper adaptation to kayaking-specific training loads. The following research hypotheses were formulated:

1. Kayakers feature large muscle mass and lower adiposity in comparison with athletes representing other sports.
2. Kayakers' muscle mass and its percentage in the total body mass increase with age.
3. The most considerable gain in muscle mass can be observed in kayakers' trunk muscles.

Material and methods

The study sample consisted of 26 young competitive kayakers from the Wałcz Sports School and AZS–AWF

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Sports Club in Gorzów Wielkopolski, Poland. With regard to their sports level the subjects represented four kayaking sports classes (sports class II, sports class I, championship sports class, international championships sports class) (Tab. 1). For the purpose of the study all the subjects were divided into two age groups: seniors and juniors. The mean age for senior kayakers was 20.3 ± 1.41, and for junior kayakers 16.5 ± 1.01 (Tab. 2). The senior kayakers in the sample included six members of the Junior Polish National Team and one member of the Senior Polish National Team. In the group of juniors one kayaker was a member of the Junior Polish National Team.

The study was approved by the Bioethical Committee of the Karol Marcinkowski University of Medical Sciences in Poznań, Poland.

The subjects' body weight and body height were measured using standard anthropometric procedures and instruments.

The kayakers' body composition was assessed using bioelectrical impedance analysis with the BIA 101 analyzer (Akern, Italy) [14]. BIA is a highly accurate assessment method which uses the measurements of reactance and resistance of the human tissue [14, 15]. The resistance was measured by a non-susceptible current (800 μA, 50 Hz).

The obtained reactance and resistance values as well as data on subjects' age, sex, body height and body weight were entered into the analyzer software for body composition analysis. The following body components were determined: FFM – fat-free mass (kg), FFMpct – fat-free mass percentage (%), FM – fat mass (kg), FMpct – fat mass percentage (%), MM – muscle mass (kg), MMpct – muscle mass percentage (%).

The human body reactance and resistance were also measured using the segmental analysis, which allowed calculation of muscle mass distribution in different regions of the body (in kg and %): RB – right side of the body, LB – left side of the body, LwB – lower body, UpB – upper body, RA – right arm, LA – left arm, RL – right leg, LL – left leg, TR – trunk.

Statistical analysis

The Statistica 8.0 software package (StatSoft, Inc. 1984–2008) was used for statistical analysis. Arithmetic means, medians and standard deviations were calculated. The level of statistical significance was set at $p < 0.05$. The distribution of variables was first checked with the Shapiro-Wilk test and the Lilliefors test. If any of these tests yielded a statistically significant result in one of the groups of subjects, the Mann–Whitney U test was applied to check for statistical significance of differences of a particular variable. Otherwise Student's t-test was used provided the equality of group variances was present which was checked with the Brown–Forsythe test. If the latter's result was statistically significant the significance of differences was measured with the Cochran and Cox test.

Results

Body composition analysis

Table 3 presents the results of measurement of the kayakers' body weight and body height as well as of their particular body components.

The subjects' body height amounted to 182.1 ± 5.31 cm for the juniors and 184.8 ± 6.7 cm for the seniors. These results are similar to those of Olympic sprint kayak paddlers from Sydney in 2000 [7]. The body weight in

Table 1. Sports levels of kayakers corresponding to the assigned sports classes: juniors (n = 17) and seniors (n = 9)

Kayaking sports class	Juniors	Seniors	Total
Sports class II	2	0	2
Sports class I	10	3	13
Championship sports class	5	5	10
International championship sports class	0	1	1

Table 2. Basic somatic parameters of junior (n = 17) and senior (n = 9) kayakers

	Juniors						Seniors					
	n	M	Med	Min	Max	SD	*n*	M	Med	Min	Max	SD
Age (years)	17	16.5	17.0	15.0	18.0	1.01	9	20.3	20.0	19.0	22.0	1.41
Body height (cm)	17	182.1	181.0	175.0	195.0	5.31	9	184.8	186.0	174.0	194.0	6.70
Body weight (kg)	17	79.0	78.0	70.0	90.0	5.85	9	84.6	86.0	71.0	97.0	8.41

Table 3. Mean values of body build components of junior (n = 17) and senior (n = 9) kayakers

	Juniors					Seniors				
	M	Med	Min	Max	SD	M	Med	Min	Max	SD
Body height (cm)	182.12	181	175	195	5.31	184.8	186.0	174.0	194.0	6.70
Body weight (kg)*	79.00	78	70	90	5.85	84.6	86.0	71.0	97.0	8.41
FFM (kg)	66.65	65.2	59.6	74.3	4.59	68.9	71.9	58.6	78.3	7.13
FM (kg)*	12.35	12.2	7.7	16.8	2.81	15.6	16.6	9.2	18.9	3.81
FMpct (%)*	15.6	16.3	10.5	19.8	3.0	18.4	20.1	11.1	22.3	4.00
FFMpct (%)*	84.4	83.7	80.2	89.5	3.0	81.6	79.9	77.7	88.9	4.00
MM (kg)*	45.61	45.1	36.8	51.5	3.21	50.1	50.1	42.2	57.1	5.41
MMpct (%)	57.8	57.2	52.5	64.5	3.2	59.3	58.8	54.5	64.8	3.46

FFM – fat-free mass, FM – fat mass, FMpct – fat mass percentage, FFMpct – fat-free mass percentage, MM – muscle mass (kg), MMpct – muscle mass percentage, *statistically significant difference at $p < 0.05$

Table 4. Mean values of muscle mass distribution in junior (n = 17) and senior (n = 9) kayakers

	Juniors					Seniors				
	M	Med	Min	Max	SD	M	Med	Min	Max	SD
RB (kg)*	20.6	21.4	15.7	23.6	2.4	23.3	23.5	21.3	26.4	1.6
LB (kg)*	20.4	20.8	14.7	24.4	2.2	23.3	23.1	20.4	26.7	2.2
LwB (kg)	19.6	19.9	14.2	24.6	2.5	22.3	22.8	19.8	24.7	1.7
UpB (kg)	21.4	22.2	16.2	25.6	2.6	24.3	24.1	21.6	28.4	2.6
RA (kg)*	1.3	1.2	0.2	3.2	0.9	2.8	3.0	1.9	3.7	0.8
LA (kg)*	1.3	1.2	0.4	2.8	0.7	2.2	2.6	1.1	3.1	0.8
RL (kg)*	4.0	3.9	1.7	6.8	1.3	5.4	5.3	3.8	7.3	1.4
LL (kg)*	3.2	2.9	1.1	7.5	1.8	6.3	5.9	4.2	8.7	1.5
TR (kg)	31.2	32.1	26.6	35.9	2.9	29.9	29.7	26.8	35.5	2.6
RB (%)	50.2	50.2	47.8	52.7	1.3	50.1	50.0	48.3	52.1	1.4
LB (%)	49.8	49.8	47.3	52.2	1.3	49.9	50.0	47.9	51.7	1.4
LwB (%)	47.6	47.8	42.9	53.1	3.1	47.9	47.4	43.5	51.3	2.6
UpB (%)	52.2	52.3	46.9	57.1	3.1	52.1	52.6	48.7	56.5	2.6
RA (%)*	3.0	2.7	0.6	7.2	2.0	5.9	6.3	4.5	7.5	1.3
LA (%)*	3.1	2.8	1.3	5.9	1.5	4.7	4.9	2.7	6.3	1.5
RL (%)*	9.4	9.7	5.2	14.5	2.4	11.5	10.8	9.0	14.9	2.3
LL (%)*	7.5	7.1	3.0	16.1	3.7	13.4	12.5	10.0	17.6	2.6
TR (%)*	76.9	78.2	56.8	88.2	9.2	64.5	66.8	54.5	73.7	7.0

RB – right side of the body, LB – left side of the body, LwB – lower body, UpB – upper body, RA – right arm, LA – left arm, RL – right leg, LL – left leg, TR – trunk, *statistically significant difference at $p < 0.05$

the senior kayakers was similar to the values attained by Ackland et al. [7] and amounted to 84.6 ± 8.41 kg. The junior kayakers had lower body weight than their senior counterparts (79 ± 5.85 kg), and the Student's t-test results pointed to a statistically significant difference. The Student's t-test results of the muscle mass (MM) assessment (45.6 ± 3.21 kg for juniors; 50.1 ± 5.41 kg for seniors) revealed a statistically significant difference with the subjects' age. Also a significant increase in fat mass (FM) was noted in the younger kayakers (12.35 ± 2.81 kg for juniors; and 15.6 ± 3.81 kg for seniors). In terms of percentage of particular body components, FMpct amounted to 15.6 ± 3% for juniors, and 18.4 ± 4% for seniors. These values are higher than the ones noted by Ackland et al. [7]; however, the body fat percentage in that study was assessed with skinfold tests. The BIA allows a more accurate measurement of total body fat than the skinfold methods [15], thus the results in the present study are higher than in Ackland et al. [7]. The U test revealed a significant difference in the percentage of body fat between the two groups of subjects.

Also larger fat-free mass (FFMpct) was noted in the junior kayakers (84.4 ± 3% as opposed to 81.6 ± 4% in the seniors). The difference was statistically significant. The differences in the percentage of muscle mass (MMpct) were statistically non-significant, and the mean MMpct values were 57.8 ± 3.2% for the juniors and 59.3 ± 3.46% for the seniors, respectively.

Table 4 presents the results of muscle mass distribution analysis in the kayakers. A statistically significant difference was found for the right side of the body (RB) and the left side of the body (LB): 20.6 ± 2.4 kg and 20.4 ± 2.2 kg for juniors, and 23.3 ± 1.6 kg and 23.3 ± 2.2 kg, respectively, which was related to the proportional increase in muscle mass on both sides of the body. An increase in the lower body muscle mass (LwB) was also noted (19.6 ± 2.5 kg in juniors, and 22.3 ± 1.7 kg in seniors, respectively) as well as a significant muscle mass increase in the limbs. In the case of arms the muscle mass value amounted to 1.3 ± 0.9 kg (RA) and 1.3 ± 0.7 kg (LA) in junior kayakers, and 2.8 ± 0.8 kg (RA) and 2.2 ± 0.8 kg (LA) in senior kayakers. A lower trunk muscle mass (TR) was also noted in the seniors as opposed to the juniors, but the difference was statistically non-significant.

The analysis of muscle mass distribution revealed a slight, non-significant difference between the two groups of kayakers in the percentage of the lower body muscle mass (LwB) (47.6 ± 3.1% in juniors, 47.9 ± 2.6% in seniors) and upper body muscle mass (UpB) (52.2 ± 3.1% in juniors, 52.1 ± 2.6% in seniors).

A significant difference in the percentage of muscle mass of the arms was found: 3.0 ± 2.0% (RA) and 3.1 ± 1.5% (LA) for juniors, and 5.9 ± 1.3% (RA) and 4.7 ± 1.5% (LA) for seniors. Statistical differences were also found in the percentage of muscle mass of the kayakers' legs. The juniors had a significantly lower percentage of muscle mass in the legs than their senior counterparts: 9.4 ± 2.4% (RL) and 7.5 ± 3.7% (LL) in juniors; and 11.5 ± 2.3% (RL) and 13.4 ± 2.6% (LL) in seniors. The analysis of the percentage of trunk muscle mass (TR) revealed a higher value of this parameter in the juniors (76.9 ± 9.2%) than in the seniors (64.5 ± 7.0%).

Discussion

The kayakers' total body mass was observed to increase with age including significant changes of their muscle mass (Fig. 1) and fat mass (FM) (Fig. 2). The increase of muscle mass confirmed its significance in achieving high sports results in kayaking [4, 7]. The percentage of particular body tissue components changed with kayakers' age. A statistically significant increase in fat mass was noted from 15.6% to 18.4% (Fig. 3) resulting in a decrease in fat-free mass from 84.4% to 81.6%. The percentage of muscle mass was

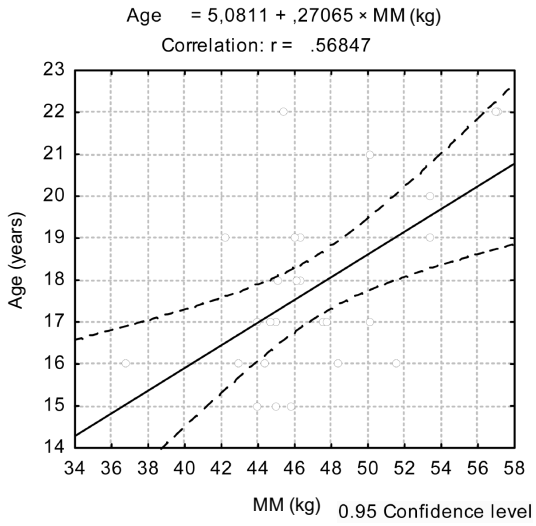

Figure 1. Kayakers' muscle mass (MM) and age (n = 26)

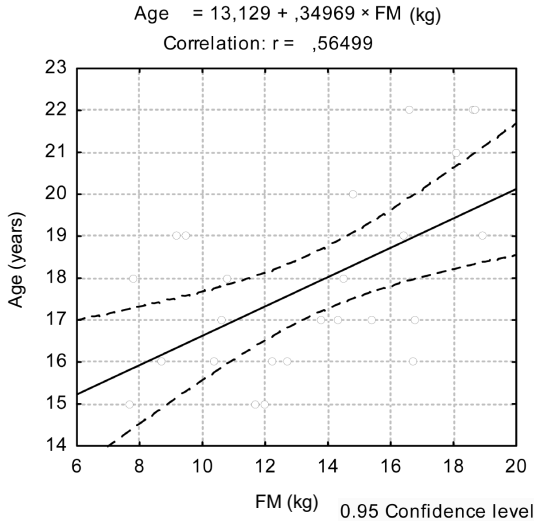

Figure 2. Kayakers' body fat mass (FM) and age (n = 26)

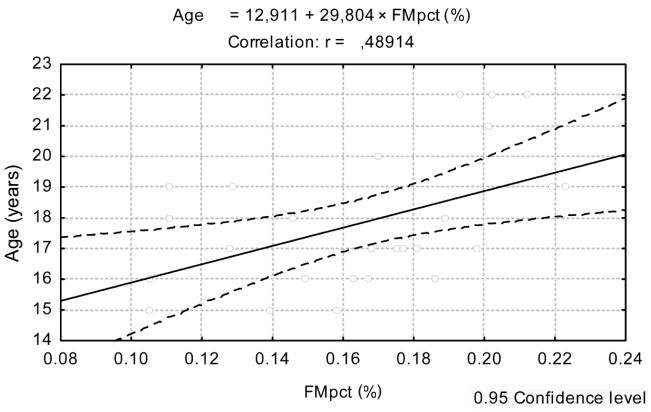

Figure 3. Percentage of body fat mass (FMpct) and kayakers' age (n = 26)

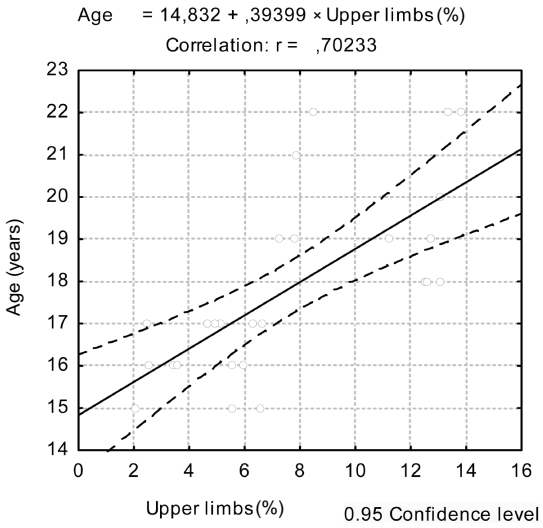

Figure 4. Percentage of muscle mass in the right arm (RA) and left arm (LA) and kayakers' age (n = 26)

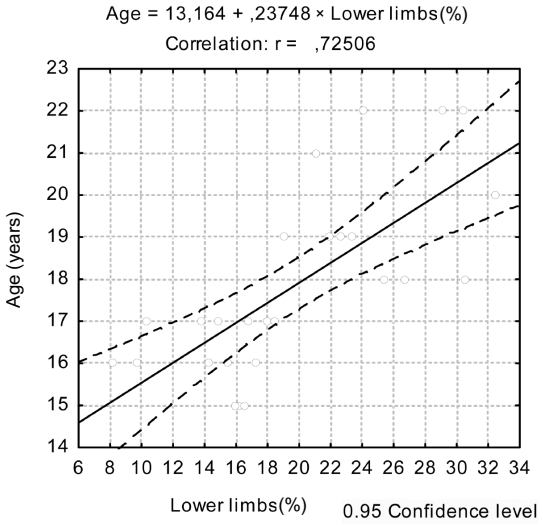

Figure 5. Percentage of muscle mass in the right leg (RL) and left leg (LL) and kayakers' age (n = 26)

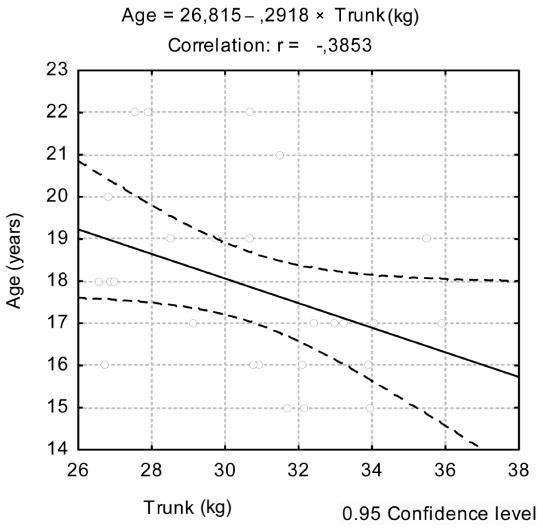

Figure 6. Trunk muscle mass (TR) and kayakers' age (n = 26)

not changed significantly. The noted significant increase in the kayakers' fat mass influencing the total body mass has an adverse effect on paddling speed [16]. The rapid increase in muscle mass (kg) caused by excessive amount of strength training and improper diet can also trigger larger accumulation of fat, which is highly undesirable in kayaking training. One should remember that the subjects were during the pre-season training stage during the measurements. Burke et al. [17] in their study of Australian Rules footballers revealed fat accumulation during the post-season and a significant increase in body fat in the pre-season period. On the other hand, Ostojic and Zivanic [18] observed a significant drop in fat mass only in the competitive period. Further studies into kayakers' body composition during different periods of their annual training cycle would definitely contribute to a more complete analysis of the changing percentage of particular body components.

The gain in muscle mass in the senior kayak paddlers was observed in their arms and legs (Fig. 4, 5). No statistically significant differences in the trunk muscle mass were found (Fig. 6). The juniors featured slightly higher results of measurement of this parameter than the seniors. According to Tesch [8], Fry and Morton [2], and Ackland et al. [7] the trunk muscle mass is one of the significant factors affecting sports results. Top level athletes are characterized by higher than average muscle mass of the trunk. The proportions in the study sample were not correct since the percentage of trunk muscle mass out of the total body mass in the senior kayakers was lower for over 13% (Fig. 7). Also insignificant dif-

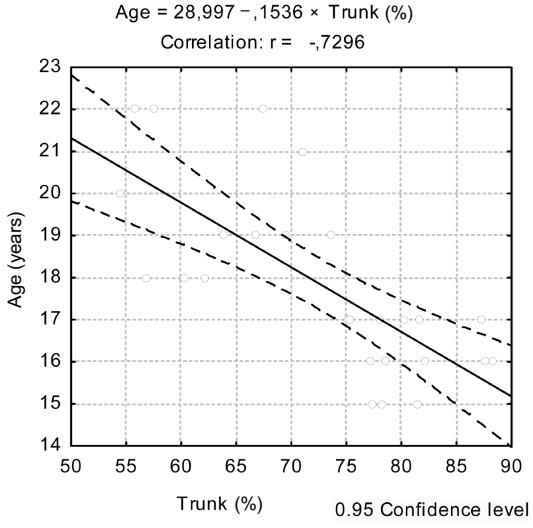

Figure 7. Percentage of muscle mass in the trunk (TR) and kayakers' age (n = 26)

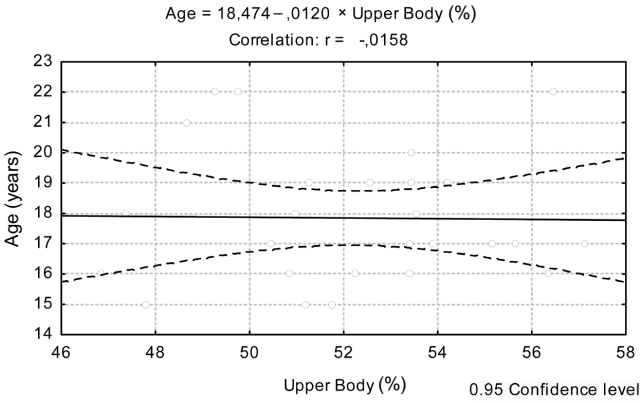

Figure 8. Percentage of muscle mass of the upper body (UpB) and kayakers' age (n = 26)

ferences were found in the proportion of the upper body muscle mass to lower body muscle mass between the juniors and seniors. The upper body muscle mass in the former was 0.1% bigger than in the latter (Fig. 8). This tendency can be a result of improper strength training of the senior kayakers, which can ultimately lead to a significant increase in the muscle mass of the limbs but not the trunk. Another cause could be focusing on the strength training of the lower and upper limbs to attain the highest possible sports results, especially over short kayaking distances. Akca and Muniroglu [11] showed a significant correlation between the biceps circumference and on-water performance of Turkish kayakers over the distances of 200 and 500 meters.

Conclusions

1. Kayakers have a significant body muscle mass and small mean body fat mass. An adverse tendency of growing percentage of body fat mass in senior kayakers was noted. It seems necessary to carry out measurements of body fat mass in different periods of the training cycle, in particular, during the competitive period.
2. Kayakers' gain in muscle mass with age and its percentage distribution tend to remain unchanged.
3. Senior kayakers featured a slightly smaller trunk muscle mass. Its percentage was significantly lower than in the group of junior kayakers. This tendency can be explained by the reliance of senior kayakers on strength training often unsuitable for the sport of kayaking.

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EFFECTS OF PLYOMETRIC TRAINING ON MAXIMAL POWER OUTPUT AND JUMPING ABILITY

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ABSTRACT
Purpose. The study aims to determine the effect of plyometric exercises performed with minimum ground contact time on the maximal power output of the legs and jumping ability. **Basic procedures.** This study sample comprised 44 non-training students of physical education. Following randomization, the experimental group performed plyometric exercises for six weeks, whereas the control group participated only in lectures. The subjects performed counter movement jumps (CMJ), depth jumps (DJ) and a five-hop test. **Main findings.** After the completion of plyometric training, an increase in the relative maximal power output ($p \leq 0.001$) in CMJ and DJ was observed, whereas the center of mass elevation and the five-hop test distance length did not change significantly ($p > 0.05$). Additionally, the rebound time in DJ was significantly shorter and the range of counter movement in the knee decreased ($p \leq 0.01$). **Conclusions.** Depending on the aim of programme, plyometric training should determine the ways of performing exercises. Methodological guidelines in plyometric training aimed at increasing the maximal power output may be different from indications concerning jumping ability.

Key words: jumps, depth jumps, biomechanics, training, legs, measurements

Introduction

Plyometric exercises are used primarily to increase the maximal power output [1, 2] and jumping ability [3]. They are characterized by a specific muscle action sequence: a rapid muscle lengthening movement, i.e. eccentric phase, is followed by an immediate explosive muscle contraction, which has greater strength and power than a contraction without the eccentric phase [4]. The greater force produced by the muscle during plyometric training is related to the storage of elastic energy during muscle stretch (eccentric contraction) and its rapid release during the shortening movement (concentric contraction). It also engages the myotatic reflex and tendon reflex. This process is often referred to as the stretch-shortening cycle (SSC) [5].

Different authors point to the possibility of simultaneous development of maximal muscle power output and jumping ability through plyometric training [6, 7]. On the other hand, some authors prove these two abilities cannot be shaped identically [8, 9]. To increase the maximal power output the movement should be performed rapidly, while in regular jumping training the movement performance does not have to be that fast, i.e. exercise performance time is an individual parameter. In some studies subjects achieved the maximum jump height with the widest range of counter movement, and their performance time was often longer than that when they generated the maximal power output [10]. Thus it can be assumed that the performance of exercise can significantly determine the plyometric training effects. Plyometric training programs account for training loads (drop box height), number of rebounds, and length of intervals between sets of exercises, but they often lack precise instructions about the way the exercises should be performed, i.e. speed and range of movement, position of individual body parts during push-off, etc. The precise performance instructions are crucial in plyometric training since incorrect performance of such exercises may not only fail to bring the expected results but also lead to injuries.

The aim of the study was to assess the effects of plyometric exercises performed with the minimum ground contact time on the maximal power output of the legs and jumping ability. The following research hypothesis was formulated: plyometric training with

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minimum ground contact time improves the maximal power output but does not affect jumping ability.

Material and methods

The subjects were 44 non-training second-year full time university students of physical education. The sample was randomly divided into two groups; plyometric (experimental) and control (Tab. 1). The subjects were informed about the research aims and procedure and a pilot study was carried out. The study was approved by the Research Ethics Committee of the Józef Piłsudski University of Physical Education in Warsaw.

Plyometric training program

The experimental group performed plyometric exercises on Mondays and Thursdays for six weeks. Each plyometric training session commenced with a 5-min run of low intensity, followed by five minutes of stretching exercises (Tab. 2). During each session the subjects were instructed to perform jumps as quickly as possible with the minimum ground contact time. After each rebound the legs were to be straightened in the hip, knee and ankle joints. The feet during jumps were set slightly outwards and the jumps were performed on a synthetic surface. During the exercises no subject complained of muscle or joint pains. The control group did not take part in the exercise program but, like the plyometric group, in regular classes of gymnastics, swimming and football.

Table 1. Parameters of study groups before the commencement of plyometric training

Parameter	Plyometric group (n = 22)	Control group (n = 22)
Age (years)	20.3 ± 0.5	20.6 ± 0.5
Body height (m)	1.81 ± 0.06	1.80 ± 0.06
Body mass (kg)*	73.2 ± 6.9	73.9 ± 6.7

* body mass did not change significantly after plyometric training ($p > 0.05$)

Measurements

Vertical jumps

The measurement station consisted of a force platform (Kistler, Switzerland) with the sampling frequency of 1000 Hz, amplifier, analog-to-digital converter and the BioWare 3.24 software package. Two types of vertical jumps were measured: counter movement jump (CMJ) and depth jump (DJ) with the drop box height of 0.31 m [11]. The subjects were to achieve the maximum height in CMJs and in DJs after a rebound. The arms swung first backwards and then high upwards. The knee flexion angle was not specified. Each subject performed three CMJ and DJ attempts. The best results out of three (the highest results of center of mass displacement) were analyzed. Before each set of exercises the subjects were shown a presentation of correct performance of the jumps. The following parameters were calculated:

- P_z – maximal power output (concentric phase)

$$P_z(t) = F_z(t) \cdot v_z(t) \quad [12]$$

where: F_z – vertical force, v_z – velocity;

Table 2. Plyometric training program

Week	Plyometric training program number of sets × number of rebounds
1–2	Standing vertical hops 2 × 10 Single foot hops 4 × 8 Multiple two-foot hurdle jumps (hurdle height 0.55 m) 6 × 6 Counter movement jumps 3 × 5 Depth jumps (drop box height 0.20 m) 3 × 6
3–4	Lateral two-foot jumps 2 × 10 Two-foot jumps 4 × 8 Counter movement jumps 3 × 5 Multiple two-foot hurdle jumps (hurdle height 0.65 m) 6 × 6 Depth jumps (drop box height 0.30 m) 3 × 6
5–6	Two-foot jumps forward and backward: 2 × 10 Single foot jumps 2 × 8 on each foot Counter movement jumps 3 × 5 Multiple two-foot hurdle jumps (hurdle height 0.76 m) 6 × 6 Depth jumps (drop box height 0.40 m) 3 × 6

- t_o – rebound time:
  calculated for CMJs and DJs as the time between the moment of the lowest position of the body center of mass and the zero ground reaction force;
- H_{max} – maximal jump height:

$$H_{max} = \frac{v_o^2}{2g}$$

where: g – gravitational acceleration (9.81 m/s^2),
v_o – rebound velocity.

The momentary velocity (v) of the center of mass was calculated by way of integration of momentary acceleration (a), i.e. force (F) exerted on the platform minus body weight (BW) divided by body mass (BM) [13, 14]. The knee flexion angle was determined by video motion analysis. Three markers were placed on the right-hand side of the subject's body at the greater trochanter, lateral condyle of the tibia, and lateral malleolus of the fibula [15]. The knee flexion angle was calculated as the difference between the angle at the moment of contact of the foot with the ground (α_{max}) and the lowest flexion value (α_{min}) [16]. The jumps were recorded with a digital vision camera (Basler piA640-210gc, Germany) with the sampling frequency of 100 Hz. The two-dimensional video motion analysis was carried out using the System APAS XP software package (USA). The footage was flat calibrated.

Five-hop test

The five-hop test was carried out at a track and field jumping facility. Before the test the subject stood on a take off line on the runway 10–11 meters before the sandpit. The aim of the test was to jump the maximum distance possible. Each subject performed five consecutive jumps: a two-foot push off, four consecutive single alternate leg jumps and two-foot landing in the sandpit. The best result (longest distance) out of three attempts was taken into consideration. The jump length was measured with a tape measure from the take off line to the nearest mark made in the sand by the jumper.

Each test was preceded with a warm up. The measurements were taken twice: three days before the plyometric training program and three days after its completion.

The parameters were expressed as means and standard deviations (± SD). The normal distribution was assessed with the Shapiro-Wilk test. The statistical significance of differences was determined with a two-way analysis of variance (ANOVA): 2 (plyometric group, control group) × 2 (test: before and after). At $p < 0.05$ Tukey's test was used. The correlations between the measured parameters as well as the reliability of the tests were estimated with the Pearson correlation coefficient. All statistical calculations were made with the use of the Statistica v. 5.1 PL software package.

Table 3. Mean values (± SD) of maximal power output, center of mass elevation, rebound time and knee flexion angle in CMJ

Parameter	Plyometric group		Control group	
	Before	After	Before	After
Maximal power output (W/kg)	37.2 ± 7.3	43.8 ± 7.7*	37.8 ± 9.8	39.2 ± 5.7
Center of mass elevation (m)	0.41 ± 0.08	0.42 ± 0.07	0.41 ± 0.07	0.39 ± 0.06
Rebound time (ms)	314 ± 32	307 ± 28	319 ± 39	315 ± 37
Knee flexion angle (degrees)	96 ± 8	95 ± 8	95 ± 8	96 ± 7

*$p \leq 0.001$ for differences between measurements before and after the plyometric training program

Table 4. Mean values (± SD) of maximal power output, center of mass elevation, rebound time and knee flexion angle in DJ

Parameter	Plyometric group		Control group	
	Before	After	Before	After
Maximal power output (W/kg)	52.2 ± 11.6	59.0 ± 10.6**	53.0 ± 9.6	53.8 ± 9.4
Center of mass elevation (m)	0.40 ± 0.07	0.42 ± 0.06	0.40 ± 0.07	0.41 ± 0.08
Rebound time (ms)	283 ± 31	228 ± 25*	292 ± 34	281 ± 33
Knee flexion angle (degrees)	92 ± 8	86 ± 7*	91 ± 8	90 ± 7

*$p \leq 0.01$, **$p \leq 0.001$ for differences between measurements before and after the plyometric training program

Results

The reliability of the tests was determined with the test-retest method – the subjects performed two CMJs and two DJs at a five-minute interval. The test's reliability was determined with the coefficient of correlation: $r = 0.98$ (CMJ) and $r = 0.96$ (DJ) for the center of mass elevation; $r = 0.92$ (five-hop test); and $r = 0.96$ (CMJ) and $r = 0.93$ (DJ) for the maximal power output. The obtained values corresponded to data in literature [11, 17, 18].

The plyometric training caused an increase in the relative maximal power output in CMJ (significant interaction between group and time: $F_{1.42} = 5.12$, $p \leq 0.05$) and in DJ (significant interaction between group and time: $F_{1.42} = 10.23$, $p \leq 0.01$) (Tab. 3, 4).

No significant changes in the center of mass elevation were noted in either type of jumps. The changes in the five-hop test results, before and after the completion of the plyometric training were also non-significant: 13.02 ± 0.68 and 13.07 ± 0.61 m in the plyometric group; and 12.97 ± 0.93 and 12.95 ± 0.84 m in the control group, respectively.

A significant reduction of the rebound time (significant interaction between group and time: $F_{1.42} = 8.15$, $p \leq 0.01$) was noted in the DJs as well as significantly lower knee flexion angles were noted in the plyometric group (significant interaction between group and time: $F_{1.42} = 10.63$, $p \leq 0.01$).

Discussion

The subjects from the plyometric group significantly improved their maximal power output in the vertical counter movement jump (CMJ) and depth jump (DJ). Their jumping ability in CMJ, DJ and five-hop test remained unaffected. This confirms the hypothesis that performance of plyometric exercises aimed at improvement of the speed of execution can improve the maximal power output of the legs, but not the level of jumping ability.

The different impact of the plyometric training program on the same parameters (rebound time, knee flexion angle) in CMJs and DJs may be related to a different characteristic of both tests. Hennessy and Kilty [19] claim that the CMJ involves a long stretch shortening cycle (SSC), whereas a DJ a short SSC as the ground contact time in the latter is relatively shorter. This is why the same parameters measured in both jumping tests do not reveal strong correlations [20, 21].

The results of the present study point to the need of inclusion of precise instructions about the performance of plyometric exercises as they can significantly affect the direction and size of changes in the development of skills. Insufficient control of the performance of plyometric exercises may lead to unintended consequences [22]. Unfortunately, as shown in a review study by Markovic [3], the instructions in the methodological parts of plyometric training programs which describe the execution technique are often missing or are too vague.

The issue of technique of performing plyometric exercises in the context of improvement of the maximal power output and jumping ability has been rarely discussed in research studies [23]. Among the very few researchers who have dealt with the problem are Walsh et al. [24], who showed that depth jump technique affects the key determinants of maximal power output and jumping ability more significantly than, for example, drop box height.

The results of the present study also indicate those components of plyometric training programs (performance of exercises strictly following precise instructions) which can improve one ability (maximal power output) without affecting another one. It is therefore important to remember that guidelines on improving the maximal power output may differ from guidelines on improvement of jumping ability.

The study also shows that effects of training aimed at the shortening of the time of jump performance are reflected in the reduction of the knee flexion angle and the rebound time. Most likely, the changes noted in these two parameters affected the increase of the maximal power output [25]. Such changes are highly desired in the majority of sports in which the results rely on the speed of a start task execution, e.g. in 100 m sprint races. Although the study failed to reveal any significant changes in the jumping ability level, plyometric exercises can be nevertheless recommended as part of jumping training in volleyball or basketball players. The possibility to reach the same jump height, however, in a shorter time, can bring measurable effects in rebounding or blocking. Thus if a player's jump height is satisfactory but the entire movement lasts too long the speed of execution of exercises should be emphasized. If the player's jump height requires improvement the rebound time can be lengthened and the knee flexion angle reduced.

In all likelihood the lack of improvement in jumping ability in the depth jump test was related to the reduc-

tion of time of force release (smaller knee flexion angle, shorter rebound time) and thus a lower force impulse, which determines jumping ability to a large extent [10]. According to Trzaskoma et al. [26] a significant improvement of jumping ability without strength training is rather difficult to achieve. Trzaskoma and Trzaskoma [27] revealed that when strength in the legs was not changed significantly, a significant increase in the maximal power output was noted with a decrease in the level of jumping ability. The effect of plyometric training on strength has not been precisely determined as yet. Some authors observed an increase in strength after plyometric training [28, 29], and some found no changes [30, 31].

The present study shows that performing jumps with the fastest possible rebound and the shortest ground contact time improves the maximal power output with no effects on jumping ability. The question remains whether it is possible to improve jumping ability without improving the maximal power output. The results of the present study confirm this indirectly [31]. However, the precise instructions of training aimed at the improvement of jumping ability are difficult to formulate since – as stated before – the highest jumps were achieved with fairly diverse kinematic parameters [10].

Conclusions

The results obtained show that each plyometric training program should include precise instructions of performance of exercises. Methodological guidelines in plyometric training concerning the improvement of the maximal power output can differ from the guidelines aimed at the improvement of jumping ability.

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THE BODY ANGLE OF ATTACK IN FRONT CRAWL PERFORMANCE IN YOUNG SWIMMERS

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ABSTARCT

Among factors influencing frontal (form) resistance in swimming the angle between the swimmer's body and the line of his/her horizontal movement is particularly important. The measurement of this angle called the angle of attack (α) represents indirectly active torque (τ_a) during swimmer's body movement. **Purpose.** The aim of the study was to measure the angle of attack in front crawl swimming in young swimmers at long (2000 m), medium (400 m) and short (25 m) distances and to examine the correlation between the angle and swimming speed at those distances. **Basic procedures.** Swimmers' angles of attack formed between the line of swimmer's movement direction (horizontal direction) and (a) the line connecting the swimmer's hips and goggles (αH–G), and (b) the line connecting the swimmer's hips and shoulders (αH–S) were measured. **Main findings.** The body angle of attack in front crawl swimming was negatively correlated with swimming speed. In the analysis of αH–G (7.3 ± 2.74°) with swimming velocity at 2000 m the correlation was on the verge of statistical significance (–0.38, $p < 0.06$). **Conclusions.** The angle of attack index in controlled front crawl swimming races at the distances of 2000, 400 and 25 m was negatively correlated with swimming speed only at 2000 m, and it was smaller in older, more experienced swimmers.

Key words: swimming, body angle, stroke parameters

Introduction

Parameters which can be modified and thus enable improvement of sports results have been sought in a number of sports including competitive swimming. Proper swimming training should be aimed at the development of swimmer's physical fitness and mental and tactical preparation. It should also concentrate to a great extent on the optimization of swimming technique and improvement of swimmer's hydrodynamic parameters.

Rumyantsev [1] in his study of hydrodynamic resistance during passive towing at a velocity of 2.0 m/s^{-1} calculated the total hydrodynamic resistance according to the formula:

$$F_{\text{total}} = F_{\text{friction}} + F_{\text{wave-making}} + F_{\text{form}}$$

The total hydrodynamic resistance amounted to 98.55 N, and the values of its particular components were: F_{form} = 93.5 N, $F_{\text{wave-making}}$ = 5 N, and F_{friction} = 0.05 N, respectively.

Despite the very small share of friction resistance in the total hydrodynamic resistance, its reduction is often emphasized in swimming training, mostly by designing swim suits enhancing laminar flow. The use of proper swim suits reduces the friction of water particles against the swimmer's body and shortens the time necessary to cover a given swimming distance [2–5]. Wave drag can be minimized by swimming underwater [6]; however, the length of the swimming distance underwater is strictly regulated by the International Swimming Federation (Federation Internationale de Natation de Amateur, FINA) and restrained by swimmers' ability to perform exercises with limited pulmonary gas exchange capacity.

Form (frontal) resistance is the largest component of the total hydrodynamic resistance. Frontal drag is exerted by the swimmer's body, which according to Bernoulli's principle, while moving in the water generates higher pressure in the front and lower pressure in the back. The difference between these pressure areas determines the value of frontal drag, but it also depends on the length of the body's transverse section and swimmer's speed in the water. These factors point to the need of seeking an ever more streamlined silhouette underwater (at the start and the turns) but also during per-

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forming propelling strokes breaking the surface of the water. According to Vorontsov et al. [7] and Toussaint [8] a long body is more streamlined because the zone separating the boundary layers of high and low pressure is located further to the back than in a short body and thus it causes a lower turbulence wake [8]. In fact, the fastest front crawl swimmers feature high body height and slenderness indices [9].

Among the factors affecting pressure (frontal) resistance in swimming De Groot et al. [10] emphasizes the angle between the swimmer's body and his/her horizontal movement direction, known as the angle of attack (α) which is strictly correlated with the resultant active torque (τ_a) during swimming [11]. The component forces of active torque are exerted on the self-propelling swimmer's body in the sagittal plane. Active torque (τ_a) is the result of the buoyant force and the gravitational force acting on the body as well as the propulsion forces of swimmer's extremities and their alignment to the body's center of mass. Active torque is generated in front crawl by the arms performing the strokes causing the rotation of the body on its transverse axis, i.e. sinking of the legs. The moving legs generate active torque which lifts the swimmer's lower body. An inhalation also increases the buoyancy of the upper body causing the legs to sink. Yanai [12] noted that the generation of active torque (τ_a) is also affected by moving the arms above water and the swimmer's head breaking the surface of the water, all of which shifts the center of buoyancy towards the legs causing torque to lift them.

The aim of the study was to find a correlation between the angle of attack in front crawl swimming in young swimmers at long (2000 m), medium (400 m) and short distances (25 m), and the mean value of the horizontal component of the vector of swimmers' velocity (V_x) at these distances. The angles of attack were defined as: (a) αH–G, i.e. the angle between the movement direction (horizontal direction) and the swimmer's hips–goggles line; and (b) αH–S, i.e. the angle between the movement direction and the swimmer's hips–shoulders line.

The study also attempted to establish correlations between swimming technique parameters and the body's angle of attack at selected swimming distances.

Material and methods

The study sample comprised 26 high-level competitive swimmers aged 16.0 ± 1.09 years (from 15 to 18 years of age), with the body height of 177.5 ± 8.07 cm and body mass of 65.4 ± 9.40 kg. The subjects trained swimming in two groups in a sports school. Only one subject specialized in sprint swimming over the distance of 50–100 m; none of the subjects was a breaststroke swimmer. All subjects consented in writing to take part in the study.

The anthropometric data gathered allowed determination of the swimmers' somatotypes according to Carter–Heath [13] and lean body mass (LBM – 58.7 ± 8.05 kg) following Slaughter et al. [14]. Within the sample 11 swimmers represented the ectomorphic somatotype and 15 the mesomorphic somatotype. The measurements were taken with a set of precision instruments by Sieber Hegner Maschinen AG (Switzerland) and the Harpenden-type skinfold caliper with constant pressure of 10 g/cm^{-2}. The percentage of body fat amounted to 10.21 ± 2.41%.

The swimming tests at the distances of 25, 400 and 2000 m were carried out in a 50 m pool with the start from the water. Swimmers' body movements were recorded with a rapid shutter speed GRV 9800 JVC video cam (Japan) at a frequency of 50 frames per second. The recordings were executed from a side view about 1 m below the water surface and 6 m from the swimmer's lane.

The recording analysis allowed identification of characteristic cyclic elements of arms movements in front crawl: stroke rate (SR), index of coordination (IdC) and arms movement phases according to Chollet et al. [15]. The parameters mentioned were calculated from three full arm movement cycles over the distance of 25 m, and two cycles over the distances of 400 and 2000 m. The stroke length (SL) at the respective distances was calculated as the ratio between the SR and average swimming velocity (V_x) at a 20 m distance without the 5-meter zone before the turn. The total (Δt_{glob}) times of covering individual lengths of the pool (Δt_i) were measured with a stopwatch with the accuracy of 0.01 s. The parameters for assessing front crawl technique were measured at the 8th, 18th, 28th and 38th 20 m long swim segment for the 2000 m distance; and at the 2nd, 4th, 6th and 8th segments for the distance of 400 m.

The following parameters were used to assess swimming technique during each segment analyzed (i = 1, 2, 3, 4):

- mean swimming velocity $V_i = 20$ m/Δt_i,
- stroke rate (SR_i) calculated as the reciprocal of the arithmetic mean of duration of two (at 2000 m and

Table 1. Basic parameters of front crawl technique and swimming velocity (V_x) at 2000, 400 and 25 m

$n = 26$, $\bar{x} \pm SD$	2000 m	400 m	25 m
V_x (m/s^{-1})	1.35 ± 0.07	1.42 ± 0.07	1.73 ± 0.12
SR (cycles per min^{-1})	37.4 ± 4.62	39.6 ± 3.95	55.0 ± 4.87
SL (m)	2.16 ± 0.29	2.13 ± 0.32	1.90 ± 0.16
LQ (beats per cycle^{-1})	3.7 ± 1.61	3.8 ± 1.73	4.8 ± 1.61
IdC (%)	–7.9 ± 7.17	–5.9 ± 6.55	3.3 ± 5.91

V_x – mean swimming velocity, SR – stroke rate, SL – stroke length, LQ – legs movement quantity, IdC – index of coordination

400 m) or three (at 100 m and 25 m) swimming cycles analyzed: $SR_i = 1/T_i$,

- stroke length (SL_i), calculated as the average velocity (V_x) to SR_i ratio: $SL_i = V_i/SR_i$.

To assess the cooperation of the arms in body propulsion the index of coordination (IdC_i) was used, which was expressed as percentage of the arms movement cycle duration [15, 16]. Legs movement quantity (LQ_i) was counted from the same shots as arms movements. The legs movements were qualified as six-beat kicks, corresponding to six complete alternating immersion and/or emersion movements in one movement cycle of the arms, and four- and two-beat kick, for four and two leg movements in one arm movement cycle, respectively.

The angles of attack: αH–G and αH–S were determined when the line connecting the shoulder joints was in a horizontal position. The calculations were made using software package for analysis of kinematic information: KAVideo and KA2D [17].

Means and standard deviations were used in statistical analysis. The Pearson correlation coefficient was calculated between the angles of attack αH–G and αH–S at 2000 m, 400 m and 25 m as well as swimming velocity (V_x) at these distances. The correlations between the angles of attack (α) at particular swimming distances were also calculated as well as between the αH–G, αH–S, swimmers' calendar age and swimming parameters at 2000 m. Analysis of variance for repeated measures was used to examine the changes in the angles of attack at 2000 m, 400 m and 25 m. Normal data distribution was tested to confirm their formation similar to normal Gauss–Laplace curve. The level of statistical significance was set at $p < 0.05$. All calculations were made with the use of Statistica 6.1 software (Statsoft, Inc).

Results

Figure 1 and Table 2 present the calculations of the angle of attack in front crawl.

The calculated parameters revealed a negative correlation between V_x and the angle of attack in front crawl. The correlation between the αH–G and V_{2000} was on the verge of statistical significance (Tab. 2). The α H–G in consecutive 500 m segments of the 2000 m distance ranged from 7.2° to 7.5°.

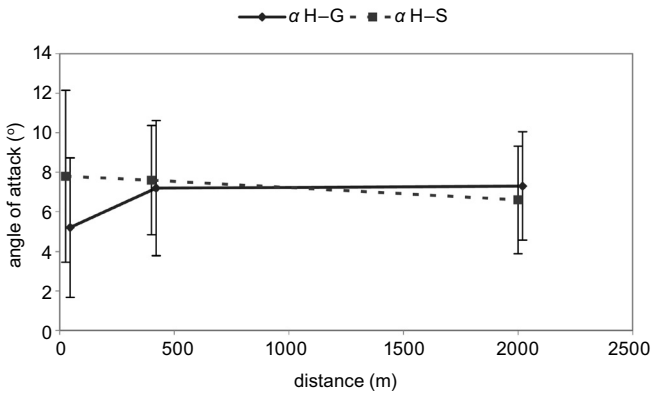

Figure 1. Correlations between the body's angle of attack (αH–G and αH–S) and the swimming distance (2000, 400 and 25 m)

Table 2. Coefficients of correlation of the angle of attack and V_x at 2000 m, 400 m and 25 m

$n = 26$	2000 m	400 m	25 m
αH–G (°), $\bar{x} \pm SD$	7.3 ± 2.74	7.2 ± 3.41	5.2 ± 3.53
correlation with V (m/s^{-1})	**–0.38**	–0.20	–0.31
αH–S (°), $\bar{x} \pm SD$	6.4 ± 2.71	7.6 ± 2.76	7.8 ± 4.34
Correlation with V (m/s^{-1})	–0.30	–0.02	–0.02

αH–G – angle of attack between movement direction and swimmer's hips–goggles line; αH–S – angle between movement direction and swimmer's hips–shoulders line; correlations on the verge of statistical significance $p < 0.06$ in bold

The angle of attack values revealed strong statistically significant correlations at 2000 m and 400 m, and also medium and statistically significant correlations were found between αH–S at 25 m and at 400 m (Tab. 3).

Table 3. Coefficients of correlation between angles of attack at 2000 and 400 m and at 400 and 25 m

2000 m	Correlation	400 m	Correlation	25 m
αB–O (°)	0.78**	αB–O (°)	0.3	αB–O (°)
αB–R (°)	0.68**	αB–R (°)	0.42*	αB–R (°)

αH–G – angle of attack between movement direction and swimmer's hips–goggles line; αH–S – angle between movement direction and swimmer's hips–shoulders line; *$p < 0.05$, **$p < 0.01$

The correlations between the angle of attack (αH–G) and mean swimming velocity at 2000 m (V_{2000}) were medium and on the verge of statistical significance. Table 4 lists the parameters determining mean velocity in front crawl swimming (V_x) at a distance of 2000 m.

Table 4. Coefficients of correlation between αH–G and αH–S and swimming technique parameters at a distance of 2000 m

2000 m	SR (cycles per min^{-1})	SL (m)	LQ (beats per cycle^{-1})	IdC (%)
αH–G (°)	**0.37**	–0.62**	–0.05	0.24
αH–S (°)	**0.35**	–0.46*	–0.06	**0.34**

SR – stroke rate, SL – stroke length, LQ – legs movement quantity, IdC – index of coordination; *$p < 0.05$, **$p < 0.01$; correlations on the verge of statistical significance ($p \leq 0.08$) in bold

The values of angles of attack at 2000 m were also correlated with subjects' calendar age. The correlations were medium. The correlation between αH–G and swimmers' age was close to the level of statistical significance ($r = –0.36$, $p = 0.07$); while the correlation between αH–S and swimmers' age was statistically non-significant ($r = –0.31$, n.s.).

Discussion

The obtained values of the angle of attack in front crawl swimming at the distances studied were correlated with swimming velocity on the verge of statistical significance only in the case of αH–G with V_{2000}. The αH–G decreased significantly along with increasing swimming velocity and shortening of the swimming distance ($F = 201.73$, $df = 1.25$, $p < 0.01$). These results are contrary to those of Kjendlie et al. [11], where the angle of attack, measured between the waterline and the swimmer's iliac spine–goggles line, increased in adult swimmers with increasing swimming velocity, similar to the αH–S in the present study ($F = 190.32$, $df = 1.25$, $p < 0.01$). However, the testing conditions in the studies were aforementioned aforementioned different from those in middle- and long-distance swimming tests which involve the swimmer's respiratory system to a greater extent. The authors mentioned had examined swimmers at a distance of 4 × 25 m, moving at submaximal speed. Such conditions eliminate the fatigue effect, require lower pulmonary ventilation and fewer head and trunk movements during inhaling, and thus allow lower positioning of the upper body in the water. The more frequent inhaling movements performed by swimmers at middle and long distances (400 and 2000 m) made the αH–G increase as compared with the 25 m distance (Tab. 2, 3).

The observed negative correlation between αH–G at 2000 m and subjects' age may be indicative of more experienced swimmers' better mastery of hydrodynamic positioning of the body in the water. A similar relationship between front crawl swimming and submaximal swimming velocity was also noted by Kjendlie et al. [11, 18] in swimming adults and children. According to Kjendlie et al. [11, 18], but also Yanai [12] more experienced adult swimmers develop more effective front crawl technique relying on more efficient leg work (higher frequency of movements) and the generated force, which decreases the angle of attack and thus reducing drag. In the present study the correlation between the number of leg movements per one arms movement cycle and swimmers' age was statistically non-significant ($r = 0.30$, n.s.); however, the force generated by leg movements could be greater in older swimmers. Furthermore, the noted correlation on the verge of statistical significance between αH–G and swimmers' age is similar to the results in the aforementioned studies.

Zamparo et al. [19], who assessed passive underwater torque (τ_p) and its impact on the energy cost of front-crawl swimming (C_S) at the speed of 1.2, 1.4 and 1.6 m/s^{-1} noted a statistically significant correlation between C_S and τ_p only at V_x of 1.2 m/s^{-1}. In another study Zamparo et al. [20] noted a linear correlation between the energy cost of front-crawl swimming (C_S) at 1.0 and 1.23 m/s^{-1} and torque modified by extra loading of the

swimmer's trunk. On the other hand, Kjendlie et al. [18] found a negative and statistically significant correlation between the angle of attack and the energy cost of swimming at 1.0 m/s^{-1} only; however, these results were obtained only in one group of adults and children. It shows that the energy cost was influenced by the body mass and the distance between the center of mass and the point of application of the buoyant force, which were greater in adult swimmers despite their smaller α during the swimming tests. A greater energy cost of a swimmer with greater body length parameters, who swims at V_x of 1.0 m/s^{-1}, can be explained by the greater torque causing the legs to sink in static conditions [21].

In the present study the αH–S was correlated with V_x more weakly than αH–G; it can thus be assumed that the position of head affects drag to a greater extent than the inclination angle of the trunk. Vorontsov et al. [7] following Onoprienko [22] and Miyashita and Tsunoda [23] showed that lifting the head at V_x below 1.45 m/s^{-1} may increase drag by about 20%. At higher swimming speeds, it can increase drag from 2% to 40%. In advanced swimmers the arching of the body backwards and the ensuing greater buoyancy and lift of the body decrease the generation of drag.

In the present study the αH–G was correlated with the stroke rate (on the verge of statistical significance $r = 0.37$) – one of the factors determining swimmers' performance at a distance of 2000 m. In the group under study the SR level should not be reduced to decrease the αH–G. For example, the SR was 91% of the value of the αH–G index in swimmers at the 2007 European Championship Finals in Antwerp at 1500 m; whereas the stroke length amounted to 95.2% in the study group in comparison with European Championship finalists. The measurements of the angle of attack in front-crawl swimming at 2000 m, 400 m and 25 m revealed a negative correlation ($r = -0.38$) on the verge of statistical significance between the αH–G with swimming velocity V_x at 2000 m. The correlation of the αH–G on the verge of statistical significance with subjects' age shows that older and more experienced and skilled swimmers are able to effectively reduce the angle of attack in front crawl swimming.

Conclusions

The angle of attack in front-crawl swimming (αH–G) decreases significantly with increasing swimming velocity V_x and reducing the swimming distance. The angle of attack was negatively correlated with V_x at 2000 m (on the verge of statistical significance). In sport practice the reduction of the angle of attack in front crawl swimming improves the swimmer's hydrodynamic parameters and sports results. It is confirmed by the results of young swimmers at a distance of 2000 m discussed in the present study.

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GAME EFFICIENCY OF WHEELCHAIR RUGBY ATHLETES AT THE 2008 PARALYMPIC GAMES WITH REGARD TO PLAYER CLASSIFICATION

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ABSTRACT

Purpose. The purpose of the study was to examine game efficiency of elite wheelchair rugby players in consideration of International Wheelchair Rugby Federation (IWRF) classification during the 2008 Paralympic Games played according to the old wheelchair rugby rules. **Basic procedures.** A group of 77 athletes representing 8 national teams participated in the study. Each team played 5 games for 32 min each. Athletes who played for more than 8 min in total at the 2008 Paralympics qualified for the study. The seven IWRF player point classes were collapsed into four groups. The game efficiency analysis was based on the IWRF Statistical Reports. The following six game efficiency parameters were analyzed: played time (T), sum of all points scored (PT), assist passes (AS), assist blocks (AB), turnovers (TO) and steals (ST). **Main findings.** The major finding of the study was that most differences in PT, AS, AB, TO and ST were found among all the examined groups (I–IV), except groups I and II. The played time (T) was not sensitive enough to identify significant differences among all the groups. This indicates that played time in the context of substitutions limited by classification point requirements does not reflect the differences between player classes. **Conclusions.** Generally, there was a tendency for high-point class players to perform better. The study findings point to the importance of analysis of game efficiency of elite wheelchair rugby players with regard to their IWRF classification during tournaments played according to the new wheelchair rugby rules.

Key words: disability sport, game efficiency, classification, wheelchair rugby

Introduction

Classification systems are used in various sports. They are particularly useful in sports for persons with various disabilities and impairments of physical function, who are classified according to their age, body weight and disability type [1]. Differences between sports results achieved by athletes within given classes are smaller than they would be between non-classified athletes, which greatly encourages the individuals with disability to participate in various sports [2]. Originally, sports for the individuals with disability were mainly propagated by physicians and physiotherapists, and the early classification systems were based on anatomic and medical criteria such as assessment of muscle strength, range of motion, length of limb stump, level of the spinal cord injury or spasticity [3].

In the 1970s wheelchair rugby[1] was played only by tetraplegics, and the wheelchair rugby athlete classification was based on a system developed by the International Stoke Mandeville Games Federation (ISMGF) in which the classes were largely determined by the level of the athletes' spinal cord injury [4]. Later on it was noted that the level of attained compensation in disabled

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[1] Wheelchair rugby is a team sport for athletes with disability developed in Canada in the 1970s [5]. In 2000 wheelchair rugby became a Paralympic sport [6]. There are currently 29 active countries playing wheelchair rugby at different international competition levels. The athletes play wheelchair rugby in custom-made sports wheelchairs. The rugby ball is identical to a regulation volleyball and the game is played on a hardwood basketball court [7]. The aim of the game is to advance the ball from the team's own back court within 15 seconds and score a goal by crossing the opposing team's goal line [5]. A goal is scored when two wheels of the ball carrier's wheelchair cross the goal line marked with two cones [4]. The team with a higher number of points at the end of regulation play wins. Wheelchair rugby is a contact sport involving such technical and tactical elements as picking and blocking. It requires speed, strength, endurance, coordination and effective wheelchair maneuverability skills.

persons was better reflected by their functional abilities, which could affect their sports successes to a much greater extent than their anatomical and medical assessments. Gradually, functional classification systems specific to the unique functional demands of particular sports superseded medical classifications. Functional classification is based on the athlete's functional abilities specific to the physical demands of each unique sport and it ensures that athletes with different kinds and levels of disabilities have an opportunity to compete in the same sport. One of the reasons for the changes in classification system in wheelchair rugby was the need to include athletes with disabilities other than spinal cord injuries with impairments similar to tetraplegia (e.g. muscular dystrophy, cerebral palsy, neuromuscular disorders). At present, wheelchair rugby athletes are individuals with neurological disorders (of the central or peripheral nervous systems) or non-neurological disabilities, with impaired or absent upper and lower limbs movement. The functional classification allows comparison of potential athletes' functional abilities with the accepted classification criteria [8]. The current wheelchair rugby medical-functional classification system was developed in 1991. The classification process comprises three components: (1) physical assessment consisting of manual muscle tests [9] and trunk tests; (2) functional skills tests (wheelchair skills: pushing forward and backward, starting, stopping, turning, changing direction; ball handling skills: one-hand and two-hand passes, catching, retrieving the ball from the floor, dribbling; blocking and picking); and (3) observation assessment of athletes during warm-up, training, practice and competition (e.g. transfers to and from the wheelchair, putting on gloves, straps and binders) [8]. Following the assessments each athlete is allocated one of seven sports classes (numerical categories) ranging from 0.5 to 3.5 points. The 0.5 class includes athletes with the most disability, and the 3.5 class athletes with the least disability eligible for the sport of wheelchair rugby. In wheelchair rugby the total number of points of all four athletes in a team on court at any time cannot exceed 8.0 points. The introduction of the point limit is aimed to equalize the medical and functional potential of the competing teams.

The wheelchair rugby classification system has been constantly verified to improve game efficiency of individual athletes and teams [4, 6, 10, 11]. The growing significance of functional assessment in the classification process has made a number of researchers examine relationships between wheelchair rugby specific fitness tests and player classification. Morgulec and Lencse-Mucha [7] revealed statistically significant correlations between the classification of Polish National Team wheelchair rugby players and the results of Beck Battery tests carried out twice – in 2001 and 2003. Similar observations were made by Malone et al. [10], who found a significant correlation between player classification and five wheelchair rugby specific fitness tests (20 m sprint, endurance sprint, up and back, passing, and slalom). The correlations observed indicated a certain tendency, while analysis of statistically significant differences between particular classes of players may yield some more detailed data about the accuracy of a classification system [13]. Morgulec et al. [12] in their study with the use of the Beck Battery revealed no significant differences between players from most IWRF classes, but only between the 0.5 class players and the remaining classes.

Wheelchair rugby combines short intense bouts of full effort exercise, thus it requires anaerobic capacity. Morgulec et al. [14] used the Wingate test to examine differences between individual classes of wheelchair rugby athletes and only noted significant differences between the 0.5 and 2.0–2.5 and 3.0–3.5 class players.

In team games, apart from the players' functional abilities necessary for development of skills and habits, also the praxeological assessment of individual players and the team as a whole are highly significant for attainment of good sports results. The praxeological evaluation is usually carried out using such criteria as rationality, efficiency, economy and profitability [15, 16]. The most basic and common praxeological criterion, measured with the level of conformity between the sport result and the goal is efficiency. An action is efficient if it achieves a specified goal, but also when it enables or enhances its achievement [15].

Very few studies concerning disability team sports, including relatively new wheelchair rugby, have been devoted to the assessment of game efficiency of players and teams. One of them is a study by Molik et al. [11] which used a modified game efficiency sheet from wheelchair basketball. The study was conducted on a sample of 105 wheelchair rugby players during the European Championships in 2005. Statistically significant differences in game efficiency were only noted between the 0.5–1.5 and 2.0–3.5 class players.

Vanlandewijck et al. [17] observed that differences between players at the national level can be determined

to a great extent by such extra factors as previous sport experience, training methods, creativity, talent as well as physical, psychical, technical and tactical potential. Thus the total of these factors and the player's functional abilities may not reflect the classification points assigned to the player on the basis of his functional abilities only. However, at the international level (world championships, the Paralympics) the extra factors determining the players' sports levels are comparable between individual players and therefore reflect better the assigned classification points alongside the assessment of functional abilities. This assumption may seem doubtful as the players' various intellectual skills may also be decisive in achieving the ultimate sports successes. An analysis of game efficiency of players with different levels of functional abilities can greatly contribute to the improvement of accuracy of the classification system. The aim of the present study was to assess game efficiency of wheelchair rugby players representing different IWRF classes.

It was assumed that an analysis of wheelchair rugby players on the highest sports level (Paralympic games athletes) would permit an objective comparison of selected parameters of game efficiency between athletes with disability representing different classes. It was also assumed that the level of game efficiency would be dependent on player classification, i.e. high-point class players (with greater functional abilities) would represent a higher level of game efficiency.

The confirmation of this assumption may contribute to the improvement of player and team sports training, in particular, to the process of optimal selection of players with regard to their classification.

The main research question was whether game efficiency was a factor discriminating between top level wheelchair rugby players?

Material and methods

The study sample included wheelchair rugby players from the world top teams: Australia, China, Japan, Canada, Germany, New Zealand, the United States and Great Britain. Only players who spent at least one quarter of the game played time on the court (8 min) were taken into consideration. Out of 88 players who took part in the Beijing Paralympics (September 6–17, 2008) 77 qualified for the study. Each Paralympic team played five matches during the tournament. The players represented all seven IWRF classes: 0.5 points (n = 9), 1.0 point (n = 11), 1.5 points (n = 7), 2.0 points (n = 23), 2.5 points (n = 10), 3.0 (n = 13) and 3.5 points (n = 4). Their percentage distribution at the 2008 Paralympic wheelchair rugby tournament is shown in Figure 1.

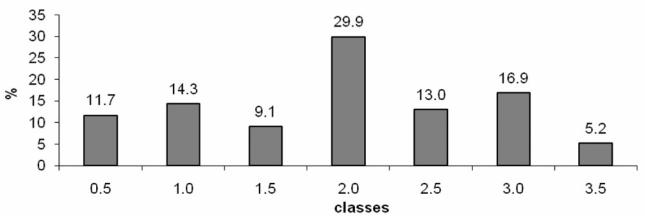

Figure 1. Percentage distribution of wheelchair rugby players from different IWRF classes at the Beijing 2008 Paralympics

The subjects (n = 77) were divided into four groups (I–IV) encompassing the respective IWRF classes.

Table 1. Profiles of the study groups of wheelchair rugby players

Group	IWRF classes (pts)	n	Age (years)	
			mean (SD)	min-max
I	0.5	9	33.9 (6.4)	26–47
II	1.0–1.5	18	31.2 (5.8)	20–42
III	2.0–2.5	33	31.8 (5.2)	23–43
IV	3.0–3.5	17	30.1 (6.6)	19–40
I–IV	0.5–3.5	77	31.8 (6.0)	19–47

On the basis of the tournament match statistics (20 matches) the following six game efficiency parameters were analyzed for each subject: played time (T), sum of all points scored (PT), assist passes (AS), assist blocks (AB), turnovers (TO) and steals (ST). An assist pass (AS) is the last pass to a player who scores a point (only one assist pass can be assigned to each scored point). An assist block (AB) is blocking of an opponent's wheelchair by a player without possession of the ball resulting in the ball carrier's crossing the opposing team's goal line and scoring a point (only one assist block can be assigned to each scored point). A turnover (TO) is the loss of possession of the ball. A steal (ST) is an interception of the ball resulting from a defending player's intended action [11]. Played time (T) was calculated as a player's averaged time played in all matches of the competition (no shorter than 8 min) over 32 min (total match time). The other parameters (PT, AS, AB, TO, ST) were averaged out over played time (T).

The Statistica 5.1 software package (StatSoft, Poland) was used for statistical analysis. In order to determine the differences in particular game efficiency parameters

between the four study groups of wheelchair rugby players the Kruskal-Wallis one-way analysis of variance was used ($p \leq 0.05$). When the Kruskal–Wallis test results were statistically significant, the Mann–Whitney test was used to determine differences between the individual study groups (I–IV). Because of multiple comparisons for paired tests between groups I–IV a correction was applied (alpha/[k(k–1/2)]), thus the level of statistical significance for each Mann–Whitney test amounted to $p \leq 0.002$.

Results

No significant differences between the groups of players (I–IV) were found with respect to age. The means and standard deviations of wheelchair rugby game efficiency parameters (averaged out over played time) are shown in Table 2. The large SD values may indicate a dispersion of the data in particular groups. In terms of such game efficiency parameters as PT, AS, TO and ST a tendency to attain higher values by players with smaller disability can be observed. It is not the case, however, with T and AB.

Table 2. Means and standard deviations (SD) of game efficiency parameters in four study groups (I–IV)

Group	T	PT	AS	AB	TO	ST
I	2.30 (1.08)	0.07 (0.20)	0.28 (0.36)	1.69 (1.17)	0.38 (0.41)	0.00 (0.00)
II	1.34 (1.09)	3.20 (3.17)	0.77 (0.83)	3.30 (2.35)	1.28 (3.38)	0.61 (1.00)
III	2.41 (1.13)	10.95 (3.69)	4.94 (2.85)	2.66 (1.83)	2.35 (1.89)	0.76 (0.74)
IV	1.99 (1.30)	18.85 (6.06)	6.67 (2.01)	1.29 (1.56)	2.84 (2.40)	1.18 (1.13)

T – played time, PT – sum of all points scored, AS – assist passes, AB – assist blocks, TO – turnovers, ST – steals

The non-parametric Kruskal–Wallis test revealed statistically significant differences between the groups under study in all parameters (Tab. 3). The level of statistical significance was $p \leq 0.001$ for the sum of all scored points (PT), assist passes (AS) and turnovers (TO); $p \leq 0.01$ for assist blocks (AB) and steals (ST); and $p \leq 0.05$ for played time (T).

Table 4 shows statistically significant differences between groups I–IV for particular wheelchair rugby game efficiency parameters. The post hoc analysis with

Table 3. Statistical significance of differences between the groups studied in particular game efficiency parameters (Kruskal–Wallis test)

	T	PT	AS	AB	TO	ST
χ^2	9.66	55.84	52.40	14.14	27.01	18.88
p	0.022	0.000	0.000	0.003	0.000	0.001

$df = 3$, T – played time, PT – sum of all points scored, AS – assist passes, AB – assist blocks, TO – turnovers, ST – steals

Table 4. Statistically significant differences between the groups (I–IV) for particular wheelchair rugby game efficiency parameters (Mann–Whitney post hoc analysis)

Groups	T	PT	AS	AB	TO	ST
I vs. II	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
I vs. III	n.s.	**	**	n.s.	**	*
I vs. IV	n.s.	**	**	n.s.	*	*
II vs. III	n.s.	**	**	n.s.	**	n.s.
II vs. IV	n.s.	**	**	n.s.	*	n.s.
III vs. IV	n.s.	**	n.s.	*	n.s.	n.s.

* $p \leq 0.002$, ** $p \leq 0.001$, n.s. – non significant, T – played time, PT – sum of all points scored, AS – assist passes, AB – assist blocks, TO – turnovers, ST – steals

the Mann–Whitney test revealed significant differences at $p \leq 0.001$ in sum of all points scored (PT; apart from those between groups I and II) and assist passes (AS; apart from those between groups I and II, and III and IV). Significant differences at $p \leq 0.002$ were noted for steals (ST) between groups I and III and between I and IV. For turnovers (TO) statistically significant differences at $p \leq 0.002$ were noted between all the groups studied, apart from those between groups I and II, and III and IV. No significant differences were found between all the groups studied at the corrected level of $p \leq 0.002$ (for repeated measures), for played time and assist blocks (with the exception of a significant difference between groups III and IV at $p \leq 0.001$).

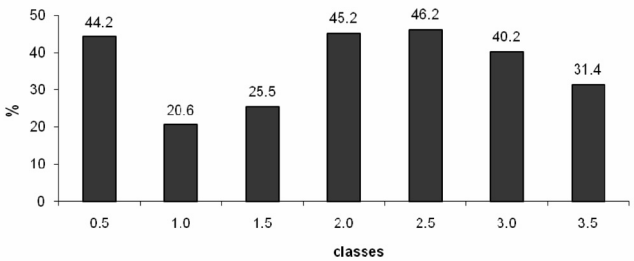

Figure 2. Percentage of total played time of each wheelchair rugby national team at the 2008 Paralympics for players representing different IWRF classes

Figure 2 shows the percentage distribution of total played time (5 matches, 160 min) of each wheelchair rugby national team at the 2008 Paralympics for players representing different IWRF classes (0.5–3.5).

Discussion

Classification is an additional factor that affects player efficiency in team games for individuals with disability. It can also make the assessment of game efficiency more difficult and complicated. Wheelchair rugby as a relatively young game without any equivalent among team games for the able-bodied, has limited possibilities of reliance on any commonly applied game efficiency assessment tools. So far the only attempt at evaluation of wheelchair rugby game efficiency has been a study by Molik et al. [11]. The present research confirms the problem of appropriate choice of assessment tools in sports for individuals with disability, which has been earlier discussed in the cases of some more developed team games for individuals with disability [17–24]. Objective methods of assessment of player and team behavior during the game are still being sought in wheelchair basketball [17–20], standing volleyball [21] and sitting volleyball [22–24]. They are to determine the level of game efficiency in relation to players' functional levels, which in consequence should contribute to the improvement of sport proficiency of these Paralympic sport events.

In the present study the assessment of game efficiency in wheelchair rugby focused on an analysis of six parameters (played time, sum of all points scored, assist passes, assist blocks, turnovers and steals). Played time (T) was not a statistically significant parameter discriminating between players from the groups studied (Tab. 2). The longest time on the court was spent by 2.5 and 2.0 class players, followed by 0.5, 3.0 and 3.5 class players, and 1.5 and 1.0 class players (Fig. 2). At the top sports level such results are not surprising. Taking into consideration the possibilities of substitutions, the players from group III (n = 33) played for the longest time. Thus their long played time cannot be attributed to the limited number of players in that group, as opposed to the less numerous group I (n = 9). This case illustrates the difficulties in assessment of an athlete's playing time in wheelchair rugby, without precise data on substitution possibilities within a team and on the coach's tactical plans related to choice of four players on the court. The obtained research data show that the players from group III (2.0–2.5 points) achieved the closest results to the athletes of the highest functional classes (3.0–3.5 points). In practice, wheelchair rugby coaches tend to select players from classes 2.0–2.5, which is most beneficial for the most optimal team tactics, with only a slight limitation of the team functional potential and without exceeding the allowed total classification points of all players on the court for a team.

In terms of sum of all points scored (PT) all the study groups differed significantly, apart from differences between groups I and II. It comes as no surprise since 0.5, 1.0 and 1.5 class athletes usually fulfill the role of blockers during offensive parts of the game. Due to their considerable limitation of hand function the low-pointers (0.5–1.5 points) are not major ball handlers and rather assist their high-point class teammates (2–3.5 points). Thus the statistically significant differences between 0.5, 1.0 and 1.5 class players and 2.0, 2.5, and 3.0 and 3.5 class players seem to be justified. The noted significant difference between players from group III (2.0 and 2.5 points) and IV (3.0 and 3.5 points) may derive from the coaches' tactical suppositions that the players from classes 3.0 and 3.5 are more likely to score points than their teammates from classes 2.0 and 2.5. On the other hand, the difference in the sum of scored points seems to confirm that functional differences between the IWRF point classes are reflected in game efficiency. The present research findings do not support the study results of Molik et al. [11], who failed to show statistically significant differences in the sum of scored points between 1.5 class players and 2.0, 2.5, 3.0 and 3.5 class players as well as between 2.0 and 2.5 class players and 3.0 and 3.5 class players. In the present study the 1.5 class players formed the same study group with the 1.0 class players. Perhaps two separate study groups might have confirmed certain similarities in game efficiency between the 1.5 class players and higher class athletes. The observed discrepancies between our results and those of Molik et al. [11] are hard to explain. Perhaps, the selection of world top players rather than European elite players only can serve as an explanation. One should not exclude either the impact of the dynamic development of wheelchair rugby over the last three years resulting in certain specializations of athletes. Also the expanded range of disability types of top world wheelchair rugby players might have affected the research results. There has been an observable increase in the number of wheelchair rugby athletes with tetra-equivalent function (e.g. four limbs amputations, cerebral palsy) usually assigned high-point classes. For instance, each athlete with tetraplegia experiences problems with trunk stability while sitting, which is not usually the case with amputees or athletes with cerebral palsy.

The analysis of assist passes (AS) revealed statistically significant differences between all the study groups, apart from those between groups I and II, and III and IV. Like in the sum of scored points, the lack of differences between players fulfilling the roles of blockers (0.5, 1.0 and 1.5 points) seems justified. The lack of statistically significant differences between groups III and IV can be explained by the limitations related to the applied statistical methods requiring correction of the level of statistical significance. Although the difference in assist passes between groups III and IV was not significant at $p \leq 0.002$, it amounted to $p = 0.009$. On the other hand, the lack of differences between high-pointers was confirmed in Molik et al. [11]. Moreover, both studies also revealed significant differences in the number of assist passes between players from classes 0.5 and 2.0; 2.5, 0.5 and 3.0 and 3.5; 1.0, 1.5 and 2.0, 2.5; and between 1.0, 1.5 and 3.0, 3.5. An analysis of the number of assist passes from the 2005 European Championships revealed a significant difference between the 0.5 and 1.0 class players. It is a curious observation taking into account the functional ability and the predominantly defensive role of these class players on the court. The noted difference could have resulted from the large differentiation of results in 0.5 and 1.0 players studied by Molik et al. [11] as confirmed by the means and standard deviation values obtained ($\bar{x} = 0.06$, SD = 0.13 and $\bar{x} = 1.11$, SD = 1.02, respectively). The lack of significant differences in the number of assist passes between groups III and IV is most certainly due to the specific nature of wheelchair rugby. The players from these two groups usually serve as ball handlers on the court, as opposed to their teammates whose functional limitations may involve a serious risk of losing the ball. It should be noted that in combination with the sum of scored points the athletes from classes 2.0–2.5 concentrate on handling the ball, by – for instance – making the final pass before scoring a goal. The functional limitations on the other hand (e.g. slower wheelchair pushing) affect negatively the sum of scored points. The 3.0–3.5 class rugby players with much stronger upper body muscles are usually much faster ball handlers and playmakers.

Assist block (AB) is a parameter determining the efficiency of offensive play without the ball. An assist block is attributed to a player who blocks an opponent with his wheelchair, in a way that leads to scoring a goal by his teammate (for a goal to count, two wheels of the player's wheelchair must cross the line while the player has possession of the ball). The statistically significant differences in the number of assist blocks were only found between players from groups III and IV. The analysis of mean values revealed a large, but non-significant difference between the results from groups II and IV ($p = 0.003$). The lowest results attained by the most functionally able athletes confirm that their role in offensive play is ball handling allowing crossing the opposing team's goal line and scoring a point. On the other hand the low-pointers, due to their functional limitations, are almost as active as high-point counterparts (2.0–2.5 points) playing without the ball. Assist block seems to be an important parameter, which can contribute to further defining of parameters determining game efficiency of 0.5–1.5 class players. Molik et al. [11] did not analyze the number of assist blocks as they were not considered to be a reliable parameter.

In terms of the number of turnovers (TO) significant differences were found between all the study groups apart from those between I and II, and III and IV. The obtained results are confirmed by earlier studies showing that the 0.5, 1.0 and 1.5 class wheelchair rugby players are usually blockers on the court, whereas players representing classes 2.0, 2.5 and 3.0 and 3.5 are mostly ball handlers and equally risk loss of ball possession. Molik et al. [11] did not find any statistically significant differences between the 1.5 (constituting a single group of subjects with 1.0 players in the present study) and 2.0–2.5 class players.

The numbers of steals (ST), i.e. ball interceptions, differed significantly only between players from group I and players from groups III and IV. The high-pointers are generally more predisposed to perform successful steals on the court owing to their better functional grip and trunk control. The surprising lack of differences between the players from group II and players from groups III and IV can be due to large differences in results in group II ($\bar{x} = 0.61$, SD = 1.00). However, steals tend to be more successful if performed by high-point class wheelchair rugby players. Similar results were reported by Molik et al. [11] in their analysis of steals.

It was also assumed that the level of game efficiency would be determinate by player classification, i.e. high-pointers (with greater functional abilities) would represent a higher level of game efficiency. The total analysis of six parameters of game efficiency revealed a significant impact of functional abilities on the efficiency of players of all classes (with the exception of classes 0.5–1.5). A similar game efficiency level between the low-point class players was not, however, significantly

correlated with their functional abilities. On the other hand, the research results obtained should constitute an important guideline to team coaches, who should use similar training loads and tasks with the wheelchair rugby players of classes 0.5–1.5. The study results reveal a significant impact of functional abilities on game efficiency of players of the other IWRF classes. The diverse levels of game efficiency should be an indication to wheelchair rugby coaches to continue further specialization of their players. It can be observed that three game efficiency parameters (AS, PT, ST) show that high-pointers tend to achieve a higher level of game efficiency; however, some of the noted differences were not confirmed statistically. The higher number of turnovers (TO) points leads up rather to a higher activity level of high-pointers as ball handlers than to a lower level of game efficiency. The number of assist blocks (AB) seems, in turn, to confirm a certain specialization of low-point class players as blockers. The above analysis of game efficiency parameters shows a similar number of scored points and assist passes among the participants in the European Championships and Paralympic Games. The results in particular groups (based on players' functional abilities) were also similar. On the other hand, high-point class wheelchair rugby athletes taking part in the European Championships achieved more turnovers and steals per game (1.75–2.94 and 3.05–5.01, respectively) than the participants of the Paralympic wheelchair rugby competition (0.76–1.18 and 2.35–2.84, respectively). An unambiguous interpretation of these results is rather difficult. The higher numbers of steals and turnovers at the European Championships can result from offensive players' own mistakes (e.g. wheelchair and ball mishandling), which can be confirmed by the lower level of training of European rugby wheelchair players. But it can also be indicative of effective defense play of European athletes, whose active and creative play as well as anticipatory skills make their opponents lose ball possession more often on the court. This way it could also be a confirmation of a higher level of game efficiency of European wheelchair rugby players. In other words, a clear and objective assessment of differences in game efficiency, using the existing methods is not possible.

It should be kept in mind that following the statistical requirements for paired tests between groups I–IV in post hoc analysis the level of statistical significance for each Mann–Whitney test was set at $p \leq 0.002$. It then decreased the number of statistically significant differences between the studied groups. At the same time large standard deviations were noted for many parameters, which was indicative of a large differentiation between results in particular groups (I–IV).

Conclusions

The above analysis of game efficiency of wheelchair rugby players from different IWRF classes seems particularly important with regard to changes in the wheelchair rugby rules introduced after the Beijing 2008 Paralympics [25]. According to the new regulations, a team has 12 seconds to advance the ball from their back court into the front court (15 seconds according to the old rules). Also a team in possession of the ball has a total of 40 seconds to score a point or concede possession (there are no such stipulations in the old regulations). The new changes are controversial since there is a certain risk that low-point class players (0.5 and 1.0 points) might not be able to take active part in offensive play within the designated limit of 40 seconds and to maintain the dynamic pace of the game. It may – in a sense – lead to some coaches' "discrimination" against the low-pointers, for whom a more optimal team on the court will comprise players from classes 1.5–3.5. The new regulations can most likely contribute to an increase in popularity of wheelchair rugby low-point tournaments (classes 0.5–1.5), in which the total classification value of all players on the court for a team at one time cannot exceed three and half points. In the long term it can lead to a split in the sport of wheelchair rugby. The new rules are also highly controversial from the standpoint of the main principle of sports for individuals with disability which should guarantee a chance to participate in sports for athletes with different types and severity of disability on equal terms. It should also be remembered that wheelchair rugby was developed by athletes with cervical spinal cord injuries for whom the pace of wheelchair basketball was too fast. The increase in the attractiveness and dynamics of wheelchair rugby resulting from the new rules could be made at the expense of those for whom the game was originally developed. The game efficiency analysis of wheelchair rugby athletes playing according to the new rules should be an implication to undertake further research. Future studies into game efficiency of athletes taking part in the World Championships in Vancouver in 2010 and Paralympics in London in 2012 according to the new rules may bring some interesting results.

Another area of studies is assessment of team game efficiency and determination of the most decisive pa-

rameters of sport success in present-day wheelchair rugby at different competition levels. Differentiation of certain technical and tactical actions seems necessary as well. For example, a loss of ball possession can be a result of player's error or the opponent's effective defensive play. The solution to these problems, however, requires further research allowing designing objective game parameters involving praxeological criteria (efficiency, reliability or economy) and expert opinions.

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ULTRA DISTANCE RUNNING IN VIEW OF HEALTH AND AMATEUR SPORT

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ABSTRACT
Purpose. The aim of the study was to examine opinions of runners regarding the effects of ultra distance running on their health. **Basic procedures.** The study sample was a group of 54 runners, participants of the Polish Supermarathon Championships in Kalisz. The method of diagnostic poll was applied using author's own questionnaire. **Main findings.** The majority of extreme distance runners stated they experienced no health problems; keeping fit was their main motivation to run long distances and since taking up running their health had improved. At the same time 36% of the interviewees admitted that running longer distances than the marathon length may have a negative impact on their health. **Conclusions.** Proper understanding of the principles of amateur and professional sport is the basis of safe physical activity. Amateur sport activity is correlated with a healthy lifestyle and positively affects the physical and psychosocial aspects of health. Simple forms of motor activity should be popularized in Poland as well as professional sport.

Key words: ultramarathon, running, amateur sport

Introduction

Running is one of the simplest forms of human movement and the most natural way of experiencing psycho-physical fatigue. During the last few decades running has been commonly recognized as an effective preventive measure against civilization diseases. For many, running constitutes a permanent component of a healthy lifestyle; for others, it is a way of life and satisfactory leisure. Running is also a competitive sport. The marathon races are now popular all over the world and for the last few years they have been undergoing a unique revival. The races are held in different locations, in rugged terrain or inclement weather (desert, polar circle) and often arouse emotions hard to find at a track and field stadium. The present-day marathons are huge commercial sport and recreational spectacles in which any healthy adult can take active part. Several thousand people can participate at one time in a modern marathon race. The attendance size determines the prestige of each race. Marathon participants include professional athletes and amateur joggers, the able-bodied and the disabled, and the old and the young, all forming together a diverse and colorful crowd [1].

The marathon is a foot race with an official distance of 42 km 195 m. It is an intensive modern Olympic event lasting a few hours. An ultramarathon is a sporting event over the distance of 100 km. At present the Polish, European and world ultranunning championships are organized. The Poland's National Athletics Federation is the body which assigns sports classes to individual runners for their results achieved at attested courses at a 100 km distance.

Different types and forms of motor activity can affect one's health to a different degree. The healthiest motor stimuli are endurance exercises of moderate intensity, for example, jogging. An endurance exercise imposes heavy demands on human organs and systems, which determine one's physical fitness [2] and health. A high fitness level greatly facilitates one's health potential [3, 4]. Although most health training recommendations focus on endurance exercises, their recommended intensity is usually average or moderate [5]. There are no explicit data confirming a negative impact of intensive training on the human body [6].

During foot races over distances longer than the traditional marathon length, the experience of competing with one's self, the weather or the distance surpasses the experience of competing against the opponents. In ultramarthon races the best runners can cover a 100 km distance in 7 hours, while novice competitors may run it for over 20 hours. Often the event organizers impose

a 24-hour time limit (with the winner covering the most distance in that time).

Long distance and marathon races are of professional and – at the same time – amateur and recreational character. The preparation of the runner's body for such an event is definitely a type of sport training rather than health training. It is not clear whether an ultramarathon can be explicitly classified as a competitive sport event or extreme recreation. In the case of ultramarathon its classification relies not so much on the type of activity (sport or recreation) but rather on its psychosocial context. Ultra runners display a variety of attitudes towards their competition as well as different aims and motivations. The egalitarianism of long-distance running events points to the mixed sport and recreational character of the contemporary, highly commercialized mass foot races. According to Naglak, the marathons and other long-distance races are non-classified. He defines them as "activities aimed at perfecting one's personality, improving one's health and physical fitness through exercise and competition. The effectiveness of these activities depends on the durability of one's psychical, physical and motor dispositions. These activities constitute a sport variety, whose growing popularity can greatly contribute to physical activity becoming an inseparable component of the way of life and physical culture of the whole society" [7, p. 5]. In non-classified sports the achieved results are of the athlete's concern only, and that is why these competitions lack all other implications related to professional sport, e.g. financial. What really counts is sheer participation in a race, overcoming one's weaknesses, and self-improvement. These aspects are inherent in the Olympic idea.

The aim of the study was an analysis of opinions of ultra runners concerning the health aspects of ultra distance running.

Material and methods

The study sample comprised a group of 54 male participants of the 2001 Polish Supermarathon Championships in Kalisz held over the distance of 100 km. The method of diagnostic poll was applied using the author's questionnaire. The subjects were asked about their training experience, participation in ultra running races and the effects of these races on their health (in their subjective opinion). They were also asked whether running ultra long distances might, in their opinion, have any negative effects on their health.

Results

Ultramarathons are egalitarian sports events open to everyone. They do not require any expensive sports equipment or special athletic skills. Each participant must be over 18 years of age and is required to provide his or her medical checkup results or a written statement of consent and pay the registration fee. The youngest participant was 23 years; the oldest 68 years of age. Altogether 5 women and 54 men took part in the Kalisz Supermarathon. In Poland, ultra distance and marathon female runners are in minority (about 5–10% of all participants). The ultra runners compete in different age categories (10-year ranges) set by the Polish Running Association. Figure 1 presents the age categories of the participants. The largest group (35%) comprised male runners aged 40–49 years; the smallest group consisted of competitors over 60 years of age (4%). The youngest age category (18–29 years) comprised 13% of participants, i.e. fewer than in the categories of 30–39 and 50–59 years.

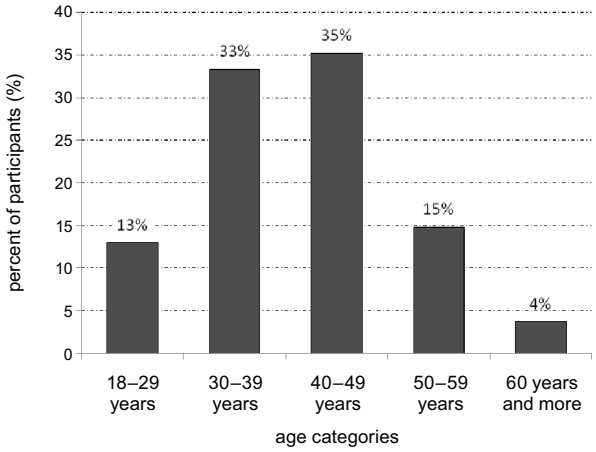

Figure 1. Age categories of participants of the Polish Supermarathon Championships in Kalisz

Participation in ultra running events requires long-term, systematic, daily training mostly aimed at the development of the body's aerobic capacity, i.e. running a great many kilometers on a weekly, monthly and yearly basis. In the study sample 39% of runners had been training systematically for several years; 24% for over 20 years, and 7% for over 30 years (Figure 2). Only 4 participants had trained for 2 years, two of whom had already participated in 100 km events, and for the other two the Kalisz competition was the first ultra running event in their life.

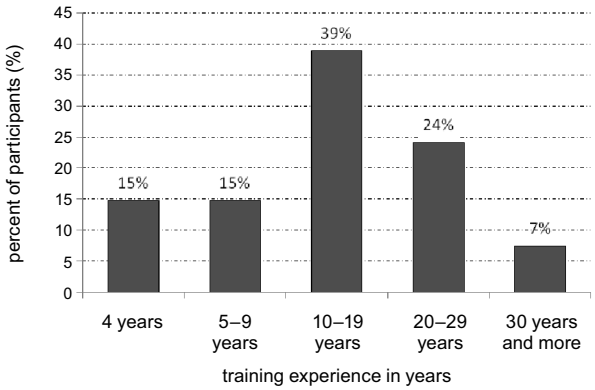

Figure 2. Training experience of ultra runners in years

43% of the participants had completed ultramarathons 1 to 4 times. For 22% the Kalisz competition was their first ultra running race; 19% had taken part in ultramarathons 10 to 19 times; and 6% more than 20 times (Fig. 3).

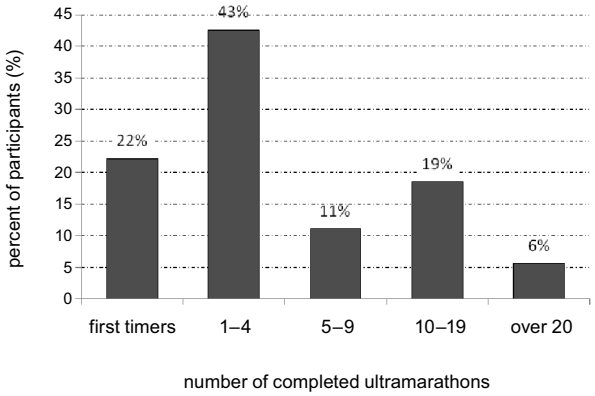

Figure 3. Number of ultramarathons completed by the participants

The ultrarunners had also taken part in running events over shorter distances, e.g. marathons (42,195 m), half marathons and other road running races as part of their preparation for the 100 km event. The runners under study had participated in a large number of different races a year: 35% in 10–19, 13% in 30–40 races (Fig. 4).

67% of the runners stated their health improved since they had taken up running over long distances (endurance training); 33% stated no improvement of their health condition (Fig. 5).

41% of the runners admitted that ultra distance running had no negative effects on their health; 35% admitted ultra distance running might have some negative effects of their health, while 24% had no opinion on the issue (Fig. 6).

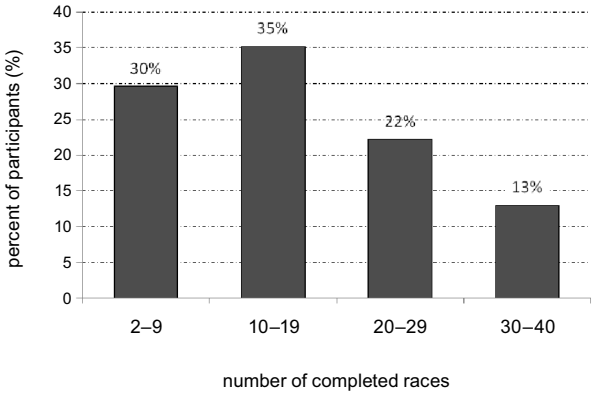

Figure 4. Number of completed road races over different distances by the ultramarathon participants

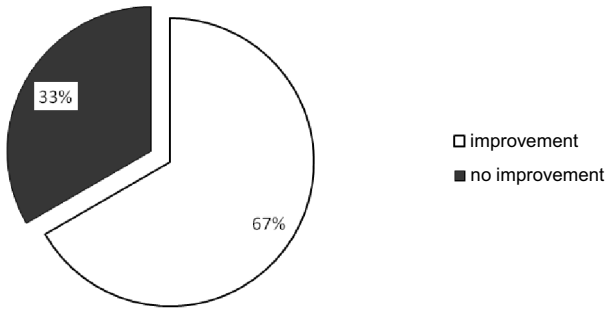

Figure 5. Participants' opinions on the effects of endurance training on their health

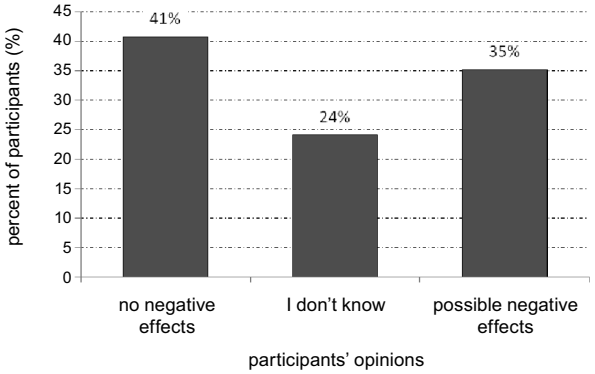

Figure 6. Participants' opinions about possible negative health effects of ultra distance running

Discussion

The annual Kalisz 100 km Supermarathon has been held every October since 1982. It is the oldest and the largest ultra running event in Poland. Five times the event was elevated to the rank of All Polish Championships. For the last few years long distance road running

events have become immensely popular in Poland, mostly due to the rapid development of the Internet social networking services, which serve as invaluable sources of information about runners, races and training methods.

The number of marathon runners in Poland has been steadily on the rise. Each year the record number of runners take part in marathon races in Polish cities, e.g. 3,000 participants in the Warsaw and Poznań marathons. A number of timed road running events (12-hour and 24-hour races) is also organized every year in Poland. The participants in 30, 40 and 50 km road races are mostly men aged 35–50 years. The completion of a 100 km race is regarded as a sports victory and all successful participants are awarded with commemorative medals. For many such a race is an immense challenge and opportunity to test one's own body in extreme conditions. Top Polish ultra runners cover the distance of 100 km under 7 hours (the Polish record is currently 6 hours, 22 min and 33 sec). Some need more than ten hours to finish a race. The ultrarunners are usually former long-distance or marathon runners who wish to prolong their sport career or simply prove themselves over an ultra long distance. With their experience and physical and psychical endurance training they willingly accept the ultra running challenge. The opportunity to accomplish an extraordinary feat increases their satisfaction and is a boost to their self-esteem. It is rather difficult to answer the question why people are ready to undertake the tremendous burden of intensive endurance training in inclement weather and over a distance of 100 km. Even the most experienced ultra runners, who devote all their time and effort to the races and training, fail to deliver a straight answer.

Is it then possible at all to discuss health aspects in the context of ultra running? One can definitely point to the aspect of a healthy lifestyle, but the question remains whether ultra running endurance training can be considered health training? Ultra distance running is a dynamic endurance exercise, with a cyclical structure of movement involving large muscle groups. In health-related physical activity the intensity of exercise should not exceed 85% of HR max. Participation in an ultra running race involves huge energy expenditure and constitutes a serious overload to the human motor system [8].

The marathons and ultramarathons are sports events featuring a great variability of time results achieved by athlete with relatively constant levels of physical fitness. Improvement of these results is relatively easy even at a later age. The result is not only determined by the quality of the runner's physical, psychical and coordination preparation but also by the race environment (season of the year, air temperature and humidity, atmospheric pressure, course surface and obstacles, strength tactics, consumption of fluids, strategies for completing the race, etc.). The unique aspect of ultra distance races is their organization outside the track and field stadium. The course of the race often leads through several towns in changing weather conditions, and the race itself may be several hours long.

The present study shows that the ultra runners have been training systematically for many years and have participated in a great number of racing events every year. The majority of the participants state their health has improved since they took up ultra running. Based on their own experience and knowledge the majority of the participants are of the opinion that ultrarunning has not caused any harm to their health, however, some of them have no opinion about this issue.

Different authors [2, 6] have noted that while strength, coordination or speed training improves the function of the neuromuscular system, endurance exercises mostly enhance the function of the cardiovascular system, respiratory system and cell and tissue metabolism.

As participation in ultrarunning races constitutes a heavy load to the human body, it also involves a risk of injuries and health deterioration. Certainly, a healthy lifestyle and properly carried out systematic endurance training do have a positive influence on one's health potential in its physical and psychosocial dimensions.

Regular physical activity (training) usually brings about positive changes to one's lifestyle. Health-oriented behaviors constituting a healthy lifestyle, i.e. proper nutrition, avoidance of stimulants, good sleep, periodic health examinations, are more frequently observed in physically active persons [9].

The propagation of mass sports events, e.g. road running events, seems an appropriate measure from the standpoint of public health. The development of proper (cautious) attitudes towards sports rivalry should be supported in order to promote such principles of physical recreation as fun, discretion and disinterestedness.

Conclusions

1. The majority of ultra runners – participants in extreme endurance races – stated they experienced no

health problems related to their activity. Their motivation is maintaining good health, and since they took up running their health has improved. 35% of the participants under study expressed an opinion that ultrarunning might have a negative impact on one's health.

2. The proper understanding of the principles of amateur and professional sport is the basis of safe physical activity.
3. Participating in amateur sport and recreation events is closely correlated with a healthy lifestyle, which can exert a positive impact on one's physical and psychical health.
4. In Poland record-seeking sports as well as mass amateur sports and different forms of health training should be widely propagated.

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"OBJECTIVE MEASUREMENTS" AND "NON-OBJECTIVE OBSERVATIONS" AS METHODS FOR ASSESSMENT OF ATHLETIC FITNESS AND HEALTH

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ABSTRACT
The sentence "measure what is measurable, and make measurable what is not so" (Galilei) can be seen as a postulate for using only objective physical or chemical methods in science to obtain hard data. Athletic fitness and health are complex states, however, including more than objective personality traits, described by hard data. Therefore, in the context of assessment of athletic fitness and health the questions arose: What does "measure" mean and how important are data that are immeasurable? Hard data are necessary, but not sufficient for assessment of all personality traits relevant for athletic fitness and health. Soft data are important as well. "Measure" in the context of athletic fitness and health should not only be restricted to physical or chemical methods, but should also include soft data, obtained by all systematic inside- and outside-observations using rating methods or only descriptions of qualitative items. For interpretation of both hard and soft data experience is necessary: this step of scientific work includes subjectivity in all cases. In order to gain experience, subjective methods must be trained, and this requires estimation of soft data and their appertaining methods, too. In conclusion, "measure" in the context of athletic fitness and health should include all objective and subjective methods for description of relevant personality traits.

Key words: assessment of athletic fitness, Galilei, objective data, subjective data, tests and reductionism, objectivity and validity

Introduction

"The objective of science is to measure what is measurable, and make measurable what is not so" – this programmatic postulate is assigned to Galileo Galilei (1564–1642) and is almost generally accepted in the scientific community [1]. Sanctuarius of Padua (1561–1636) constructed a metabolism balance [2]. He was named Iatrophysicist and he described metabolism as a sign of life and underlined by this the importance of its measurement. Later Lavoisier (1743–1794) measured metabolism of animals [3] by physical methods, and Carl Ludwig (1816–1895) invented in 1846 the Kymographion for recording and documenting physiological processes [4, 5]. It was still used in 1968 in the author's practical instructions for students of physiology. Stemmler et al. [6] wrote on the front-page of a textbook of statistics what Karl Marx (1818–1883) had stated: "A science can only be regarded as fully developed when it has reached the point where it can make use of mathematics". Altogether; objective measurements and calculations are seen as a fundamental criterion of science.

But two central questions have not been answered:

1. What does "measure" mean? Only the determination of objective physical or chemical parameters (for obtaining hard data) like Galilei's experiments about the law of gravity?
2. What do we do with those aspects which remain immeasurable?

Searching for answers

Athletic fitness and health are very complex phenomena, based on multiple personality traits. Some of those are measurable with objective physical or chemical methods. The followers of Galilei and others concentrate their activities on such "objective" measurements and tests, neglecting all other qualities which are immeasurable by their methods. This must lead to reductionism, as described, e.g. by Yates [7]: "Biological systems are complex by any definition of the term. Physics is a strongly reductionist science, and has prospered in that style; but conceptual biological sciences now suffer from permeation by a mechanistic reductionism …". Therefore objective measurements and tests only lead to a fictitious validity of the "objective" results [8].

Table 1. Interpersonal reliability (rows) of judges' scores, 2002 Olympic Winter Games in Salt Lake City

		RUS	CZE	USA	FRA	POL	CAN	UKR	GER	JPN
Be/	A	5.8	5.8	5.7	5.8	5.7	5.7	5.8	5.8	5.7
Si	B	5.9	5.9	5.9	5.9	5.9	5.8	5.9	5.8	5.9
Sa/	A	5.8	5.9	5.8	5.8	5.8	5.9	5.8	5.9	5.8
Pe	B	5.8	5.8	5.9	5.8	5.8	5.9	5.8	5.9	5.9

Judges from 9 countries about the figure skaters Be – Bereschnaja, Si – Sicharulidse, Sa – Sale, Pe – Pelletier, A – A-score, B – B-score [11]

Assessment of athletic fitness

Each kind of athletic fitness is based on a specific combination of physical, psychological and social personality traits. Only a part of them (percentage unknown) can be measured objectively; especially, the psychological and social traits are immeasurable by chemical or physical methods. But are they therefore unimportant or quite unscientific? The followers of Galilei and others propagate that there exist good correlation coefficients between their objective results and athletic fitness, but they describe only statistical and not causal interactions. The r^2 clears up only the statistical and not the causal common variance. In all cases in which objective measurements cannot contribute to description of a special athletic fitness (e.g. in artistic sports) it is generally accepted that use be made of non-objective observations and scorings as a valid method. The "coach's eye" is such a generally accepted method in many sport disciplines and it can be of very good interpersonal reliability, e.g. in figure skating (Tab. 1). The advantage of those rating methods is their characteristic to integrate various immeasurable traits and by this a respectable degree of validity.

Assessment of health

According to WHO (declaration from 1946) [9] health is based on 3 columns: physical, mental and social well-being. This means automatically that health cannot be assessed only by objective tests; an integrating point of view is necessary, too. Some "objective" parameters are necessary, but not sufficient for the state of health. In addition: mental (including emotional) and social aspects of performing sports are so powerful that humans risk their physical health for winning mental and social well-being, e.g. long distance runners and soccer- or basketball-players with their problems in knee-joints as well as ankle-joints. Therefore, health cannot be based on objective parameters only.

Test criteria

Objectivity, reliability and validity are typical criteria for the quality of tests [10]: objectivity and reliability cannot guarantee validity, and validity is typically based on validity- (= correlation-) coefficients only, neglecting all immeasurable traits.

The term "objective" has been used by the author in the sense that only those data are independent on the scientist's subjectivity which are based on physical or chemical procedures. Some psychologists took a different point of view, based on interpersonal conformity [10]: If data which are ascertained by subjective procedures show interpersonal conformity, this allows an increase in value. They are declared as "objective" in spite of the subjectivity of the associated methods. From a methodical point of view, a good interpersonal conformity of subjectively ascertained data can be seen as a sign of good reliability, but not of objectivity [11] (Tab. 1).

The subjective component of interpretation

To interpret objectively "hard data", experience is necessary. This includes the subjectivity of scientific decisions and is the source of different scientific standpoints regarding the same results. Measuring physical or chemical parameters is in the first step "objective", but in the second step of interpretation it depends on subjectivity as well as on the use of soft data (Fig. 1). Considering this, using "hard data" has no absolute objectivity-value and the value of "soft data" therefore increases. It depends on the object which way might be more advantageous to get valid conclusions, including the possibility of using both ways.

Conclusions

What does "measure" mean? Some scientists understand measure only in regard to objective physical or chemical methods. Measure can be understood also as regarding all systematic inside- and outside-observa-

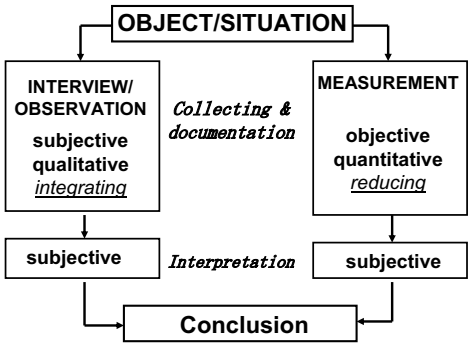

Figure 1. The two possibilities of getting conclusions about an object or situation. Left: using methods for soft data, right: using methods for hard data. In both cases subjectivity is included

tions using rating methods or only descriptions of qualitative items.

What do we do with those personality traits which remain immeasurable by physical or chemical methods? Both objective ("hard") data and subjective ("soft") data may help to assess special athletic fitness and state of health as well. But objective data reflect only those traits which are measurable in a strict sense, whereas a remarkable part of relevant traits are immeasurable by physical or chemical methods and this includes a reductionist way, if only hard data are interpreted. Subjective ("soft") data can include immeasurable, relevant traits with high reliability and validity if the experience of the observer is sufficient. In consequence, each sport scientist should not only appreciate objective "hard" data, but also the subjective "soft" data: no blind confidence in objective data!

These considerations are conceived as a pleading to appreciate the integrating aspect of subjective data, if experience of the observer is sufficient. Therefore, it is necessary to train these subjective methods and to accept their results as well as those from objective methods.

Trickery is possible with objective methods as well as with subjective methods, the subjectivity of soft data cannot be declared as a disadvantage in principle.

Therefore, "measure" in the context of a special athletic fitness and health should not be restricted on objectively measurable, i.e. by physical or chemical methods, personality traits. "Non-objectively" ascertained traits are relevant, too. Assessment of a special athletic fitness should include all objective and subjective methods for the description of relevant personality traits.

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BODY FAT DEPOSITION AND RISK FACTORS OF CARDIOVASCULAR DISEASES IN MEN

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ABSTRACT

Purpose. To determine whether risk factors for cardiovascular diseases (anthropometry, blood pressure, blood lipid profile) differ between men classified into the three relative body fat %BF categories (%BF ≤ 19: healthy; %BF > 19 and %BF < 30: overweight, and %BF ≥ 30: obesity). **Basic procedures.** A total of 112 volunteers from Brasília, Brazil, were submitted to the measurement of body weight, height and waist, abdominal and hip circumference. The body mass index (BMI) and waist-to-hip ratio (WHR) were calculated. %BF and body fat topography (arm, leg and trunk %BF) were estimated by dual-energy X-ray absorptiometry (DXA). Blood pressure was measured by auscultation and blood variables were determined by an enzymatic method. Univariate analysis of variance, one-way analysis of variance and the Scheffé post hoc test were used for statistical analysis ($p < 0.05$). **Main findings.** The three %BF groups differed significantly in terms of body weight and body circumference measures, with higher mean values being observed the higher the %BF. Fasting glycemia and high-density lipoprotein did not differ between groups, indicating the interference of other factors. BMI, WHR, blood pressure, total cholesterol, low-density lipoprotein, triglycerides, atherogenic index and atherogenic cholesterol were statistically similar in the overweight and obese groups and differed significantly from the healthy group. **Conclusions.** Abdominal, waist, hip circumference and body fat topography (arm, leg and trunk %BF) differ between the three %BF groups. None of the blood variables differed significantly between the overweight and obese groups. The cutoff %BF > 19 (measured by DXA) seems to be a good parameter to indicate cardiovascular risk factors in men.

Key words: anthropometry, body fat, coronary disease, DXA, HDL, LDL

Introduction

Worldwide, more than one billion adults present excess body fat and at least 300 million of them are obese [1]. In Brazil, about 43% of the adult population is estimated to present some degree of excess body fat, with 11% of severe cases [2]. Excess body fat contributes to the development of different risk factors related to cardiovascular diseases. In addition, excess body fat represents a constant overload which puts an extra workload on the heart [3].

Studies have indicated that men with a relative body fat (%BF) above 19% are at a higher risk for the development of nontransmissible chronic diseases such as heart diseases, strokes [4–6], hypertension [7], dyslipidemias, diabetes mellitus, atherosclerosis [8–10], gallstones, neoplasms, and liver diseases, among others [11]. Thus, the following important factors should be monitored for the evaluation of the development of these diseases: a rise in systolic and diastolic blood pressure, fasting glycemia, total cholesterol (TC), low-density lipoprotein (LDL), triglycerides (TG), atherogenic index (AI) and atherogenic cholesterol, in addition to a decrease in high-density lipoprotein (HDL) concentrations.

Individuals presenting some degree of obesity (%BF >30) and an android profile of body fat distribution (topography) characterized by greater fat deposition in the central region of the body are at a higher risk of developing cardiovascular diseases [6, 12]. To classify these cardiovascular risks resulting from excess body fat, some studies have used indicators such as body mass index (BMI), waist-to-hip ratio (WHR), body circumference [8, 12–14] and body fat topography [4, 6, 10]. However, it remains to be determined whether variations in these risk factors indeed exist with increasing %BF stores (%BF ≤ 19: healthy; %BF > 19 and %BF < 30: overweight, and %BF ≥ 30: obesity). This %BF classification is based on conclusions reported in different studies [2, 5, 8, 11, 13].

Therefore, the objective of the present study was to determine whether risk factors for cardiovascular dis-

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eases (anthropometry, blood pressure, blood lipid profile) differ between men classified into the three %BF categories (healthy, overweight and obese).

Material and methods

Subjects

The sample consisted of 112 adult men living in Brasília, DF, Brazil. All participants were employees of the same metallurgy company but performed different functions (workers and administrators). The study was approved by the Ethics Committee of the Catholic University of Brasília. The volunteers signed a free informed consent form containing detailed information regarding the type, conditions and place of data collection and an authorization for the use of their data in scientific publications.

Variables

The following variables were measured on the first day of data collection: body weight, height, waist circumference (WC) 2.5 cm above the umbilical scar, abdominal circumference over the umbilical scar and hip circumference (HC) in the most prominent portion of the greater trochanters. BMI and WHR were calculated using the following formulas: BMI = weight (kg) / height^2 (m) and WHR = WC / HC (cm).

Whole body fat and body fat topography (arm, leg and trunk %BF) were estimated by dual-energy X-ray absorptiometry (DXA). A whole-body scan was performed with a Lunar DPX-IQ apparatus (software version 4.7e) according to manufacturer's instructions.

After the end of this procedure, the volunteers remained in the supine position for the measurement of systolic and diastolic blood pressure in the left arm by auscultation using a stethoscope and an aneroid sphygmomanometer.

On the second day, a venous blood sample was collected between 6:00 and 8:00 am after a minimum fasting period of 12 h for the quantification of plasma glycemia, TC, HDL, and TG. These variables were measured by a colorimetric enzymatic method using Doles kits in a semiautomatic BIO-2000 spectrophotometer (Bioplus®). LDL was estimated using the formula of Friedewald et al. [15]: LDL = ((TG / 5) + HDL) – TC). In addition, the AI was estimated using the formula AI = TC / HDL [9, 13]. The higher the amount of LDL and very low-density lipoprotein (VLDL) in relation to HDL, the higher the chances of developing atherosclerotic disease [13]. The concentration of atherogenic cholesterol (AC) was calculated by the formula AC = TC – HDL, since TC corresponds to the sum of HDL + LDL + VLDL [16, 17].

After data collection, the sample was divided into groups by %BF and age: %BF ≤ 19 (n = 53) classified as healthy and characterized as subjects at a lower risk for cardiovascular diseases, %BF > 19 and %BF < 30 (n = 44) classified as overweight, %BF ≥ 30 (n = 15) classified as obesity; age 40 years old, and age > 40 years old.

Statistical analysis

Descriptive variables are reported as mean, standard deviation and range. With %BF as the dependent variable, was performed a univariate analysis of variance on the independent variables %BF groups and age groups. The results in terms of main effects showed that there is no interaction between %BF groups and age groups. Therefore, the one-way analysis of variance was used to compare %BF groups. The post hoc Scheffé test was adopted to localize possible differences (p < .05).

Results

A wide variation in minimum and maximum values was observed for age, body weight, height, BMI, body circumference measures and %BF, characterizing the heterogeneity of the sample (Tab. 1).

The age has no significant effect on %BF and there was no interaction between %BF groups and age groups (Tab. 2).

The anthropometric variables according to the accumulation of %BF are presented in Tab. 3. Height was

Table 1. Descriptive characteristics of the 112 adult men participating in the study

Variables	Mean ± SD	Range
Age (years)	34.1 ± 9.0	20–55
Body weight (kg)	71.7 ± 10.2	51.7–95.0
Height (cm)	168.4 ± 7.0	152.0–189.0
Body mass index (kg/m^2)	25.3 ± 3.1	17.8–33.6
Waist circumference (cm)	85.6 ± 9.1	67.5–103.0
Abdominal circumference (cm)	86.9 ± 9.5	54.7–106.0
Hip circumference (cm)	93.5 ± 6.2	77.0–109.3
Relative body fat	20.0 ± 8.3	6.0–31.7

SD – standard deviation

Table 2. Relative body fat (%BF) in the two age groups

%BF group	Age group	Mean ± SD
%BF ≤ 19	≤ 40 years (*n* = 46)	12.3 ± 3.9
	> 40 years (*n* = 7)	13.9 ± 3.4
	Total (*n* = 53)	12.5 ± 3.8
%BF > 19 and %BF < 30	≤ 40 years (*n* = 26)	24.1 ± 3.1
	> 40 years (*n* = 18)	26.2 ± 2.2
	Total (*n* = 44)	24.9 ± 3.0
%BF ≥ 30	≤ 40 years (*n* = 13)	32.5 ± 2.0
	> 40 years (*n* = 2)	31.8 ± 1.4
	Total (*n* = 15)	32.4 ± 1.9
Total	≤ 40 years (*n* = 85)	19.0 ± 8.5
	> 40 years (*n* = 27)	23.4 ± 6.4
	Total (*n* = 112)	20.0 ± 8.3

SD – standard deviation
%BF group: F test = 145.4 ($p = 0.000$), observed power = 1
Age group: F test = 1.1 ($p = 0.304$), observed power = 0.176
Interaction %BF group × age group: F test = 0.611 ($p = 0.545$), observed power = 0.150

Table 3. Anthropometric variables in the three relative body fat (%BF) groups

Variables	%BF ≤ 19	%BF > 19 and %BF < 30	%BF ≥30
Body weight (kg)	$65.2^a \pm 8.5$	$75.9^b \pm 7.5$	$82.2^c \pm 6.1$
Height (cm)	$168.7^a \pm 6.8$	$167.1^a \pm 7.2$	$171.0^a \pm 6.4$
Body mass index (kg/m^2)	$22.9^a \pm 2.2$	$27.3^b \pm 2.0$	$28.1^b \pm 2.2$
Waist circumference (cm)	$77.9^a \pm 5.6$	$91.5^b \pm 5.3$	$95.2^c \pm 3.6$
Abdominal circumference (cm)	$79.1^a \pm 6.6$	$92.6^b \pm 5.6$	$97.4^c \pm 3.5$
Hip circumference (cm)	$89.6^a \pm 4.8$	$96.0^b \pm 5.1$	$100.1^c \pm 3.7$
Waist-hip ratio	$0.88^a \pm 0.06$	$0.97^b \pm 0.04$	$0.97^b \pm 0.04$

Data are reported as mean ± standard deviation
Means followed by the same letter did not differ significantly ($p > .05$)

Table 4. Blood pressure and body fat topography in the three relative body fat (%BF) groups

Variables	%BF ≤ 19	%BF > 19 and %BF < 30	%BF ≥ 30
SBP (mmHg)	$124.0^a \pm 11.2$	$133.6^b \pm 17.3$	$141.0^b \pm 20.0$
DBP (mmHg)	$78.4^a \pm 11.0$	$90.0^b \pm 12.8$	$93.3^b \pm 13.3$
% Arm fat	$6.7^a \pm 2.4$	$15.4^b \pm 3.6$	$19.4^c \pm 3.2$
% Leg fat	$12.6^a \pm 3.8$	$23.6^b \pm 4.0$	$32.3^c \pm 4.0$
% Trunk fat	$14.0^a \pm 4.8$	$28.0^b \pm 4.7$	$36.4^c \pm 1.9$
%BF	$12.5^a \pm 3.8$	$24.9^b \pm 3.0$	$32.4^c \pm 1.9$

SBP – systolic blood pressure, DBP – diastolic blood pressure
Data are reported as mean ± standard deviation
Means followed by the same letter did not differ significantly ($p > .05$)

Table 5. Blood variables in the three relative body fat (%BF) groups

Variables	%BF ≤ 19	%BF > 19 and %BF < 30	%BF ≥ 30
Fasting glycemia (mg/dL)	$91.2^a \pm 10.0$	$96.8^a \pm 21.3$	$94.5^a \pm 6.7$
Total cholesterol (mg/dL)	$147.3^a \pm 28.4$	$174.7^b \pm 40.9$	$188.4^b \pm 29.8$
High-density lipoprotein (mg/dL)	$41.9^a \pm 12.5$	$36.5^a \pm 8.6$	$36.1^a \pm 7.8$
Low-density lipoprotein (mg/dL)	$84.1^a \pm 26.7$	$105.0^b \pm 41.1$	$120.2^b \pm 26.6$
Triglycerides (mg/dL)	$109.8^a \pm 71.0$	$168.4^b \pm 91.6$	$164.3^b \pm 72.4$
Atherogenic index	$3.8^a \pm 1.5$	$5.1^b \pm 1.8$	$5.4^b \pm 1.3$
Atherogenic cholesterol (mg/dL)	$109.1^a \pm 35.8$	$143.5^b \pm 49.2$	$153.1^b \pm 29.2$

Data are reported as mean ± standard deviation
Means followed by the same letter did not differ significantly ($p > .05$)

similar in the three groups. Body weight and the body circumference parameters differed significantly between the three groups. In contrast, BMI and WHR were statistically similar in the overweight and obese groups and differed significantly from the healthy group. The overweight and obese groups were also similar in terms of systolic and diastolic blood pressure. Body fat topography and %BF differed significantly between the three groups (Tab. 4).

With respect to the blood variables, fasting glycemia and HDL did not differ significantly between the three %BF groups. Atherogenic cholesterol, TC, LDL, TG and AI were statistically similar in the overweight and obese groups and differed significantly from the healthy group (Tab. 5).

Discussion

Several lines of evidence indicate that excess body fat promotes the development of non-transmissible chronic diseases and risk factors for cardiovascular diseases [1, 2, 6–8, 10], and that %BF is affected by age, sex, body build and level of physical fitness [18]. In this study, it was shown that there is no interaction between %BF groups and age groups, and that age has no significant effect on %BF. This can be explained by the rise in worldwide obesity and/or overweight [1, 2] and in Brazilian children and adolescents [19, 20]. Thus, in view of the practicality of BMI for the classification of subjects into underweight, healthy weight, overweight or obesity, this parameter has become one of the indices most often used worldwide for this purpose [12, 13]. However, its main utility is to facilitate the comparison and interpretation of body weight estimates standardized for height based on the assumption that excess body weight corresponds to large amounts of stored body fat [21]. However, it should be emphasized that BMI does not distinguish between body mass components (fat, muscle and bone mass), a fact requiring greater care when using this index as an indicator of adiposity. Although not discriminatory for true amounts of body fat, BMI can be a good epidemiological marker [22]. This affirmation seems to agree with the present results since BMI did not differ significantly between overweight and obese subjects (Tab. 3), indicating an important classification error that might assign obese individuals to a less worrisome condition and thus delay appropriate treatment.

With respect to the lack of a significant difference in the WHR between the overweight and obese groups, one may speculate that, although the mean difference in waist and hip circumference between the two groups was approximately 6 and 5 cm, respectively (Tab. 3), the mathematical equation adopted masked this difference. Since the ratio of these measures generates values close to 1.0, very close results are obtained and no statistical difference might be observed. Thus, waist and/or abdominal circumference analyzed separately might be better predictors of the risk for cardiovascular diseases since in the present sample these measures differed between the three %BF groups. In this respect, the WHR loses its expressiveness for overweight or obese individuals (Tab. 3). This conclusion agrees with the results reported in other studies which also emphasized that waist and abdominal circumference alone are better indicators of the development of cardiovascular risk [12, 13, 18, 23]. Although these measures are not related to height, they are still a better parameter of excess fat in the abdominal region.

Analysis of body fat topography showed that fat accumulated in the trunk and body segments increased concomitantly with increasing %BF. In addition, the amount of trunk fat predominated compared to the other body fat deposits, a fact emphasizing the android pattern of body fat distribution, irrespective of %BF classification (Tab. 4). Greater trunk-fat mass was associated with unfavorable values of most cardiovascular disease risk [24].

No difference in systolic or diastolic blood pressure was observed between the overweight and obese groups, in agreement with other studies [7, 25]. This finding may indicate that the simple state of overweight is sufficient for a blood pressure rise. As a result of physiological adaptations of an organism, the process of blood pressure increases and then becomes slower and is subject to lifestyle, dietary habits and the use of pharmacological drugs [11, 21].

Despite discussions regarding the existence of a strong positive association between arterial hypertension and obesity [7, 25], the present results (Tab. 4) show that a state of overweight is already an aggravating factor for high blood pressure. The state of obesity, however, will render the process of weight loss more time consuming and difficult, with a consequent increase in the duration of installed hypertension. This fact, together with an increase in the concentrations of blood risk factors, may accelerate the development of cardiovascular diseases.

Among the blood variables studied, fasting glycemia did not differ significantly between the three groups, demonstrating that, on average, the volunteers presented no problems of decompensation, irrespective of the amount of %BF. Changes in fasting glycemia generally tend to occur with a concomitant increase of lipid blood variables (TC, LDL and TG) above reference values [10, 13], a fact generally not observed in the present sample. High total fat mass and lower trunk-fat mass cannot be explained by insulin sensitivity [24] and, fasting glycemia was not predicted by total or regional %BF [4].

On average, TC and LDL did not exceed the borderline reference values (200 mg/dL and 130 mg/dL, respectively) for the desired fasting concentration [13]. However, overweight and obese subjects were statistically similar but differed significantly from the healthy group. Higher TC and LDL concentrations are observed during the period of installation of the state of overweight or obesity. This condition may stabilize over time and the organism tends to potentiate the uptake of LDL into adipose tissue by an increase in the number of receptors, consequently reducing TC [26]. This fact would explain the lack of difference between overweight and obese subjects.

In view of the cross-sectional character of the present study, we do not know for how long the subjects were sustaining the current amounts of %BF. A longitudinal follow-up of the sample would be necessary for further conclusions as done by Mansur et al. [27], who emphasized that the longer the time a subject is obese, the greater the chances of developing atheroma plaques because of the subsequent inability to remove cholesterol and TG from blood.

In the present study, on average, the healthy group did not exceed the desired TG concentration of 150 mg/dL, in contrast to overweight and obese subjects. The lack of difference in TG between the last two groups might be explained by the fact that this parameter is only partially influenced by %BF and is better explained by genetic factors, dietary habits and level of physical activity, among others [8]. Similarly, HDL concentration highly depends on genetic factors and the level of physical activity and is poorly influenced by the accumulation of body fat [16, 17]. Therefore, this variable probably did not show significant differences between the three %BF groups.

In contrast to the healthy group, overweight and obese volunteers presented an AI above the reference value: > 4.5 [9, 13], but did not differ from one another. This finding indicates that the presence of excess body fat was sufficient to increase the AI in this sample. One of the main consequences of an increased AI is the facilitation of the formation of atheroma plaques due to excess circulating LDL compared to HDL. This fact also indicates that, although TC and LDL did not exceed their tolerable borderline values, the balance between LDL and HDL was not acceptable, demonstrating the need for interventions to regulate these concentrations. In this case, nonpharmacological treatment should include a specific diet and regular systematic physical exercise adapted to the needs of each individual [11].

Although, on average, atherogenic cholesterol (Tab. 5) did not exceed the borderline reference value (<160 mg/dL) [16, 17], a significant increase in this parameter was observed for overweight and obese subjects compared to individuals with healthy %BF. These two groups were also found to be highly heterogenous, indicating the presence of subjects in whom atherogenic cholesterol exceeded the reference value, in partial agreement with other studies [16, 17]. It should be emphasized that, even when LDL concentrations are within acceptable limits, they might be high in relation to HDL which, according to lifestyle, may result in the future formation of atheroma plaques. This applies to both atherogenic cholesterol and AI. Thus, the ideal would be to increase HDL concentrations and to reduce LDL levels. According to some studies [16, 17], the best way to achieve this goal is the implementation of a systematic aerobic training program.

Limitations of the present study were its cross-sectional character (which does not permit the determination of how long the volunteer was sustaining the current %BF) and the use of a semiautomatic spectrophotometer (which is less accurate than an automatic one). However, various medium- and small-size laboratories in Brazil use this instrument for the diagnosis of biochemical factors such as those studied here. Another limitation is the fact that we did not evaluate the lifestyle of the volunteers in order to identify subjects presenting greater risk behaviors for the development of cardiovascular diseases.

Conclusions

In conclusion, among the anthropometric variables, abdominal, waist, hip circumference and body fat topography (arm, leg and trunk %BF) differs between the three %BF groups. None of the blood variables differed

significantly between the overweight and obese groups, demonstrating that an increase of %BF itself above healthy levels is a source of concern that should be taken into account even before the onset of obesity. The cutoff %BF > 19 (measured by DXA) seems to be a good parameter to indicate cardiovascular risk factors in men.

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THE ASSOCIATION BETWEEN BODY DISSATISFACTION AND NUTRITIONAL STATUS IN ADOLESCENTS

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ABSTRACT

Purpose. This study analyzes the association between body dissatisfaction and nutritional status in adolescents. **Basic Procedures.** The study enrolled 234 boys and 442 girls. Information was collected on body image and anthropometry performed. Nutritional status was stratified into two categories: healthy (BMI: 18.5–25.0 kg/m^2) and unhealthy (BMI: <18.5 and >25.0 kg/m^2). Body image was coded as satisfied and dissatisfied. **Main findings.** It was found that 65.5% of adolescents were dissatisfied with their body image. While the girls wished to reduce their body silhouettes (48.4%), the boys wished to increase in size (51.3%). Unhealthy nutritional status was only associated with body dissatisfaction among the girls (95%CI = 1.35–3.43). Overweight girls were 11 times more likely to be dissatisfied with their bodies than normal weight girls. **Conclusions.** Nutritional status was a determinant factor for body dissatisfaction, primarily among female adolescents, since those whose nutritional status was unhealthy had different levels of dissatisfaction from those with healthy BMI.

Key words: adolescents, anthropometry, nutritional status, body image, body dissatisfaction

Introduction

Body image is a complex phenomenon that is multidimensional in nature [1] and can involve perceptual, affective, cognitive or behavioral disturbances.

Body dissatisfaction is highly prevalent during adolescence [2, 3]. A study carried out with schoolchildren (8 to 11 years) in Porto Alegre, Brazil, revealed that 82% of them were dissatisfied with their own body image [4]. Research indicates that girls tend to exhibit greater body dissatisfaction than boys [5–7].

While body dissatisfaction is related with the desire to be thinner among females [4], among male adolescents body dissatisfaction is associated with the desire to gain weight, to achieve an athletic build [2, 4, 8].

Body dissatisfaction has often been associated with discrepancies between real and ideal silhouettes [9, 10]. Although it is a complex subject for investigations, there is evidence that social and sociocultural aspects have an influence on distorting body image [11].

A series of nutritional status disorders can be observed in adolescents today, characterized both by nutritional excesses and deficits [12, 13]. During recent years, overweight and obesity have been observed to increase in all age groups [13], and as a result overweight adolescents suffer from problems related to acceptance of their self-image and valuation of their own bodies.

There has not been found any Brazilian research that would verify the association between nutritional status and body dissatisfaction in adolescents, thus the objective of this study was to analyze this association.

Material and methods

Participants

The association between body dissatisfaction and nutritional status in adolescents was investigated by means of a cross-sectional study "Levels of physical activity, physical fitness and health-related social behavior in schoolchildren from Florianópolis, SC". This study was carried out during the second half of 2007 with a representative sample of adolescents from the public secondary education system of Florianópolis, SC, in the southern region of Brazil.

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Sample selection

The sample selection was carried out in two stages: (1) stratification by geographic region and (2) school classes as clusters. Initially the municipality of Florianópolis was divided into five regions: Center, Continent, East, North and South. Next, the largest schools in each region were selected and from each school the number of classes necessary to achieve representativeness of its geographic area was determined. All adolescents who attended school classes on the day of data collection were invited to take part.

The sample size was determined using procedures suggested by Luiz and Magnanini [14] for a finite population, assuming a prevalence of 50% (body dissatisfaction), 95% confidence interval (95%CI), estimated error of 4 percentage points and an additional 15% for possible losses from the sample. Based on these parameters it appeared necessary to collect data from 659 adolescents. Considering the characteristics of the sampling process which involves all individuals belonging to each cluster, the final sample contained 892 adolescents.

Adolescents above 18 years of age were excluded (n = 33). Adolescents who did not complete their body image questionnaire were considered as lost to the sample (n = 182). The final sample comprised 676 adolescents (234 boys and 442 girls), aged 14 to 18 years (mean = 16.06 ± 1.01).

Procedures

This research was approved by the Research Ethics Committee at the Universidade Federal de Santa Catarina (Hearing number 372/2006).

In each case, school management was contacted in order to explain the research objectives and methods. Parental consent was obtained before initiating data collection. The adolescents were informed that participation was voluntary.

Measurements

Body image

Information related to body image was obtained using a scale of nine body silhouettes proposed by Stunkard, Sorenson and Schlusinger [15]. All of the silhouettes were shown to the adolescents and they replied to the following two questions: Which silhouette best represents your body's current appearance (real)? Which body silhouette would you like to have (ideal)? Body image was evaluated by subtracting the real silhouette from the ideal silhouettes. When the difference was equal to zero, the adolescent was classified as satisfied and if different from zero as dissatisfied. If the difference was positive, dissatisfaction was due to a desire for a smaller silhouette and if the difference was negative the dissatisfaction was caused by a desire to increase in size.

Weight and height

Body weight and height were measured according to recognized procedures [16]. Body weight was measured using a digital balance, PLENNA® brand, with 150 kg capacity and 0.1 kg sensitivity and automatic shutdown. Height was measured using a flexible steel stadiometer fixed to the wall. Body mass index [body weight (kg) / height (m^2)] was used as the indicator of nutritional status [17, 18]. Adolescents with BMI below 18.5 kg/m^2 [18] and above 25.0 kg/m^2 [17] were considered to have nutritional status disorders. The expression overweight was adopted to define both overweight and obesity. The international cut-off values used for the classification of nutritional status according to gender and age are shown in Tab. 1.

Data analysis

When comparing two proportions, the test of significance for differences between proportions was applied. Differences in frequency between variables were verified using the chi-square test. The association between body dissatisfaction and nutritional status was analyzed by means of logistic regression, with a 95% confidence interval. Data were analyzed using the statistical programs SPSS 13.0 and MedCalc 9.3.3.0.

Results

The distribution of the adolescents by gender and satisfaction with body image is illustrated in Fig. 1. It was observed that 65.5% of the adolescents were dissatisfied with their body image, being significantly higher among male adolescents (72.6%) than females (61.8%) (Fig. 1a). When the subset of dissatisfied adolescents was stratified by desire to change body silhouette (Fig. 1b), it was observed that females wished to reduce their silhouette (48.4%), while males wished to increase it (51.3%).

Figure 2 illustrates the degree of body dissatisfaction according to nutritional status. It was found that

Table 1. International cut off points for body mass index for thinness, overweight and obesity between 14 and 18 years of age

Age (years)	Male				
	BMI (kg/m^2)				
	16	17	18.5	25	30
14	14.09	15.01	16.41	22.62	27.63
15	14.60	15.55	16.98	23.29	28.30
16	15.12	16.08	17.54	23.90	28.8
17	15.60	16.58	18.05	24.46	29.41
18	16.00	17.00	18.50	25.00	30.00
Age (years)	Female				
	BMI (kg/m^2)				
	16	17	18.5	25	30
14	14.48	15.43	16.88	23.34	28.57
15	15.01	15.98	17.45	23.94	29.11
16	15.46	16.44	17.91	24.37	29.43
17	15.78	16.77	18.25	24.70	29.69
18	16.00	17.00	18.50	25.00	30.00

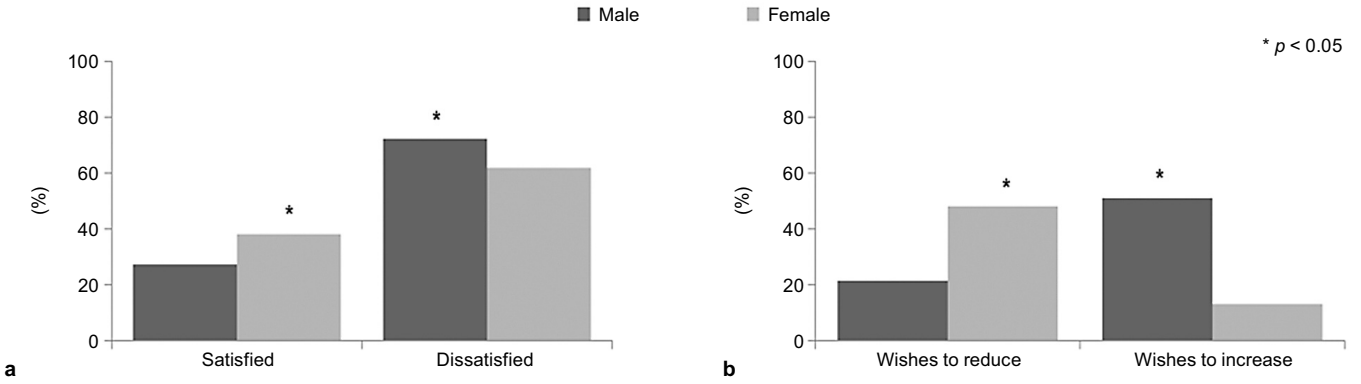

Figure 1. Distribution of adolescents according to perceived body image and gender (Florianópolis, Brazil 2007)

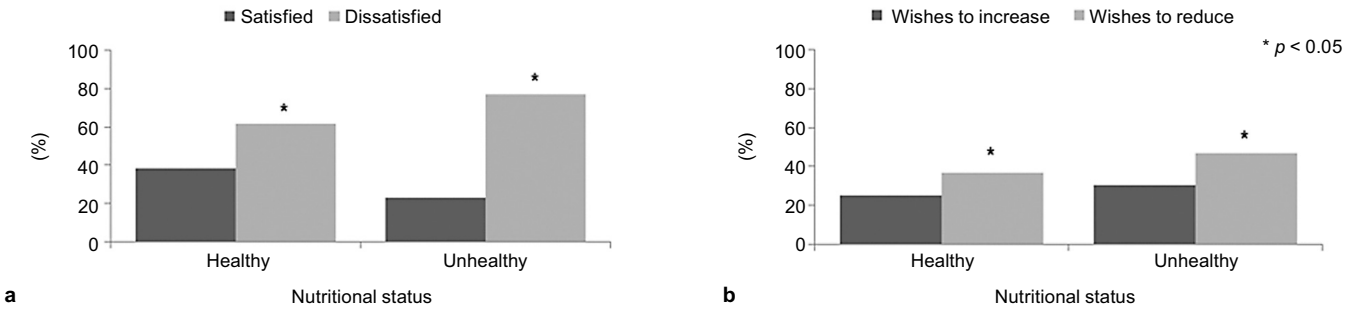

Figure 2. Adolescents' perception of body image, according to nutritional status (Florianópolis, Brazil 2007)

77.0% of the adolescents with nutritional status disorders were dissatisfied with their body image (Fig. 2a), 46.7% wished to reduce and 30.3% to increase their silhouette (Fig. 2b). With relation to the adolescents classified as having healthy BMI, it was observed that 61.8% were dissatisfied (Fig. 2a), with 36.6% and 25.2% desiring smaller and larger silhouettes, respectively (Fig. 2b).

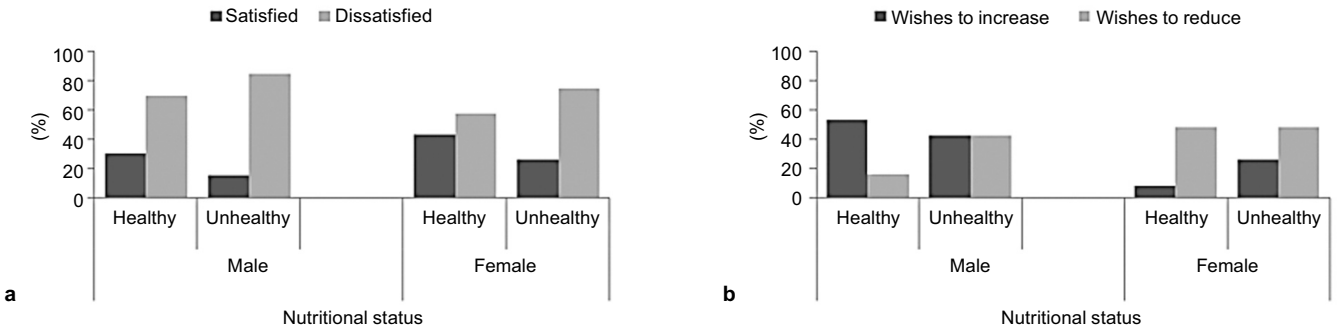

Figure 3. Adolescents' perception of body image, according to nutritional status and gender (Florianópolis, Brazil 2007)

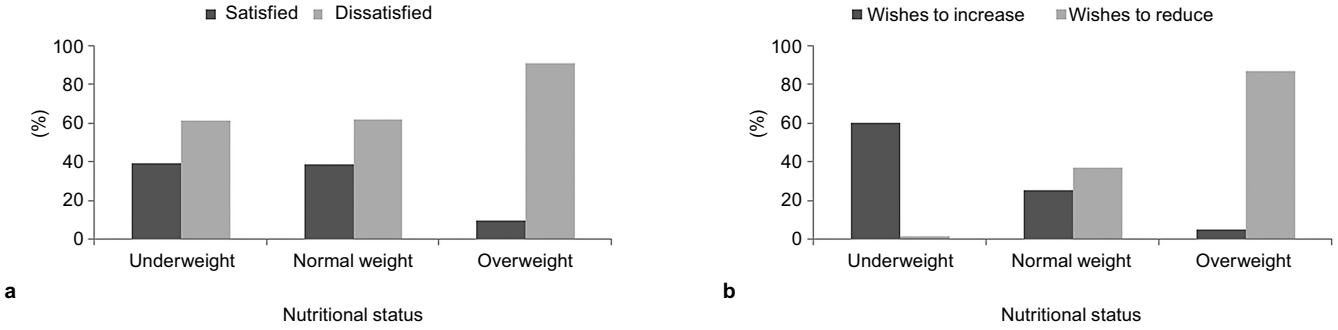

Figure 4. Adolescents' perception of body image, according to underweight, normal weight and overweight (Florianópolis, Brazil 2007)

When body image perception was stratified by gender (Fig. 3), the results revealed that male adolescents with unhealthy nutritional status exhibited more dissatisfaction (84.4%) than females (74.2%) (Fig. 3a). While 42.2% of the male adolescents with unhealthy nutritional status wished to increase their body silhouette, just 25.8% of the females expressed this wish. The predominant desire among female adolescents was to reduce the size of their body silhouette (48.3%) (Fig. 3b).

Figure 4 illustrates the degree of body dissatisfaction according to underweight, normal weight and overweight. The results revealed that 61.0%, 61.8% and 90.9% of underweight, normal weight and overweight adolescents were dissatisfied. While the underweight adolescents (59.7%) wanted to increase their body silhouette, the obese ones wanted to reduce it (86.4%).

Table 2 shows the association between body dissatisfaction and nutritional status. It was found that un-

Table 2. Odds ratios for body dissatisfaction in adolescents according to nutritional parameters (Florianópolis, Brazil 2007)

	Males	Females
	OR (95%CI)	OR (95%CI)
BMI		
Healthy	1.00	1.00
Unhealthy	2.34 (0.99–5.56)	2.15 (1.35–3.43)
Nutritional status		
NW	1.00	1.00
UW	2.16 (0.60–7.75)	0.89 (0.50–1.55)
OW/OB	2.48 (0.82–7.51)	10.69 (3.78–30.16)

OR – odds ratio, 95%CI – confidence interval, BMI – body mass index, NW – normal weight, UW – underweight, OW/OB – overweight

healthy nutritional status was only associated with body dissatisfaction among females (95%CI = 1.35–3.43). When BMI was stratified as normal weight (reference category), underweight and overweight, the association only appeared among the females, indicating that the chance of showing body dissatisfaction is 11 times greater in overweight female adolescents than in adolescents with normal weight.

Discussion

Analyzing perceived body image, it was observed that a large number of adolescents were dissatisfied with their body shapes and sizes. A study comprising schoolchildren of secondary education in greater Florianópolis, SC, revealed that 48.2% of these schoolchildren were dissatisfied with their body weight [19]. Body dissatisfaction is even observed among pre-adolescents in small towns (63.9%) [6]. Brazilian studies have found that body dissatisfaction varies from 64% to 82% in schoolchildren [4, 6]. In a population study carried out with Chinese children and adolescents (3 to 15 years), it was observed that approximately 60% were dissatisfied with their body image [3]. In Poland, the body dissatisfaction in adolescents (40.0%) tends to be smaller than found in Brazilian ones [20].

Body dissatisfaction has been observed in both gender [21], but greater proportions are found among female adolescents, as demonstrated by studies undertaken in Brazil [5, 6] and other countries [7, 20, 22]. In contrast to what can be found in the literature, the findings of this study revealed that male adolescents exhibited greater body dissatisfaction than female adolescents. This can be related the pressure exercised by the society, mainly the influence exerted by media [23], promoting muscle and athletic bodies in male adolescents. Results from another clinical study demonstrated that across all stages of development, girls were more likely to adopt strategies to lose weight, whereas boys were more likely to adopt strategies to increase muscle [24].

Excessive concern with the body and the disorders related with body image problems have until recently appeared to almost exclusively affect females, however, these problems have been reported in males with growing frequency [25, 26].

With relation to the type of body dissatisfaction, it was observed that the girls in general wished to reduce the size of their body silhouette, while the boys desired larger silhouettes. These results are similar to what was observed by Branco, Hilário and Cintra [5], demonstrating the same tendency in a sample of adolescent schoolchildren in the city of São Paulo, Brazil. In the same manner, the findings of this study confirm what was observed in Chinese children and adolescents, where the preference among females was for smaller body silhouettes and for larger silhouettes among males [3].

In contrast with females, who desire slimmer figures, male individuals are concerned with becoming stronger and more muscular. Very often, standards of beauty are influenced by media which create desires and reinforce images, standardizing bodies, so that those individuals who see themselves as outsized feel pressure and dissatisfaction.

It was observed that while the adolescents with underweight wanted to increase the body silhouette, the obese ones wanted to reduce. In parts, those results were also proven for the univariate analysis detecting an association between body dissatisfaction and nutritional status. However, this association was only present among females, in girls with nutritional status disorders having twice the chances of dissatisfaction with their own body image, in relation to normal weight adolescents. Another association detected was between body dissatisfaction and being overweight. Overweight adolescent girls were eleven times more likely to be dissatisfied when compared with normal weight female adolescents.

In São Paulo, Brazil, female adolescents exhibited a self-perception of their body image that was not compatible with their true nutritional status [5], whereas, in a study carried out in two cities in the state of Rio Grande do Sul, Brazil, it was found that nutritional status was the factor most strongly associated with body dissatisfaction, since children with obesity, risk of obesity and those below the 15th percentile, were dissatisfied [6]. In the same manner, in Santo André, Brazil, it was found that overweight adolescents were more dissatisfied with their body image [11]. In Norway, body dissatisfaction in adolescents (13–19 years) was observed to increase in line with increasing BMI [27]. In Poland, body dissatisfaction was more prevalent in obese adolescents (77.6%) than non-obese ones (36.2%) [20].

This study suffers from the limitations inherent to all cross-sectional studies, i.e., it estimates relationships between variables at a time and does not allow cause and effect relationships to be identified. The measure

used to assess body image provides very limited information and may not adequately assess boy´s body image given their concerns with muscles and an athletic body. Although the nine-silhouette scale was initially proposed for adults, it has been widely applied to adolescents [21, 28, 29]. One of the advantages of this study is the representative number of adolescents of both gender enrolled in secondary education in Florianópolis. Furthermore, this is the first Brazilian study carried out in adolescents of this age group with the objective to identify the association between body dissatisfaction and nutritional status.

Conclusions

Body dissatisfaction proved to be a highly frequent phenomenon in adolescents of both gender. Therefore, the data generated by this research should be sufficient to warn parents, educators and health professionals of the prevalence of body dissatisfaction in adolescents. Given that obesity is agreed as a global public health problem, finding that obese adolescents are dissatisfied with their body shape should signal that they are ready and motivated to act and try to lose body weight. This can lead, in part, to unhealthy behavior such as anorexia, bulimia, muscle dysmorphia and inappropriate dieting [24]. According to the analysis carried out, the findings suggest that nutritional status, primarily overweight, determines body dissatisfaction, particularly for female adolescents. In spite of the body dissatisfaction to be more prevalent in male adolescents, they tended to accept their body image more, even those with unhealthy nutritional status.

Therefore, it is suggested that studies of nutritional interventions and physical exercise be carried out in order to contribute to reducing the prevalence of overweight and obesity and, consequently, improving the self-esteem of these adolescents. Further cross-sectional investigations considering distinct social classes and different age groups are also needed to improve understanding of the relationship between body image and nutritional status.

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PRESENTATION OF ACOUSTIC WAVES PROPAGATION AND THEIR EFFECTS THROUGH HUMAN BODY TISSUES

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ABSTRACT

Three types of acoustic waves are mainly used in the medical field, Extracorporeal Shock Waves (ESWs), Pressure Waves (PWs) and Ultrasound (US). Shock waves are acoustic waves that are characterized by high pressure amplitudes and an abrupt increase in pressure that propagates rapidly through a medium. The energy distribution in the treatment area differs from being wide over a large area, or concentrated in a narrow treatment zone, and as such influences the therapeutic and biological effect of the shock wave. Pressure waves are usually generated by the collision of solid bodies with an impact speed of a few metres per second, far below the speed the shock wave travels. There are major differences between PWs and ESWs, concerning not only their physical characteristics and the technique used for generating them, but also the order of the parameters normally used. The simulation effects and therapeutic mechanisms seem to be similar, despite the physical differences and the resulting different application areas (on the surface and in depth respectively). Ultrasound therapy is one of the modalities of physical medicine used for pain management and for increasing blood flow and mobility. Ultrasound and ESWs – PWs differ, despite their acoustic relationship, basically because ESWs – PWs show large pressure amplitudes with direct mechanical effects and US propagates within periodic oscillations within a limited bandwidth, and mainly direct thermal effects. Acoustic waves have direct mechanical and mechanotransduction effects on the cells and ECM increasing porosity, angiogenesis, releasing growth factors, enhancing proteosynthesis and viscoelastisity and inducing histeogenesis and repair processes.

Key words: acoustic waves, shock waves, pressure waves, ultrasound, tissues

Introduction

The effects of acoustic waves on a variety of tissues is under continual investigation. Some of the effects are more widely accepted by the medical community than others; for example the effect of extracorporeal shockwaves for lithotripsy. Here, a brief synopsis is provided of the reported effects of acoustic waves (Extracorporeal Shock Waves, Pressure Waves, Ultrasound) on bone, skin, muscle, and vasculature.

Although it is not fully clarified what the specific universal mechanism is that leads to the clinical benefits of acoustic waves, it is believed to result from direct mechanical effects on the cells to increase porosity [1]; a mechanotransduction type effect from the acoustic differences between cells and the surrounding extracellular matrix, which results in a shear stress on the cell [2, 3]; the violent collapse of cavitation bubbles and their effects on cells [4–8] and on a tissue level due to increased angiogenesis [8, 2]. Whether the effect is direct or indirect the release of growth factors and the upregulation of cell activity is responsible for the histeogenesis and repair processes.

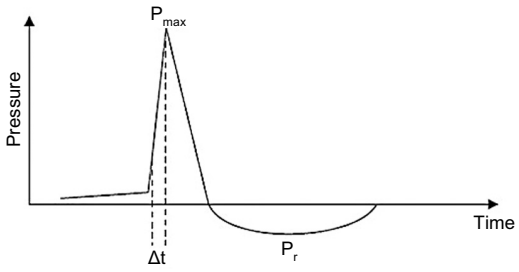
Extracorporeal Shock Wave Therapy (ESWT)

Extracorporeal shock waves were first used for kidney and ureteral stones fragmentation in 1980 and afterwards, they became the method of choice. More than 10 years later, shock waves were introduced as therapy for a number of orthopaedic pathologies such as bone nonunions, tendinopathies and chronic tissue inflammations.

Shock waves are acoustic waves that are characterized by high pressure amplitudes and an abrupt increase in pressure in comparison with the ambient pressure. As mechanical waves, they can pass through the surface of a body without injury and may act therapeutically in predetermined areas within the body [1].

There occurs pressure disturbance that propagates rapidly through a medium. The wave shows an acute

rise in pressure amplitude (representing the time between 10 and 90% of the total initial rise time) at the wave front of less than 10 nsec (Δt), a low tensile amplitude, a short life-cycle (less than 10 msec), a broad frequency spectrum (16 MHz to 20 MHz) and a variable negative pressure at the end [8] (Fig. 1). At the boundary between two media, a shockwave will be partially reflected, and partially transmitted. Attenuation of the shockwave is dependent on the medium through which the shockwave is travelling. In air, the shockwave weakens quickly. In water, however, attenuation occurs approximately 1000 times less than that which occurs in air [8]. Medically applicable shockwaves are conventionally propagated through a water medium and a coupling gel before penetrating tissue [9].



P_{max} – pressure maximum, P_r – negative peak pressure, Δt – pressure rise time

Figure 1. Characteristics of shock waves

ESW Energy (E)

An important parameter is the energy of the applied shock wave and this may have an effect on the tissue only when succeeding to overpass certain energy thresholds.

The equation for energy generation from a shock wave is $E = A/\rho c \int p(t)dt$, where ρ is the propagation medium density (kgm^{-3}) and c is the sound velocity (ms^{-1}) (both acoustical parameters), p(t) is the time curve of the shock wave (μs) and A represents the surface (mm^2), (see also Tab. 3). The acoustical energy of a shock wave pulse is given in millijoules (mJ) and this must be multiplied by the total number of shock wave pulses emitted per treatment (protocol) and thus we shall have the total emitted energy.

Energy flux density (ED)

The energy distribution in the treatment area differs from being wide over a large area, or concentrated in a narrow treatment zone, and as such influences the therapeutic and biological effect of the shock wave.

The energy concentration is obtained by calculating the energy per area (E/A): $E/A = 1/\rho c \int p(t)dt = ED$ (energy flux density), mJ/mm^2.

Table 1. Categorization of ESWaves due to Energy Flux Density

Energy category	Range of energy density (mJ/mm^2)
Low	< 0.08
Medium	0.08–0.28
High	> 0.6

Shock wave generation makes use of three different principles: electrohydraulic, piezoelectric and electromagnetic. They are focused using spherical arrangements, acoustical lenses or reflectors [1].

Among shock wave generation techniques developed and used until now in clinical applications, electrohydraulic (EH) and electromagnetic (EM) waves have been found to be the most suitable for orthopaedic treatment [8]. The EH device generates a SW by a high-voltage discharge applied across the electrode tips to the first focal point within a water-filled ellipsoid reflector. The EM device generates a SW by inducing a magnetic field in a metal membrane, which is forced away rapidly, and as a result compresses the surrounding fluid medium. The EM acoustic wave is then focused by a lens onto the focal therapeutic point [3].

Piezoelectric systems (PE) have a high accuracy of repetition and are easy to control even in low energy ranges. They can provide focussing on very small spots with pressures of up to 150 MPa (1500 bar). They work using a large number of piezoelectric elements arranged on a spherical shape, which can be displaced in the direction of the centre of the spherical shape by synchronous excitation. Eventually, a convergent spherical wave spreads out and increases its pressure amplitude to therapeutically effective values on its way to the centre [1].

Pressure Waves Therapy (PWT)

In addition to the shock waves described above, also pressure waves with different features are used in medicine. Whereas shock waves typically travel with the propagation speed of the medium (approx. 1500 m/s for soft tissue), pressure waves are usually gener-

Table 2. Physical and technical characteristics and differences of shock and pressure waves

	Shock waves (focused)	Pressure waves (unfocused)	Difference
Focus	Yes	No	
Propagation	Non-linear	Linear	
Steepening	Yes	No	
Rise time	Typically 0.01 μs	Typically 50 μs	Approx. 1:1000
Compression pulse duration	Approx. 0.3 μs	Approx. 200 – 2000 μs	Approx. 1:1000
Positive peak pressure	0–100 MPa	0–10 MPa	10:1 – 100:1
Energy flux density	0–3 mJ/mm^2	0–0.3 mJ/mm^2	Approx. 10:1

ated by the collision of solid bodies with an impact speed of a few metres per second, far below the sound velocity [1]. First, a projectile is accelerated, e.g. with compressed air (similarly to an air gun), to a speed of several metres per second and then abruptly slowed down by hitting an impact body. This is the reason why pressure waves are also called Balistic or Pneumatic waves. The elastically suspended impact body is brought into immediate contact with the surface of the patient above the area to be treated, using ultrasound coupling gel, if necessary. When the projectile collides with the impact body, part of its kinetic energy is transferred to the impact body, which also makes a translational movement over a short distance (typically < 1 mm) at a speed of around one metre per second (typically < 1 m/s) until the coupled tissue or the applicator decelerates the movement of the impact body [1]. Then a pressure wave is propagated by transfering the motion of the impact body to the tissue at the point of contact.

There are major differences between Shock and pressure waves, concerning not only their physical characteristics and the technique used for generating them, but also the order of the parameters normally used. The differences between the most important parameters listed in Tab. 2 are approx. 1–3 orders of magnitude.

The simulation effects and therapeutic mechanisms seem to be similar, despite the physical differences and the resulting different application areas (on the surface and in depth, respectively). However, the pressure waves are not able to fragment hard concrements such, as e.g. kidney stones, deeper in the body (> 1 cm). Nevertheless, unfocused pressure waves seem to be well suited for orthopaedic indications near the surface as well as, e.g. trigger point therapy [10].

Tissue effects of ESWT and PWT

Bone tissue

Although it is still being debated by the research community, there is evidence that extracorporeal shockwaves act to increase the volume of laminar bone and the density of trabecular bone (Fig. 2A, B). In one model an uninjured rabbit femur was given a dose of shock wave therapy and after intial short term microdamage, extensive cortical thickening and minor trabecular bone remodelling was observed [11]. ESWT has also been found both to increase repair in non-unions in an animal model (dog radius) [12] and have clinically significant results in the human long bones [13–15]. Another area of potential application for ESWT in osseous tissue is osteonecrosis, specifically of the femoral head [16, 17]. In one of these clinical studies of osteonecrosis of the femoral head, ESWT was found more effective than the current treatments of core decompression and nonvascularized fibular grafting [17].

As with many of the beneficial effects witnessed by ESWT, the mechanism of its altering on osseous tissue is still not fully comprehended. Some of the effects can be espoused from various animal models, *in vitro* models and interpretation of human studies. One mechanism that has been espoused is that microfracture and microdisruption of the vasculature induce angiogenesis [8, 18]. *In vitro* cell models and animal studies revealed the upregulation of osteogenic cell proliferation, the expression of osteogenetic growth factors and differentiation of mesenchymal stem cells [2, 3]. One factor that is gaining increasing support is the idea of angiogenesis resulting from the application of ESWT due to an overexpression of vascular growth factors including εNOS and VEGF [2, 19]. The positive finding for the application of ESWT as a treatment for osteonecrosis is con-

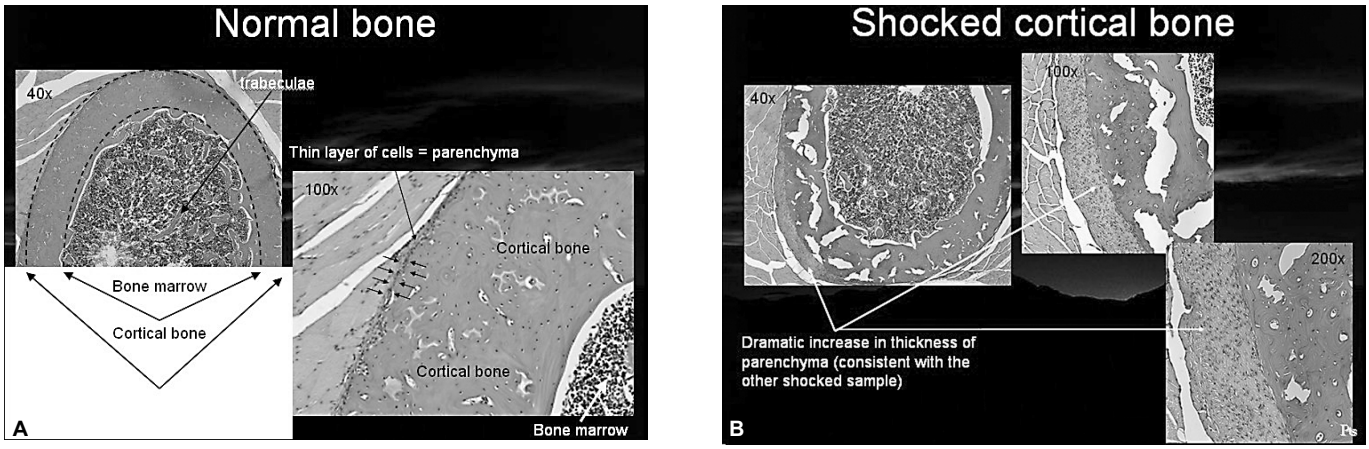


Figure 2 A, B. Osteogenetic response after ESWT, protocol (Tsaklis, preliminary data)

sistent with the idea of neovascularization; the neogenesis helps supply nutrients to the area where the tissue had died [16, 17].

Skin

ESWT is increasingly being recognized to have a positive effect on the healing of skin wounds, particularly in the case of severe wounds where the prognosis is poor. It has been less rigorously studied than some of the other models but clinical reports on ulcers and other lesions have been published that are promising [20–23]. An animal model that studies the effect of ESWT on a skin flap survival model in rats showed significant increase over the controls [24].

The exact mechanism leading to an improved skin lesion repair is still under investigation but as with most of the tissues, it is believed to result from the increased vascularity and upregulation of cell activity [24]. A second mechanism that is postulated to have an effect, is the antibactericidal effect that has been reported in an *in vitro* study [25].

Muscle tissue

To the best of the author's knowledge, no adverse effects of ESWT on muscle have been reported. On the contrary, ESWT appeared to be promising in treating patients with hypertonia by reducing muscle tone [26, 27].

The mechanism leading to the muscle relaxation is believed to result from the release of nitric oxide (NO), which acts as a muscle relaxant [27]. Direct mechanical effect of the ESWT on the muscle fibers is also proposed; and it is not believed to result from denervation as none was deemed to have taken place [27].

Vasculature

It has been previously stated several times that increased angiogenesis occurs after application of ESWT due to the overexpression of angiongenic growth factors. A second effect that results in increased blood flow is the release of NO which acts as a vasodilator due to the reduction in muscle tone of smooth muscles, [26].

One exciting effect of ESWT is its potential for angiogenesis in ischemic myocardial tissue [28]. Recent reports have shown an increase in blood supply to ischemic cardiac tissue both in an animal model and in a preliminary clinical trial [28, 29].

Ultrasound Therapy (US)

Ultrasound therapy is one of the modalities of physical medicine which is used by specialists for pain management and for increasing blood flow and mobility.

Ultrasound and shock waves differ, despite their acoustic relationship, basically because shock waves show large pressure amplitudes. Another difference is that ultrasound usually consists of periodic oscillations within a limited bandwidth (Fig. 3), whereas shock waves are represented by a single, mainly positive pressure pulse that is followed by comparatively small tensile (negative) wave.

For this reason, steepening effects due to nonlinearities in the propagation medium (water, human tissue) have to be taken into consideration [1].

Ultrasound has a frequency above the range of 20 kHz. The ultrasound generates high-frequency mechanical vibrations created when electrical energy is converted to acoustic energy through mechanical deformation of a piezoelectric crystal located within the transducer.

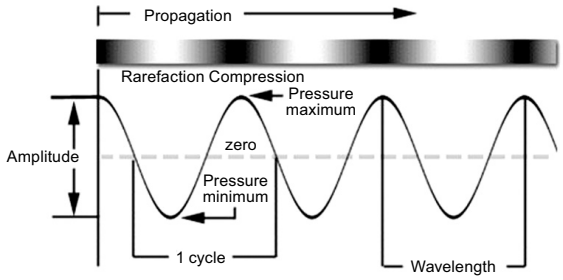


Figure 3. Ultrasound wave characteristics

Therapeutic ultrasound has a frequency range of 0.75 MHz (referred to as lower frequency) up to 3 MHz (referred to as higher frequency), with most machines set at a frequency of 1 MHz or 3 MHz. Using Low-frequency ultrasound, waves have greater depth of penetration but are less focused. Ultrasound at a frequency of 1 MHz is absorbed primarily by tissues at a depth of 3–5 cm [30] and is therefore recommended for deeper injuries and in patients with more subcutaneous fat. A frequency of 3 MHz is recommended for more superficial lesions at depths of 1–2 cm [30, 31].

Tissues can be characterized by their acoustic impedance, the product of their density and the speed at which sound will travel through them [32, 33] (Table 3).

US stimuli effect

When using US therapy, two phenomena can occur on the underlying tissues. These are: the tissue heating and the cavitation phenomenon. During the ultrasound therapy, it is possible to create tissue lesions through tissue heating due to ultrasound absorption, especially when the application is prolonged in the same area and the US wave has a constant emission mode [6]. This phenomenon can be avoided when we constantly move the US transducer head in the treatment area, or/and use intermittent emission mode [5].

The acoustic cavitation phenomenon which occurs during the US emission, refers to the activity of bubbles or micro-bubbles of gas undergoing movement due to an acoustic field, into the tissue [7]. Every living medium contains certain amount of dissolved gas present in the form of bubble micronuclei. Under the effect of an ultrasound field, the nuclei expand through a physical phenomenon known as rectified diffusion to reach a critical size known as the Blake threshold. Cavitation phenomena become even more accentuated as acoustic intensity increases. Bubbles expand up to their resonant size, and then implode violently. The energy accumulated by the bubbles is simultaneously released in the form of a shock wave, with intense heat (generally from 1.000 K to 20.000 K, or 726.85°C to 19.726°C) and microjets that can introduce speeds of 100 m/s up to 250 m/s through the water medium. All this leads to the creation of free radicals and mechanical destruction of surrounding tissue.

Thus, there are two types of cavitation: *stable cavitation* where the walls of the bubbles are oscillating at the frequency of the ultrasound field without too great a consequence for the surrounding cells and can appear at very low pressure levels as soon as bubbles are present in the medium. Stable (regular) cavitation is considered to be beneficial to injured tissue. The other form is the *transient cavitation* where bubbles expand up to their resonant size, and then implode violently and cause tissue damage, [4].

Table 3. Acoustic impedance of different tissues in relation to density and sound propagation. Modified from Wolbarst [33]

Material	Density ρ (kgm^{-3})	Speed c (ms^{-1})	Characteristic impedance Z (kgm^{-2}s^{-1}) × 10^6	Absorption coefficient α (dB cm^{-1}) at 1 MHz
Water	1000	1480	1.5	0.0022
Blood	1060	1570	1.62	(0.15)
Bone	1380–1810	4080	3.75-7.38	(14.2–25.2)
Brain	1030	1558	1.55–1.66	(0.75)
Fat	920	1450	1.35	(0.63)
Kidney	1040	1560	1.62	–
Liver	1060	1570	1.64–1.68	(1.2)
Lung	400	650	0.26	(40)
Muscle	1070	1584	1.65–1.74	(0.96–1.4)
Spleen	1060	1566	1.65–1.67	–

Table 4. The biological and resultant effects of therapeutic ultrasound

Type of effect	Result
Thermal	Increase in tissue extensibility
	Increase in blood flow
	Modulation of pain
	Mild inflammatory response
	Reduction in joint stiffness
	Reduction of muscle spasm
Non-thermal	Cavitation
	Acoustic microstreaming
	In combination may result in stimulation of fibroblast activity, increase in protein synthesis increased blood flow, tissue regeneration and bone healing

The stimulation effects of US on specific tissues such as the skin, bone, muscle and vascular, are dependent on the phenomena of heating and cavitation described above.

Different intensities of pulsed ultrasound have distinct biological effects on bone mineralization in the process of bone fracture repair, even across a narrow range (e.g. 30–120 mW/cm^2), [32]. During high-intensity focused US administering on or near the skeletal system care should be taken because thermal damage can cause osteocyte damage and necrosis, characterized by pyknotic cells and empty lacunae not just at the bone surface, but more deeply within the bone [32].

The stimulating effect on bone tissue gives evidence that low intensity (30 mW/cm^2), but not high-intensity (120 mW/cm^2), pulsed ultrasound may accelerate the formation of the molecular packing of collagen fibers conducive to mineralization. There is an increased Cyclooxygenase COX-2 mRNA expression and PGE2 production by osteoblasts in an ultrasound, intensity-dependent manner. This high dose of Prostaglandin E2 (PGE2) induced by high-intensity ultrasound may be detrimental to the physiological cross-link formation required for initiation of the mineralization process [32].

Concerning the skin tissue wounds, ultrasound seems to interact with one or more components of inflammation, and earlier resolution of inflammation [34]. In vitro founded an accelerated fibrinolysis and a stimulation of macrophage-derived fibroblast mitogenic factors. This also leads to a heightened fibroblast recruitment and an accelerated angiogenesis, followed by an increased matrix synthesis. The collagen fibrils are more dense and the tissue shows increased tensile strength [31].

The stimulation effect on the vasculature tissue points that the ultrasound can be effective during the early inflammatory phase, after a wound. In the later phase of repair the ultrasound treatment does not appear to have any further significant effect on angiogenesis. In this early phase, the macrophage, which are present in large numbers in the wound bed and contain factors which stimulate angiogenesis, are a possible target of the US. Ultrasound at a low frequency, i.e. 0.75 MHz, can cause a greater effect on angiogenesis than higher frequency, i.e. 3.0 MHz, which suggests that there may be a nonthermal component of the ultrasound involved in the stimulatory process [35].

The intramuscular effect of the US is associated mainly with the heating phenomenon and the resultant increase of blood supply, proteosynthesis and viscoelastisity of the tissue.

Research has established that both 1 and 3 MHz continuous ultrasound can produce subcutaneous tissue temperature increases of 4°C or greater when the appropriate ultrasound treatment parameters are selected, including a treatment area no greater than 2 times the effective radiating area (ERA) of the ultrasound applicator, [36].

Further research showed that pulsed ultrasound (3 MHz, 1.0 W/cm^2, 50% duty cycle, for 10 minutes) produced similar intramuscular temperature increases to continuous ultrasound (3 MHz, 0.5 W/cm^2, for 10 minutes) at a depth of 2 cm in the human gastrocnemius, assuming that pulsing ultrasound precludes the development of a heating response in human tissue, as well [37].

Conclusions

Acoustic wave therapy includes extracorporeal shock waves, pressure waves and Ultrasound waves. There are distinct differences between these three types of waves. These mainly refer to the technical way each type of wave is produced, as well as the physical-mechanical characteristics of each modality. The extracorporeal shock waves and the pressure waves show typically the same mechanical characteristics, concerning the way the wave propagates with big differences in the amplitude – energy flux and focussing in the treatment area. Thus, the ESW, are more intense and focused than the pressure waves, with more mechanical energy released and consequent biological effects. On the other hand, the mechanical characteristics of the periodical

oscillations of the ultrasounds make them differ from the other two types of waves and the dominant phenomenon here is the production of heating energy. All three types of waves appear to influence and propagate a biological response from different tissues in the body. This depends of the protocol (parameters of intensity – time – energy flux, etc.), the anatomical location and the nature of the tissue itself. Eventually, acoustic waves comprise a very useful therapeutic modality with the reservation that the therapist must be familiarized and well educated on their use and consequent effects.

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MORPHO-FUNCTIONAL DEVELOPMENT OF CHILDREN AND ADOLESCENTS FROM JEDLINA-ZDRÓJ WITH REGARD TO OBJECTIVE QUALITY OF LIFE OF THEIR FAMILIES

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ABSTRACT
Purpose. The purpose of this study was to determine relationships between the somatic build and motor abilities of children and adolescents from Jedlina-Zdrój and objective quality of life of their families. **Basic procedures.** 524 children aged 8 to 16 years were examined. Body height, body mass and three skinfold thickness measurements were taken as well as BMI and LBM were calculated. The subjects performed the following fitness tests: plate tapping, 10 × 5 m shuttle run, standing broad jump, sit-ups, 1 kg medicine ball throw and sit and reach. Maximum anaerobic power (MAP) was calculated. The study was completed with a survey questionnaire of parents on quality of life of their families. **Main findings.** Mean values of somatic parameters in boys examined represent an increasing gradient in relation to increasing objective quality of life. In girls the social-economic status of their families affected only their body height and body mass. In boys the average values of locomotive speed, lower limb explosive strength and maximum anaerobic ability test results increase along with improving social-economic status of their families. In girls the objective quality of life has a significant impact only on the upper limb movement speed. **Conclusions.** The objective quality of life differentiates the somatic growth of children examined. The social-economic status of children's families affects subjects' motor ability, but the correlations are lower and more multidirectional than in the case of somatic parameters.

Key words: somatic growth, motor ability, objective quality of life

Introduction

Research shows that child's development is affected by such socio-economic factors as parents' education and occupation, income and expenditure, financial situation of the family, number of children in the family, etc. [1–3]. All these variables affect indirectly children's morpho-functional development as elements of ways of life having a direct effect on the human body. The latter include dietary habits, incidence of diseases and access to medical care, amount of physical work, unhealthy habits and psychical and nervous stress [4, 5]. One of the categories used to describe the socio-economic status is objective quality of life that is the total of goods, states and situations constituting the general well-being of individuals [6]. Quality of life is based on statistical measurements of variables, e.g. income, education level or number of children in a family, or uses life quality indices constructed on the basis of these measurements. Despite extensive research the socio-economic parameters of children's development remain partially unknown, especially with regard to children's functional traits. There are no studies attempting to rank socio-economic factors as elements of a synthetic index of objective quality of life. According to Bielicki et al. [7], the application of such an index would allow involvement of a larger number of ranked variables in the analysis of quality of life. Strong correlations between variables would make it possible to carry out a proper analysis of variance if all the variables are treated as factors.

The aim of the study was to examine relationships between somatic build and motor fitness of children and adolescents from Jedlina-Zdrój, and objective quality of life of their families.

Material and methods

The study examined anthropometric measurement results obtained from primary and middle school students from Jedlina-Zdrój in Poland from September to December 2004. In total 524 school students (277 boys and 247 girls) aged 8 to 16 years took part in the study (Tab. 1). The examination was cross-sectional and covered all students present at school on the days of examination, i.e. 95% of all students from both schools. All

Table 1. Subjects' sex and age

Sex	Age (years)								
	8	9	10	11	12	13	14	15	16
Boys	29	32	41	20	32	31	37	29	26
Girls	35	36	28	22	29	25	23	27	22
Total	64	68	69	42	61	56	60	56	48

measurements took place in the morning hours, at the same time each day, on the school premises. The subjects wore sports outfits and had been informed about the aim and procedures of the experiment.

The subjects' body height was measured with an anthropometer, body mass with a scales and skinfold thickness with skinfold calipers in three locations: abdomen (between the umbilicus and the anterior superior iliac spine), subscapula (beneath the edge of the shoulder blade) and triceps (posterior midline of the upper arm). The body mass index (BMI) was then calculated as the individual's body mass divided by the square of his or her body height:

$$\text{BMI} = \frac{\text{body mass}}{\text{body height}^2}\left(\frac{\text{kg}}{\text{m}^2}\right)$$

The subjects' lean body mass (LBM) was estimated through known equations with the use of regression coefficients [8]. The following physical fitness tests were carried out: plate tapping, 10 × 5 m shuttle run, standing broad jump, sit-ups and sit and reach [9]. Also the maximal anaerobic power (MAP) was estimated according to the following formula [10]:

$$\text{MAP} = \text{body mass} \times \text{standing broad jump result} \times 9.81\ (\text{kg} \times \text{m}^2 \times \text{s}^{-2} = \text{J})$$

The examination of children was completed with a questionnaire survey of the parents on the quality of life of their families. A modified version of the quality of life questionnaire for students was used [11]. A pilot study was conducted on a small group of subjects before the main questionnaire survey. The survey reliability index was 0.884. An objective quality of life index was constructed on the basis of survey data such as number of children in a family, parents' education, parents' occupation, family type and child's ways of spending vacation using multivariate comparative analysis (MCA) [13]. The mean values and standard deviations were calculated for individual somatic parameters and fitness test results in particular age groups. The total sample was divided into series according to the objective quality of life index values. The subjects were divided into three equal-size groups (tertiles), at a low, medium and high objective quality of life level, respectively. The statistical significance of differences between the means of somatic parameters and fitness test results were determined using ANOVA for independent variables at $p < 0.05$. The significance of differences between the means was also assessed with the least significant difference test (LSD).

Results

Objective quality of life significantly differentiated somatic parameters in boys under study. The mean body height and body mass, BMI, total skinfold thickness (from three locations) and LBM represented an increasing gradient corresponding to the increasing objective quality of life index. The statistically significant differences were found between the groups of boys from families with the low and medium levels of quality of life, and medium and high levels of quality of life. No significant differences between somatic parameters of boys from families with an average and high socio-economic status were found (Fig. 1).

The correlations between objective quality of life and somatic parameters were less significant in girls. The socio-economic status of the girls' families was a differentiating factor only with regard to their body height and body mass. The highest values of the parameters examined were noted in girls from families with an average objective quality of life index. The differences between the groups of girls from families with low and high quality of life indices were statistically significant (Fig. 1).

The socio-economic status also affected the locomotive speed and explosive strength of the legs and the calculated maximal anaerobic power (MAP) in boys. The mean results of these tests increased monotonically along the improving socio-economic status of the families. However, differences between the groups of boys

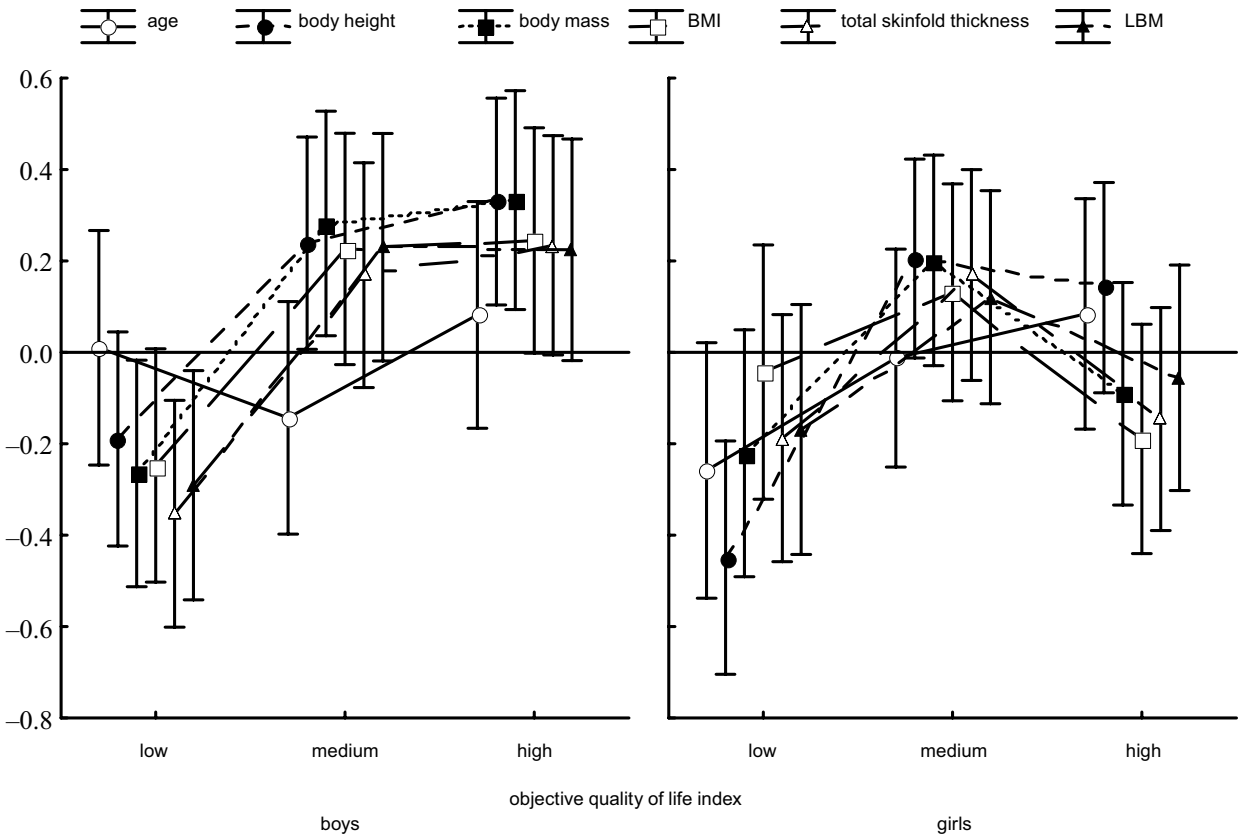

Figure 1. Normalized somatic parameters and objective quality of life in boys and girls

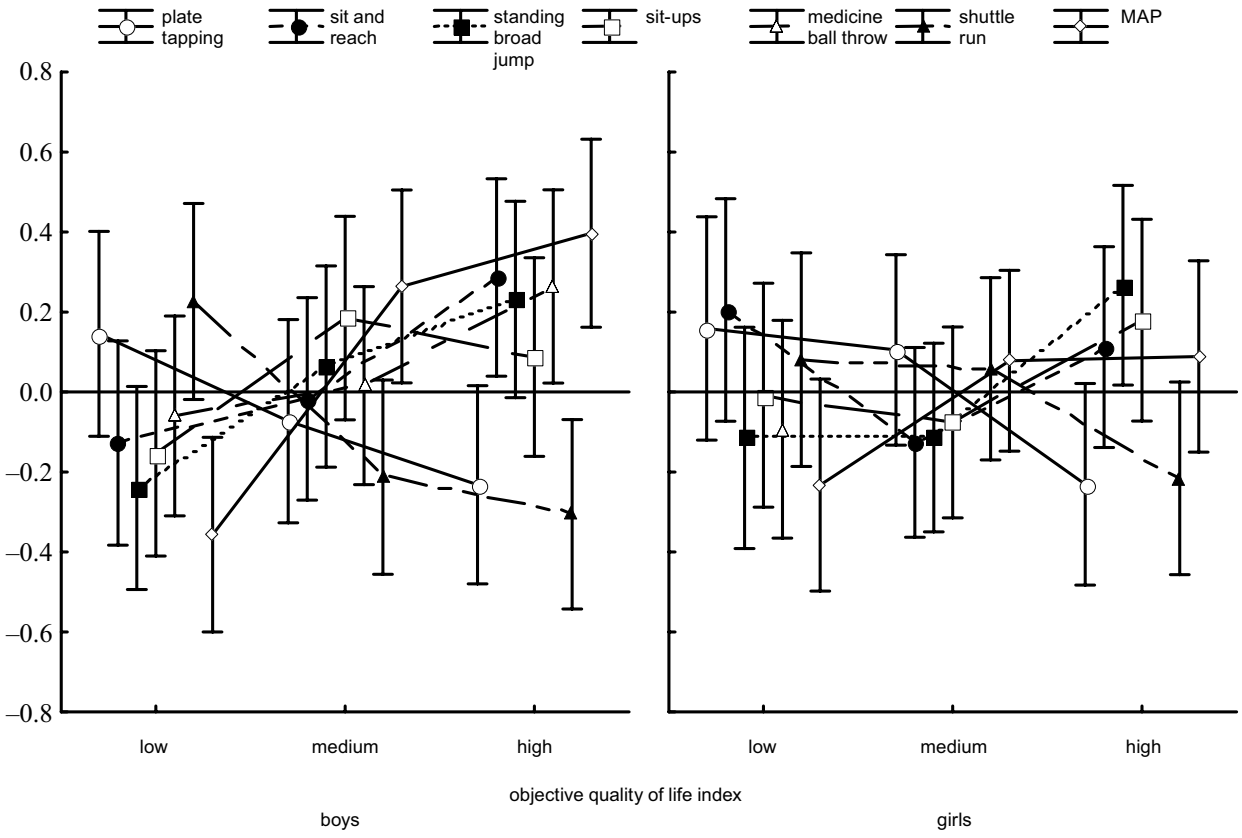

Figure 2. Normalized fitness test results and objective quality of life in boys and girls

with average and high quality of life indices of their families are not statistically significant (Fig. 2).

Also objective quality of life is a differentiating factor with regard to the motor test results to a lesser degree in girls than in boys. Only the plate tapping test results were significantly affected by the objective quality of life index. The highest locomotive speed results were obtained by girls from families with the highest socio-economic status and the lowest results by those from families with the lowest socio-economic conditions. No significant differences were observed between girls from families with low and average objective quality of life indices, which is indicative of the impact of high quality of life on the development of the locomotive speed (Fig. 2).

Discussion

Individual differences in human morpho-functional development result from a number of conditions. First of all, they can be determined by different living conditions of particular individuals in their childhood and adolescence. On the other hand, these differences can result from individual genetic predispositions determining the pace and level of morpho-functional development. An important role is also played by interactions and correlations between the genotype and the environment [13]. Indirectly the morpho-functional development is also affected by socio-economic factors represented in the present study by a synthetic objective quality of life index. Certainly, parents' education or income level have no direct effect on child's development but rather on the living conditions created for children by their parents who have a good education or high income. Thanks to the good living conditions children are assured proper accommodation, food and clothes. Parents' education affects the child's hierarchy of values, increases parental awareness of proper upbringing, nutrition, leisure pursuits and standards of hygiene [1]. Children from families with a higher socio-economic status are taller, healthier and enter the pubertal growth spurt earlier [13]. The environmental impact on the child is different during particular stages of its ontogenetic development. The impact is greater when the developmental processes are faster. It reaches the highest level in childhood and pubescence, i.e. two periods of development studied in the present work [14].

The analysis of biological development of children and adolescents from Jedlina-Zdrój confirms the existence of developmental differences between groups of subjects functioning in different socio-economic conditions. In the groups of boys the somatic traits studied revealed a monotonic correlation with the objective quality of life level. Among the girls under study the highest somatic parameters were found in the group of subjects from families with an average socio-economic status. It can be concluded that even average living conditions have a beneficial effect on child's development. The lower mean values of body mass and skinfold thickness in girls from families with a higher socio-economic status are indicative of a higher awareness of the impact of proper dietary habits and physical activity on health. These results have also a cultural dimension as they illustrate a common tendency to maintain a slim figure among teenage girls, especially those from families with a high socio-economic status.

Physical fitness consists of somatic, motor, behavioral and genetic components [15]. The correlations between these intrinsic fitness properties and environmental factors as well as lifestyle point to somewhat less explicit relationships between children's motor development and the socio-economic status of their families. The parents' socio-economic status has a secondary effect on the level of their children's motor development determining their interests, hierarchy of values, habits and lifestyles. It triggers a transformation of cultural factors (customs, axiological system) into biological mechanisms effecting changes in physical fitness. This can be compared to a conjunction of cultural, socio-economic and biological influences [16]. Parents who are well-off can enhance their children's development by providing higher living standards, better ways of spending free time and proper nutrition [17].

The present study revealed a smaller, however significant, impact of environmental factors on different aspects of human motor function. In the groups of boys the objective quality of life index was a differentiating factor in relation to the explosive strength of the legs, maximal anaerobic power (MAP) and locomotive speed. The boys from families with the highest objective quality of life achieved the best results of those fitness tests which examined these aspects of human motor function. Similar monotonic correlations between socio-economic factors and the level of motor development were also noted in other studies, particularly with regard to results of dynamic tests [16]. In girls the objective quality of life significantly affected only the speed of movement of the arms. Although the plate tap-

ping test is designed to examine one's speed abilities, it also allows diagnosis of one's coordination predispositions resulting from the functioning of the nervous system and sense organs as well as from the development of cognitive processes and intelligence level [18]. It is hardly surprising that girls from families with the highest socio-economic level, who have the best education, achieved the best plate tapping test results. These observations were also confirmed in studies by Sławinska [19] and Szopa [20].

The complexity of developmental processes and the multitude of factors affecting them point to the necessity to conduct further research into the environmental conditions of children's and adolescents' somatic development. Such studies should not be confined to local or regional communities but also cover much larger populations.

Conclusions

1. Objective quality of life is a differentiating factor with regard to children's level of somatic development. Children from families with average or high quality of life indices feature the highest values of morphological parameters examined.
2. The socio-economic status of families also affects children's motor fitness; however, the revealed correlations are lower and more multidirectional than the correlations with the somatic parameters.

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HEALTH EDUCATION IN THE TEACHER TRAINING PERSPECTIVE – THE AREAS OF CHANGES

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ABSTRACT
Purpose. To question the possibility of following the *Education for change* model in contemporary schools is, in fact, to question the teachers' professionalism and readiness to introduce *changes*. Professionalism involves a constant building up of processual knowledge based on academic education. It allows the teacher to build up the necessary competence to function effectively in open educational situations. The term *vocation* is limited to a set of closed, predefined skills which one can acquire by modeling and repetition. These are patterns of behavior in schematically perceived school situations. This view of the teacher's role limits the possibilities for the modification of those patterns. **Basic procedures.** I discuss the readiness of teachers in terms of their professional knowledge as well as in the context of the (im)possibility of realizing the tasks and goals of health education. I focus on the structure of this general, professional and normative knowledge. Due to its quality changes can be introduced in the educational process. This is connected to the question of understanding, and forms the basis for the teacher's conscious decisions. **Results.** The issues which the teacher has to confront with his or her professional knowledge are subjective in character. They relate to the creation of good relations between the teacher and the pupil. They are connected to the learning environment which, in turn, conditions the pupil's own level of activity and involvement. In this article I also discuss the conditions related to the building up of the pupil's senses of subjectivity and competence. **Conclusions.** Based on the above, I point out three complementary areas for the necessary changes in the preparation of health educators. The change goes from the perception of oneself as an object steered from the outside to the perception of oneself as an active subject of the occurring changes.

Key words: teacher's professionalism, professional knowledge, sense of subjectivity, sense of competence

Introduction

This work is a voice in the ongoing discussion about how to educate a teacher–health educator. Everybody agrees that it is necessary to work out such an approach which would guarantee an efficient implementation of the theoretical assumptions of goals and tasks in the contemporary model of health education. A lot of factors indicate that a role of health educators should be assumed by teachers of physical education.

Speaking about a contemporary teacher I use the terms *profession*, *professionalism* to make distinction from *vocation*. Professionalism requires a constant building up of processual knowledge based on university education, which enables the teacher to gain the level of competence indispensable for efficient functioning in open educational situations. The term *vocation* indicates just learning a set of closed and predefined skills, which can be acquired by modeling and repeating. The skills assume behavioral patterns in school situations, also seen in a schematical way, which reduces a possibility of modifying actions.

If one wants to know if it is possible to introduce the *Education for change* model in the reality of today's school, they had better asked about the teacher's professionalism and his ability to introduce *changes*. In this work the emphasis is not put on the teacher's professional preparation (though it is necessary to discuss the contents related to health issues in the teacher training curricula), which is essential, but on its credibility in the pupil's eyes. My deliberations regard the teacher's competence in his professional knowledge which makes realization of the goals and tasks in health education (im)possible. Contemporary theoreticians underline the fact that one of the goals of school health education related to physical health is an improvement of the individual's empowerment understood as an ability, power and competence to control his own health and to make the right choice concerning his and others' health. Empowerment means taking actions consciously based on full comprehension and inner conviction about their value. Such an assumption requires that the teacher should create a possibility for young people to search, for their own forms of physical activity, to develop the

need for exercise and, in consequence, their empowerment becomes stronger.

The difference consists in a shift:

- from teaching to learning,
- from steering (compulsion, imposing) to offering (freedom of decision, freedom of choice),
- from the pupil as an object of the teacher's influence to the pupil as a co-participant in the process of education,
- from a strategy of rivalry to a strategy of cooperation.

Literature on teacher training calls for a change, which implies abandoning training (i.e. vocational preparation) for teacher education (professionalism) [1, pp. 309–310]. The expected effect of the change would be the interpretative openness of health educators to the pupils' multiple worlds of meanings, reflection on actions and a constant redefining of events which would replace the pedagogical routine based on one variant of activity. It is difficult to introduce changes without taking into consideration the kind, structure and quality of the teacher's professional knowledge.

Material and methods

The teacher's professional knowledge consists of three kinds of knowledge: general, specialist and normative. Each kind of knowledge has two layers: an information layer, which answers the question "what are the things like" (it is a basis for declarative knowledge of the type "I know that ...", which can only describe the educational world and assumes the character of technical, statistical knowledge comprising a set of skills learned by repetition), and a scientific layer – "why are the things like this" and "I know how to make use of this" (explanatory and interpretative knowledge). The latter layer of knowledge allows making changes during the pedagogical activity, because it is related to comprehension, as well as it is "the basis for the teacher's conscious decisions" and "the source of empowerment" of his actions [2, p. 53]. The specialist knowledge about the pupil and the ways of interaction in the interpersonal and task-oriented spheres, about the reasons why various social groups are established also comprises the knowledge about oneself. The specialist knowledge is not only identified with the set of certain facts, but also with the structure of the facts which are important for the course of the educational process. The specialist knowledge is the basis for improvement of pedagogical skills in arranging a social environment of the class, in providing support and help to pupils, in overcoming the distance, in learning to listen, in solving problems, in setting in motion group processes which will help pupils cooperate in setting norms and to assume responsibility for the process of learning.

The normative knowledge [3, pp. 110–113] concerns openness to the other people's worlds of meanings and helps to keep a balance in relationships: me – teacher and you – pupil. It is essential because it refers to what the teacher thinks to know or what he believes in owing to the values accepted by the teacher. The knowledge is fundamental to unite three words: me – you – us [4, p. 193]. It is connected to the teacher's responsibility, as a member of the community, for what he says. Due to it the pupil learns how to interpret and understand others' intentions, as well as he develops an ability to interpret. In this way, meanings flow between the worlds Me and You creating a common understanding of terms; that is the world Us. The process of achieving the common understanding of meanings and values proceeds with a mutual respect to either of the worlds.

The values which the teacher appreciates have an influence on his pedagogical activity in different ways. As a rule, they determine his decisions taken during the educational process. His beliefs, based on the system of values adopted by him, cause a rejection of certain solutions in school situations on a priori grounds, so he can choose only from among a few (even if he does not express explicitly his principles).

The system of knowledge understood in this way is close to Kwaśnica's concept [5, pp. 16–17]; according to him there are two types of knowledge: practical-moral and technical, which are fundamental to acquire two groups of competence. The first group comprises practical and moral competence and the second technical competence [5, pp. 17–20]. The practical and moral knowledge (desirable by the modern model of health education) is acquired by the teacher in a practical communicative activity; it allows him to ask "about the conditions which enable communication by dialogue" [5, p. 17]. The structure of the competences is built by ability to empathize with another person and accept him unconditionally, ability to criticize as a means of search for hidden beliefs and conducts, a non-directive attitude, a personal point of view as one of the possible answers.

The quality of the teacher's professional knowledge is important for the effectiveness in handling various school situations. Problems the teacher has to confront

his professional knowledge with are of a subjective character; they concern the ability to create good relationships between the teacher and the pupil, as well as favorable conditions for the pupil's own activity, that is a sense of subjectivity and a sense of competence.

People develop a sense of subjectivity and an interdependent on it sense of responsibility during school experience. An assessment of themselves and others is a consequence of the knowledge resulting from their own reasoning and the belief that their conduct is right, which has a positive influence on the self-esteem. In order to favor the development of subjectivity, some definite conditions have to be fulfilled; among others, Straś-Romanowska indicates two principle ones. The first condition consists in giving the pupil a possibility of knowing himself genuinely and recognizing his distinct identity by discovering his interests and preferences. That is possible due to the teacher's non-restrictive requirements, acceptance of individuality of each participant in the educational process, encouragement to make use of subjective experience, thoughts and feelings. The second condition consists in encouraging the pupil to articulate and review his own beliefs, and to consider them while taking a decision. Due to such an attitude the pupil tends to have a sense of psychological integration, because a conviction of doing right raises the sense of self-esteem [6, p. 24]. It is necessary to create an atmosphere of psychological security (sense of acceptance) and to offer the pupil opportunities to experience positive relations between his activity, effort, action and the result achieved (sense of causation).

If the teacher's professional knowledge and competence are reduced to the level of practical teaching skills, it will mostly lead to teaching by imparting the knowledge, instructing the pupil, which creates a danger of associating the process of learning with school activity and, in consequence, will not have any influence on his life outside school. In extreme cases, it may encourage the teacher to take up manipulative actions, where the pupil is treated as an object (when in a given time it is necessary to achieve complex goals, known only to the teacher). The pupil brings with himself the experience gained at home, within his peer group and often has knowledge based on commercial messages. This is the child's first-hand knowledge, therfore he refers to it while acting. If the new knowledge presented to the pupil at school is too much different and distant from his experience, it will be perceived as too theoretical, i.e. useless in practice. The best way to check "the truth of the knowledge" is to verify if it is useful in practice. Therefore, the knowledge possessed by the pupil and his current beliefs can become an "epistemological obstacle" in forming and reforming his knowledge and attitudes, and contribute to the educational results far from the expectations.

The teacher can avoid the threat by treating the pupil as a subject, reflecting on the pupil's real needs and rights as well as on a sense of mutual relationships, which should favor development and realization of the pupils' constructive capacities. However, this is both essential and hard to achieve, because in spite of numerous fixed elements, educational situations are unique and open as the participants are different entities. An important role in helping the pupil be perceived as a subject is played by interactions constructed on the principle: mutual giving and receiving, as well as changing roles played in the interactive system. They indicate the man's real causation and determine the level of his subjective activity [7, p. 47]. The teacher interacts with many subjects, each with a separate personality; therefore, every situation requires openness to many worlds of meanings. The goal of the interactions teacher–pupil, pupil–teacher is an intention of reaching a point where both parts agree to work on a common world interpretation [5, p. 18]. Interaction is a technique used in achieving an agreement during mutual negotiations. It becomes even more important when the school and the teacher are not the only source of information, so the teacher has to stand up to the knowledge already acquired by the pupil and the meanings fixed in his mind [8, p. 73].

The teacher influences the pupil not only by words, gestures, conducts and interpretation of the world. In this context, it is not indifferent what philosophy he refers to. It is worth asking a question if the pupil is perceived by the teacher in the educational process as free and internally controlled human being or if he is a predetermined one. The paradigm of the subject-oriented education assumes a creative development of personality and shaping individuality of the pupil by making him participate in various forms of activities [9, p. 58].

Results

Education for change is geared to help both the teacher and the pupil discover and realize their own subjectivity; it is particularly directed to free the pupil from the relationship of domination and the mechanism of

selection prevailing in the school. To favor a change for better, it is advisable, among others, to ask crtitcal questions about the goals and contents of education. The process of subjecting is possible if a subject assessment standard is accepted, whereas it is impossible in case of an object assessment standard. Therefore, it is important in which assessment standard the teacher works, what experience he has had in building up his own subjectivity in the course of education. The two standards are in contrast. Accepting Obuchowski's approach [10, pp. 3–15] to the subject assessment standard, the teacher sees himself as a source of his behavior; the personal goals as a subject of his intentions, and the world around as an opportunity for his abilities. Due to such an approach all choices are the effect of reflection on himself. The object assessment standard manifests itself in a form of certain predefined stereotypes and due to that the teacher sees himself as somebody who fulfills the criteria of the assigned social and professional role; the goals are identified with duties, and the world around is seen as an area of duties to fulfill. As a result, the teacher doing tasks ascribed to his "role" evades responsibilities for the actions.

Balicki broadens this approach by adding a mixed assessment standard, which is characterized by an ambivalent judgment of oneself, duality of goals (on the one hand they are imposed, official ones, on the other, personal, private goals) and the vision of the world as an area both of obligation and an opportunity for self-realization [11, pp. 59–60]. According to Puślecki in the Polish school prevails the object assessment standard. It is so because of the system of rigid and complex behavioral patterns, which often do not allow individuals to choose between their desires and the external demands; as a result, they lead to passivity and lack of reflection [12, p. 17]. Subordination to the assigned role eliminates conscious direction of one's destiny. Kwiatkowska presents the teacher who works in that standard as the one who does not tolerate doubts and, in consequence, does his best to eliminate them, mostly by categorizing and standardizing the situations [13, p. 119]. This is the teacher who expects obedience, who does not support opposition, who identifies goals with duties, who thinks in terms of stereotypes, who gives marks arbitrarily – good or bad. Due to that the atmosphere created in the class does not favor an involvement of individuals, because the teacher does not accept the pupil who has doubts and opinions different from his.

The teacher who adopts the subject assessment standard allows the pupil to express his individuality. Thanks to it the teacher creates situations favorable for individuals to get involved, check their capacities, take decisions and predict effects of their choices, in other words, they are given an opportunity to be subjects.

The teacher's convictions, in practice, are expressed by the adopted style of managing a class of pupils, which is an effect of the mix of professional knowledge, accepted educational philosophy, personal professional and life experience and personal qualities. The views on various ways of learning, individualization of education, treatment of oneself and the other participants in the educational process as subjects have an influence, to a great extent, on the style; all of them create a social climate in the class and enable us to set the conditions, mentioned above, necessary to develop a sense of subjectivity. American literature on the subject presents seven styles of managing a group of pupils [14, pp. 62–65]:

- the assertive style when the teacher gives support and warmth to all the pupils; it requires formulation of clear expectations defined by the teacher in the form of rules to observe by all the participants in the educational process, the teacher included; pupils are aware that the teacher expects them to behave in a defined way and that they are responsible for their conduct; knowing the binding rules pupils can assess their conduct by themselves;
- the style which focuses on school achievements also requires clear communication; work organization and feedback information given to pupils during lessons are always subordinated to their achievements of a high level of competence; the teacher is required to apply different ways of knowledge acquisition and to know motivating techniques;
- in the style geared to modify pupils' conducts, the teacher is an endless source of rewards and punishments; he disciplines, corrects pupils' conducts by giving them frequent feedback information; the teacher decides about the reward or punishment, therefore all his conscious and unconscious conducts, verbal and non-verbal, become a source of reinforcement;
- the style geared to manage a group; it puts emphasis on an immediate reaction to the group's conduct in order to avoid serious problems; pupils are expected to fulfill well their school duties resulting from the fact that they are school-goers; the teacher should communicate clearly what is desirable and what is not; the teacher's goals are strictly related to his role;

the style develops in pupils a feeling of making progress and provides them with challenging tasks;
- the style geared to manage with the help of the group; the teacher is required to know and understand the needs and interests of the group in order to have a better influence on its conducts; without this knowledge, in aspiration to make changes in an individual's conduct, the teacher may cause improper relationships among pupils; must be aware that his conduct has an influence on the group;
- the style focused on pupils' achievements; it gives them possibility of making choices in accordance with their own predictions about the positive or negative results; to experience a sense of high self-esteem and success is the determining factor in making good decisions; as a result, the pupils' sense of responsibility rises; the teacher only suggests and gives hints, has a role of an assistant offering help;
- the style geared to give acceptance; it is based on the assumption that people have an inborn need for acceptance; the teacher claims that for pupils it is more important to feel a member of the group than to learn; the teacher encourages and supports pupils in their efforts, does his best so that pupils could experience immediately the consequences of improper conducts, which favors self-discipline; underlines the pupils' strong points, does not allow the application of a trial-and-error method, uses an error-and-correction method, instead.

From the above presentation it results that the styles differ in proportions of preventive actions and interventions, a degree of control and supervision on behalf of the teacher as well as an orientation towards the task or the pupil. A method of realization of the adopted style can limit or support the process of forming the pupil's subjectivity, which depends on the teacher's competence.

There are also examples where subjectivity is treated as a demand for education. They function in a form of tasks assigned to school and the teacher. Among the general educational and didactic demands presented by Puślecki, there are a lot of hints for teachers (the total number is 140) about how to create the climate of freedom [12, pp. 77–84]. His list is so detailed because he realizes that teachers accept the idea of subjectivity, but, in practice, are not able to apply pedagogical actions which determine the real subjectivity. That is why it exists only in declarations. The pupil, during traditional sports lessons, has a limited possibility of creating a positive image of himself and to experience a sense of being a subject, mostly due to the teacher's "instructive" approach to education. Even the teacher who agrees with the idea of subjectivity, but who applies routine educational solutions, e.g. verbal, may treat the pupil as an object by creating difficult situations (e.g. marks in physical education), where the pupil is considered week, clumsy, which will result in a fall in self-esteem. When the pupil experiences such an interaction with the teacher, his sense of causation and the subject-oriented development are at risk.

It is possible to find internal and external sources of attitudes towards subjectivity. The internal source is a human aspiration to ideals resulting from the personal vision of the world and the image of oneself. School and the teacher are an exteranal source; they can increase the probability that the pupil feels as the subject or reduce his chance in this matter.

Another, equally important, factor which determines the building up of an active attitude towards health is a sense of competence. It is the teacher's duty to help the pupil to build up a feeling that there is a sense in his activity and to experience relations between decisions and his and others' well-being, between health and a lifestyle. This goal is usually reached by engaging the pupil's personal resources and skills, by motivating him to make an effort. Therefore, help should include an organization of a situation favorable for mutual learning (peer tutoring), so that the pupil can make use of various experiences and competence of all the participants in the educational process (learning based on cooperation strategy). It is necessary to create educational situations based on the pupil's real development needs, his knowledge and opinions included.

Erikson places pupils aged between 12 and 16 in the phase which is the most important for the development of the man's identity [15, p. 139]. A child gets to know the world and the teacher becomes his intermediary in gaining experience and creating a vision of the world, because the main form of activity is learning subordinated to the school system, which becomes the source of successes or failures. Pupils ask penetrating questions. Looking for the answers involves criticism, often rejection of the current authorities. They assume a wait-and-see attitude towards the teacher, though they can be persistent if they really care about something [16, p. 335]. At this age individuals can manifest both childish "me" conducts (expressed by e.g. excessive demands or irresponsible actions) and highly responsible and mature conducts.

Growing up, young people are becoming aware that not all problems are simple and easy to solve. They know their minds are inmature, so they do not give their opinions hastily. Sometimes, the hesitation is so intense that even simple situations seem complicated to them and they leave adults to make judgements about the things. At this age they are already able to analyze their brains' activities, which favors the creation of a conception about themselves. Pupils are capable to set up long-term objectives, therefore their activities take on an organized and planned character. The direction of activitiy changes: from the natural and material world to the inner world. A need to perform deeds or even feats becomes evident [17, p. 180]. Activity also takes on a group form. It is the period when cooperation with peers creates an inner need to treat other people in the way they would like to be treated.

At this stage of development a child is characterized by increased emotional excitement, irresoluteness and ambivalence of feelings. The fear of social exposure and failure becomes more intense. The lack of self-confidence and the embarrassment in various everyday situations are typical symptoms. In this period it can be observed that some teenagers tend to treat their own experiences excessively as if they were unique. They are more interested in peer relationships, at first, single-sex. It is time when a sense of community is born: "we" against "them" (adults, teachers). Growing up, they become more and more self-contained, they feel a need for more freedom and they change their attitudes towards adults, from blind acceptance to criticism, and even contrariness. Criticism is uncompromising; they notice, first of all, faults omitting achievements. They point out an evident discrepancy between the theory and the practice in the everyday life, especially in adults' conducts. They can clearly see injustice and every sort of social discrimination. On the other hand, it is a period when children develop and maintain positive indentification with those who are competent. Then, they aspire to and acquire personal independence. The aspiration is manifested in various forms, often by opposing the authorities of the adult world.

The phase of adolescence is an important period for search of a personal identity. It is expressed by taking up various trials to find and manifest their own uniqueness. Since the task is still too difficult, at this stage teenagers identify with many TV celebrities, sports idols and members of youth organizations. Faithfulness to the idols is a source of a growth in self-esteem and self-confidence.

Children, constantly judged by teachers and other adults, begin to compare with each other. The point of reference is a peer group. At the same time, they become more realistic in judging themselves, especially girls' self-assessments are appropriate to the reality. A self-assessment is built both by positive and negative information. Due to them children know their good and bad sides. Therefore, the image of oneself is a structure in active and constant development. A psychological self-portrait created by a child is based on "reflected personality" – he adopts the point of view of other people; in consequence, he cares about other people's opinions about himself. He is also able to judge the efficiency of his actions [18, p. 521]. At the same time the growing self-consciousness results in a fall in self-acceptance. The main factor having an impact on the way one perceives oneself as a pupil is the information received from the teacher. The processes of extending the range of perfomed roles and broadening "the radius of social interactions" condition the psychosocial development of a child [15, p. 144]. They allow him to be an organizer, observer, performer, and from that perspective to build up the vision of himself. It is a long lasting process. When the offer of roles is not attractive enough or when the range is limited, some undesirable phenomena may occur, for example, identification with the values counter to those socially accepted, manifestation of being "nobody" in the world of authorities.

According to Erikson, a child demands a confirmation of his own consonance with the social expectations as to competence, perfection and actions according to the defined rules. The point of reference for a sense of consonance is its accordance with the requirements of the adult world. Recognition in the adults' eyes reinforces a self-esteem, "a sense of competence"; lack of recognition causes a sense of unsatisfied expectations and a feeling of being worse than others. However, in extreme cases an increase in competence may lead to an excess of consonance, as was defined by Erikson. Thus, a child may be in a situation where an excessive sense of duty will cause him to behave exclusively to satisfy the social expectations denoted by the role performed. Erikson claims that in no other period of life a child is so disposed and ready to learn quickly and to take full advantage of the relation with the teacher. The child's activity and aspirations to "setting in motion" underlined by psychologists [15, s. 140], and readiness to

achieve satisfaction resulting from the determined personal relationships make up the readiness to confirm his competence. This potential of pupils must not be neglected. They should be trusted and given a sense "of being together with them on their side".

Discussion

Looking from this perspective at the development potential of children, one may expect that with the help of the teacher they are able to build up a proper attitude towards their activity and high competence, which will allow them to take independent decisions and responsibility for them, to assess critically, to cooperate with others and be creative. Health education conveys this message: ability to create attitudes favorable for lifelong physical activity is a basis for the quality of human life.

The teacher's educational activity consists in helping the pupil wrestle with the world so that when he completes his education and he does not have to go to school any more and there is no teacher educating him, still he will want to be active in all his life. Helping is always an interference in another person's world and it is connected with the danger of overstepping the boundries of the pupil's world. In educational practice there are two ways to help pupils: assisting as steering and assisting as offering. Accepting one or the other method results in different effects. Each method of assisting has its own outlook on the world and different values [19, pp. 8–9]. The teacher and the chosen method of assisting pupils are means of conveying values. Looking at the teacher's attitude and the way he helps them, pupils will comprehend what is valuable, which is the right way to live and to treat other people, what attitude and what sort of activity is socially desirable. What pupils will learn – passive acceptance or active criticism, repeating information or making use of it, giving the Only Right Answer or searching for other possible ones, rivalry or cooperation, obedience or also reflection – depends, to a great extent, on the way of acting that the teacher applies.

From the point of view of a possibility of building up a sense of competence, such help becomes less effective if the pupil's right to decide about his actions is limited. A situation in which the pupil has to take a decision provokes in him certain anxiety, hestation, doubt. However, this is a desirable state, because it requires critical thinking, considering consequences of the chosen solution, so it plays an important part in learning, aspiring to independent discoveries of his desires and preferences. In this way, the pupil becomes a researcher of the reality around, who tries to comprehend phenomena. Such an attitude helps him not only to discover interelations among the phenomena, but also to understand his own actions; in consequence, it leads to ability to make use of experience in situations in real life. The pupil bases his intentions on a strong conviction that he can influence events, which helps him to gain confidence in his capacities.

What consequences can result from the form of assistance to the pupil adopted by the teacher? In the case of steering, the teacher's assistance consists in indicating pupils the right – in the teacher's opinion – way to solve the problem. Such help often means providing a pattern or algorithm of the answer, whereas pupils are required to follow faithfully the track, the teacher's way of thinking. In educational practice this way of help is expressed by an application and object-oriented method of activity, characterized by the teacher's narration, monologue of meanings, "dogmatism, fundamentalism, and replacing thinking by confessing" [20, p. 110]. The axiological base for this form of help is the assumption that the teacher understands the world better and, for pupils' sake, has the right to demand that pupils follow his recommendations; since he knows what is good for pupils, the teacher is obliged to give the right directions otherwise pupils will make mistakes. In other words, it is an arbitrary statement what is good and right. Therefore, pupils know only one solution provided by the teacher. They are also given information that they cannot achieve anything on their own, which results in the syndrome of "learned helplessness", as pupils learn not to take up any action and to wait for help passively. For pupils' sake, the teacher controls their way of thinking and acting. From the perspective of communication the teacher's steering becomes of manipulation-like pattern. In this pattern the teacher makes use of pupils' emotions and needs in order to urge them to take actions in accordance with his expectations and at the same time makes them think that they do it on their own initiative. There is another aspect of this form of help. If, in fact, it is the teacher who takes decisions instead of pupils and imposes them his way of acting, is he prepared to take responsibility for the consequences of the actions (not)taken by pupils? Can the teacher be brought to justice?

The axiomatic base for the other form of help is completely different; it is offering. The fundamental assumption is that every man, the pupil included, is creating his own knowledge in the process of constant inter-

pretation of the arriving information. In this way, the pupil reaches his own comprehension of the world. Therefore, if the pupil needs help, it should consist in giving him possibility to search, creating the conditions which would contribute to broaden his knowledge. Such an approach accepts a right to make mistakes, to learn by a "repeated trials-and-search" method, to correct own mistakes, so that the pupil would not acquire a "radar orientation", i.e. guessing "what the teacher means" [21, p. 33]. Help does not consist in imposing ready made solutions and interpretations as the only right ones. The offering teacher presents his point of view or solution as one of the possible ones. It is typical of critical and reflexive way of teacher's activity, related to the interactive and problem education. Offering means multiplication of alternatives which can be used by the pupil. It is always an offer to choose from. To help pupils the teacher should share his experience with them, to start a dialogue of meanings, to encourage an exchange of opinions and experiences, to make them create their ideas; in order to make the prediction of consequences of the selected solutions easier for them, they should be encouraged to be critical about themselves; anyway, a decision must be left to pupils.

It should be added that the man is fully active only when he acts fully convinced, when accepts the solutions and rules. He will not accept them under an obligation and control. In order to educate an active man of a "health caring personality", one should propagate social norms in an offering form, so that the pupil could have an opportunity to interpret them personally and accept. The recognition of norms and values by the pupil as his is possible when the relationships teacher – pupil is based on partnership. They will have sense if they are established in action.

Based on these assumptions an offering teacher introduces didactic and educational principles of his activity. The first ones include the principle of avoidance of imposing ready made interpretations on the pupil and the principle of making use of after school sources of knowledge. The principles of trust and respect for the pupil's rights are included in the educational principles. Undoubtedly, the pupil needs assistence, but not by means of taking decisions for him, rather by creating favorable conditions for his own search. Being a helpful and responsible teacher consists in such acting that enables the pupil to act.

An important element supporting reinforcement of a sense of competence is an application of a learning-by-cooperating strategy. It should replace competition and rivalry, so deep-rooted in Polish schools. Education for rivalry does not have any social justification; it encourages egoistical attitudes, stigmatization of less able people, hierarchization, entrust. For the people who experience to be "out of the podium" there are created anti-conditions to work on their self-esteem, a sense of competence or a sense of security. Achieving objectives of health education is a complex operation, it demands commitment and cooperation of many subjects, which have to say in unison, so that pupils perceive the coherence of their actions. Cooperation is one of the strategies of solving complex health problems, where trust is the key to success. It is also an essential skill in life, indispensible at different levels of activity:

- macrosocial – international cooperation, taking advantage of experience of other countries,
- mesosocial – acquiring/developing skills practical in life requires cooperation between specialists in various fields, teachers of various subjects, between school and the family environment, community and mass media,
- microsocial – taking advantage of the potential of the group, learning from each other, preparing and implementing sports projects, promoting healthy lifestyle – all of them require a cooperation of pupils with each other and with teachers.

Sports activity carried out in groups offers a lot of natural situations favorable to emphasize the values of cooperation. In the groups which are united by the common goal and the will to solve the same problem, the ties of interrelationships, positive relations, are developed, which increases the motivation to complete the common task. A well-organized team work creates strong relations of friendship, trust, which favor an atmosphere of learning. In the conditions of cooperation all pupils act as subjects. Such a strategy is good to build up a confidence in oneself and to take a decision to change the attitude; it has a value, because in the shared activity – real and not fictitious – a positive attitude to changes is formed.

Conclusions

At the end a question arises: during the studies will the future health educators acquire the professional knowledge which can be a reference for them while establishing their own procedures of pedagogi-

cal behavior in creating the conditions for pupils to experience the senses of subjectivity and competence?

The research carried out on the knowledge being built up by the teacher shows that in an educational practice the teacher makes use mostly of the knowledge based on experience, which is the most important for him [22, pp. 130–164; 23, p. 38]. The teacher discovers the meaning of knowledge by experiencing personally its usefulness. If the teacher does not have personal experience, he adopts the patterns transferred from his experience as a student, thus copying the routine procedures of establishing relations between the subjects of the education process; the procedures which were established in different from today's social and economic conditions. In aspiration to professionalism, the educator can be restricted by the past experience and his personality as well as by extra-didactic measures of the educational activity. The acquired experience, beliefs and personal history derive from the past when the normative knowledge and the expectations for oneself were established. While interpreting school events, both the teacher and the teacher trainee refer to their own systems of values. The key category in the process is comprehension, a basis for planning future actions, which determines the ability to act. The activity can be understood as implementation of the plan based on the comprehension of the situation which constitutes a part of the environment interpreted by the teacher. The teacher takes up different kinds of actions; among them, according to Weber's classification, are the following [24, p. 19–20]:

- actions of traditional origin, deep-rooted in the past, which are present in the school practice in the form of "methodological ethnocentrism" – term introduced by Klus-Stańska – whose sense lies in the assumption that this is the way we have been doing it "since time immemorial" [20, p. 112];
- actions based on emotions, which are characterized by the ability to direct emotions to reach the goal; an affective action can arrive at the limit of rationality if under the influence of strong emotions, it leads to less rational actions or even to a loss of the situation control;
- actions based on the values and rationalism; related to the external goals and in strict correlation with the values cherished by the teacher; he gives a rational meaning to the behavior and not to the values which generate the behavior;
- practical actions (based on the goal and rationalism) oriented to the achievement of concrete and real goals in everyday activities.

The discussion presented to date excludes the assumption that for health educators it is enough to have technical, professional and closed knowledge which they acquire in the course of traditional education. No kind of studies make candidates for teachers really good professionals. It seems necessary to reconstruct the model of teacher training. A desirable educator is a professional who searches for his own procedures to reach a goal, who reflects on his activity, who is open to different interpretations, to the school microcosm and to the pupil's development needs. Such a teacher perceives his educational activity as an obligation towards pupils, which is expressed by the need to bring their capacities to full development. In order to be able to do it, the educator has to work on his professional development, that is to make a shift from perceiving himself as a reactive object controlled externally to perceiving himself as an active subject of the occurring changes. Only this kind of teacher can be a guide for pupils in search of their own lifestyles, for whom activity can be a desirable value.

Since the above mentioned premises are accepted, it is time to indicate three complementary areas which call for necessary changes in the professional preparation for health educators:

- the first area assumes that knowledge is not static, but is characterized by constructiveness and subjectivity; so a change regards the teacher's reflexiveness, capacity to shift from "I know" to "I think";
- the second area concerns the process of becoming a teacher; a change should occur already during the studies by giving students possibility of reflective practicing and by shifting from practice of dominating students' thinking to practice supporting their thinking;
- the third area refers to the curriculum of teacher education; so far it has been understood as a set of issues to present, which must be rejected, and replaced by a set of pedagogical problems to solve; the source of the problems should be school practice.

According to the author, the issues listed above are important points of orientation on the map of theoretical and practical problems in educating teachers – health educators. It would be a mistake to assume it is a closed list of the proposals for the discussion on changes in the quality of health education in Polish schools.

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A PHYSICAL EDUCATION TEACHER AS A PART OF SCHOOL HEALTH EDUCATION

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ABSTRACT
The article discusses the changes in carrying out health education introduced by the school curricular reform. The new *podstawa programowa* (curricular basis) introduces some important changes in health education by choosing Physical Education as the most suitable subject to deal with health education. Therefore, a physical education teacher becomes a person responsible for carrying out health education at school (a coordinator of activity). The article demonstrates the new role of the physical education teacher which requires the adequate students' preparation for their future careers as well as the appropriate training of the physical education teacher, in the scope of their knowledge, skills and attitude. The teacher's responsibility, genuineness and reliability are also emphasized, since, due to the new tasks, the teacher becomes a creator of healthy lifestyle at school.

Key words: a physical education teacher, health education, a school curricular reform

"The teacher's mission, according to a centuries-old tradition,
originates from vocation. It demands particular personal predispositions,
a thorough preparation for the job, constant deepening of the competence,
and a cultivation of the mind, will and heart. Since it is a service rendered to
another man. And that is why, it is connected to an exceptional responsibility".
M. Rusiecki

Introduction

Anthropological and axiological reflections on what is important in bringing up a man...

Educating is a service rendered by a man to another man, a service based on mutual relation. In educating somebody it is necessary to assume an appropriate attitude towards the effects of the relation: to recognize and respect the pupil, to listen to his needs, to strengthen his will, to indicate the way of the truth which will lead him to goodness. One should treat the pupil with kindness, openness and trust, become an authority for him, somebody who will always say what is right, good and true [1, p. 169].

In the comprehensive education of a man, which is the aim of the school education, all fields of education are important. Therefore, one should not neglect either physical education or health education when it comes to the integrated education of a man.

Searching for a proper perspective of education (including physical and health education), one should assume that "educating is a constant process of supporting human efforts in development of his humanity" [2, p. 12]. Kowalczyk points out that the right perspective of education should resemble "multidimensional realism" which includes living, cognitive, psychological, axiological, ethic, and existential dimensions [2, p. 12]. The aim of such education is to create favourable conditions to become more and more human, that is to "humanize" the human being (to mould the pupil) [3, pp. 269–270; 4, p. 119]. Education is not, and cannot become, only a spontanous growth and development of bios (the drive for life). It is not only the influence of institutions (ethos), but it is also a deliberate moulding of the pupil by the educator's actions (agos) together with the influence of destiny, which is of great significance in education [5, p. 18]. Destiny imposes parents, teachers (...), equips with hereditariness, arranges vicissitudes of one's life as a fortunate lot or one full of adversities, thus, prepares the pupil for different situations in his life [6, p. 25].

Education assumes "a dynamic structure of a man, which underlines a process of becoming a man, changing for better" [7, p. 19]. This is a "deliberate action of adults (educators) orientated mostly towards children and young people (pupils) in order to shape in them certain notions, feelings, attitudes and aspirations" [5, p. 19].

Looking for the right conception of education, one should underline that the conception of the integrated education is particularly useful; it assumes a full and dynamic formation of the pupil. However, education is not only moulding the pupil, but also opening to the values offered in education. Education as an action which forms the pupil is a personal action; it means meeting persons (the pupil and the educator) in different relations, intended and unintended actions, whose objective is always a comprehensive development of the pupil [3, p. 173].

If education is understood in this way, educational actions should comprise: custody, entertainment and culture, physical, health, mental, moral, social and esthetic education as well as teaching, training, preparing for various tasks (to take up different roles in the adult life) [5, p. 23].

From this assumption there results a set of detailed educational tasks for the contemporary school and teachers.

The 21st century school should be the place where people from different social backgrounds can meet, where education (educating, teaching and bringing up) takes place while the educator and the pupil are speaking to each other. This is a school where young people find directions (humanistic values giving a sense to their lives), which rooted in the past are "a solid rock, foundation, to build the future on" [7, p. 18]. In such school it is the pupil who plays an important part (as a subject of the implemented education), but the teacher is equally important. Educating can be compared to a meeting of the pupil and the teacher. A lesson is a basic form of school activity, which should become a kind of interaction between a teacher and his pupils. The effects of teaching and other educational processes depend, to a great extent, on the interaction (if it is created and consolidated).

A friendly, but demanding school – at the beginning of the new reform ...

The Polish school has to face another important change which was introduced on 1st September 2009 by the new curricular basis. The Ministry of Education indicates a few important reasons which triggered off the need for change:

1. giving equal opportunities in education by providing a better access of the youngest to education (reducing the age of the first class pupils);
2. keeping cohesion of curricula – an educational process must be coherent in the curriculum and organization, described from the point of view of educational effects, adapted to the pupil's capacities, taking into consideration rising educational aspirations of young people, offering equal educational opportunities, fitting well in-between the pre-school education (kindergartens) and the university school system;
3. raising the level of education, thus increasing the competitiveness on the labour market [8].

The changes approved and proposed by the Ministry of Education have as a principal objective **quality** and **trust** [8], **efficiency** (in accordance with the praxeological educational model); it must be pupil, teacher and parent **friendly** (a new paragraph which indicates the triple subjectivity of the educational process), **modern** (properly equipped classrooms which enable pupils to gain knowledge from different sources and developing abilities to use the acquired knowledge in everyday situations). School which not only educates, but also orientates the pupil to knowledge, develops his ability to learn as a way to satisfy a natural curiosity of the world and discover his interests, and it also prepares for further education [9].

One of the important changes in the curricular basis is the rejection of the educational paths, "a health education path" included, which were introduced to the Polish school in 1999. Health education, however, does not disappear from the school reality; the form and the way lessons are organized change, but health education remains systematic (it is present at all the levels of school education).

Appreciation of the importance of health education

In the preamble to the curricular basis for all the three school levels of compulsory education, there is a regulation on health education which indicates a need to raise its status in the comprehensive education of children and young people: "Another important school task is health education, whose aim is to form the pupil's habit to take care of his and others' health, as well

as an ability to create a health friendly environment" [9]. The regulation underlines the importance and status of health education among the school tasks. As a result, health education becomes a part of the school curriculum: didactic, educational and preventive.

The previous solutions (health education in the form of an educational path) imposed on every teacher an obligation to include health issues while teaching their subjects or conducting other activities [10, 11]. Teachers could choose the way to do it: in-between subject or after school. Such an assumption meant that health education was a duty of every teacher [12, p. 42]. The observations of the school reality revealed that the task was carried out by means of various (often improper and insufficient) actions based on haphazardness, pretence and improvisation. The school practice proved that if all the teachers are responsible, in reality, nobody is. Therefore, it was necessary to make changes in order to find a subject and a person (teacher) coordinating all these activities.

Physical education, a priority subject in providing health education

In the new solution physical education was recognized as the most suitable subject to carry out health education (it is a subject saturated with health education issues: similar approach, coincident objectives). Due to this solution, the holistic (comprehensive) conception of the approach to health can be implemented, because the physical education curriculum comprises actions which concern moulding and developing *physical health* (physical movement – its various forms condition health, not only physical), as well as the influence of physical movement on well-being (*mental health*). Interpersonal relations (e.g. participation in team games) result in the formation of friendship bonds, which have a favourable impact on *social health.* Moreover, sport evokes a sense of fulfillment, provides positive feelings (*spiritual health*).

The new curricular basis (worked out to make the requirements uniform, and to define the effects) is the so-called *educational pattern*; it is a *civilizational and educational standard* common for both physical and health education, which tells the teacher "what to teach" (knowledge, skills, attitude) [9].

A connection between health education and physical education – health education at all the levels of school education

The new approach includes health education within physical education, thus placing it at all the levels of school education. It has been assumed that health education spread systematically throughout the whole educational process has a positive influence on the effectiveness of the actions undertaken. However, it is worthwhile to remember that the effectiveness of health education is particularly difficult to evaluate, as its effects are visible years after [13, p. 56]. Stretching actions over time (including health education in the overall curriculum of education, at all the levels of school education, that is treating health education as a process) allows a regular shaping of the pro-health attitude (by imparting knowledge, developing abilities and forming the pupil's attitude). It coincides with the assumptions of the modern concept of health education based on regularity, continuity of effects and introduction to health issues as early as possible [12, pp. 23–24; 14, pp. 30–32; 15, pp. 38–39; 16, p. 28].

In the new curricular solution, physical education and health education appear already in the curriculum of pre-school education in the area entitled: "Health education and shaping physical fitness of children" [8]. Pre-school health education introduces the child in some issues of health, physical fitness and security, it prepares the child for the school education. Further contents of health education can be found in the regulations of the curricular basis for all the levels of school education system [9].

School education has a constant character; each earlier stage of school education is the base for the next one, and so it is in the case of physical and health education. Following the modern concept of health education orientated towards the holistic approach to health, the teacher gradually introduces pupils to the perception of health as a whole; from the one-dimensional approach: physical health (stage I: classes I–III of primary school), through the three-dimensional one: physical, mental and social health (stage II: classes IV–VI of primary school, and stage III: *gymnasium*, a three-year uniform comprehensive secondary school), to the multi-faceted one: physical, mental, social and spiritual health (stage IV: three-year high schools of various types).

The new solution approved by the Ministry of Education assumes that at stage I (early school education) physi-

cal and health education is provided by the teacher of primary education, who was recognized as the most competent person to work with children aged 6–12 (due to his factual and methodological preparation), though there is a possibility (headmaster's opinion) of holding this subject by a specialist, i.e. physical education teacher [8]. At this stage, health education is incorporated in sports lessons and has an introductory character. Lessons are especially recommended to be held in open space, the so-called green gyms (sports field, park, forest, meadow). The requirements in health education were placed in theme blocks of physical education: physical fitness, sports exercises, lifelong sports, relax, security and health education [9].

From stage II it is the teacher of physical education who is responsible for conducting health education and its coordination at school. Health education is held in the class-and-lesson system and facultative activities, "recreation and health" ones included, which "should enable pupils to take up physical activity useful for health" [8]. The requirements in health education have been incorporated in the theme blocks of physical education, such as: diagnosis of fitness and physical activity, sports training, lifelong sports, safe physical activity, hygiene, sport and dance, which are also present in stages III and IV [9].

The physical education teacher has to face a more complex assignment in the gymnasium (extended stage) and the high school (self-improvement stage). At these stages, apart from holding health education in the class-and-lesson system and in the form of facultative activities (theme blocks of physical education), a "health education" block is introduced. The requirements concerning health education included in the theme blocks of physical education constitute five areas of pro-health activities: (1) physical activity, work and rest, nutrition; (2) physical development in adolescence and youth; (3) body care, security, diseases; (4) health and health care; (5) mental and social health, and abilities useful in everyday life [8]. The "health education" block should be held regularly by the teacher as a course or workshop, thus reinforcing the teacher's actions in forming a pro-health attitude in the pupil [8].

The regulation on the leading role of physical education in health education obliges the teacher of physical education to coordinate its teaching at school and cooperate with other teachers. The teacher of physical education is seen, after an appropriate training course, as best prepared to take the new role [8].

It is necessary to improve (by more teacher training) physical education teachers, because, as it was noticed e.g. by Pawłucki, "the teacher of physical education is not always aware of being a 'health teacher', though he often uses another, also much promising, term of a physical culture teacher. In this case the teacher does not know (may not always realize – B.W.) that the definition itself of the name comprises a role of a guide to the health culture (...). In his work style, however, the teacher resembles more an organizer of 'some fun in the corridor' as well as he shows a tendency towards lessons of pure sport" [17, p. 69; 18, pp. 345–348].

To make the teacher more interested in including health education in his lessons, it is important to follow the evolution model of the physical education teacher suggested by Pawłucki. It indicates the need of a shift from "**an instructor of body exercises** (object-orientated approach, no reflection, basic tool – a whistle), through **a bio-teacher** (excessive belief in educational effectiveness of body exercises) to an **axioteacher** (ability to explain to pupils the sense of body's value in the context of the social standards of conducts and the system of values accepted in the given culture)" [19, pp. 152–153].

Therefore, Krawański is right to notice that it is necessary to change the way of thinking of physical education students and graduates; they have to reject the conviction that their aim is to teach movement and organize sports events at school; they must accept the new approach to physical education whose aim is to change the way of pupils' thinking, to make them perceive sport and sports activities as important elements of human education which take an important part in the intellectual, professional and social developments (health one included) [18, p. 338].

Physical education teacher – the key person in school health education

In the new approach to health education held within lessons of physical education, the role of a teacher becomes particularly important, as he is the person responsible for the process of school health education, who accomplishes its main objective, i.e. moulding a personality that takes care of health [18, p. 351].

Woynarowska underlines the fact that "the teacher is the key person in school pro-health education" [14, p. 16]. His role and tasks in moulding the pupil's pro-health attitude are indispensable, which is strongly em-

phasized by Demel, the author of the theory of health pedagogy: "the teacher keeps together" the whole education [20, p. 108].

The reform presently taking place in the school system and the new approach to health education implemented in its framework [12, pp. 27–32] assign a new role to the physical education teacher as the most competent person to conduct actions in this matter. The teacher becomes the pupil's **guide** and **advisor**, an **animator** of actions and not "an omniscient expert". According to the curricular assumptions the physical education teacher should take up regular efforts to raise the level of his competence in order to be able to assume not only the role of a teacher, but also that of an educator. "The curricular basis for comprehensive education" indicates obligations and tasks of the teacher–educator. In the reformed school every teacher is responsible for teaching and bringing up, which is an integral part of the entire educational process [10]. It is especially important in the case of the new approach to health education. Including health education in lessons of physical education (and some other subjects like: nature, biology, education for security) [8] oblige school to conduct the actions in this matter integrated in a systematic way with the entire educational process.

Health education has been enhanced and included in the process of teaching and bringing up; it has become an element of human education. It demands an appropriate preparation from the physical education teacher who deals with this matter. Demel, already in the '60s of the previous century, underlined that "the educational and health effectiveness of the teacher's work depends on the following factors:

- the way he was brought up himself and what role model he represents for pupils;
- his hygienic and pedagogical knowledge, particularly about the developmental needs of young people;
- an interest and vocation for this kind of activity" [20, p. 108].

The author also indicated a need for an appropriate preparation of the teacher in the teacher training centers. Since then, the situation has not changed, the teacher who deals with health education has to be well prepared. Therefore, a demand for changes (uniforming health education curricula) has been made: lectures and classes preparing students (the future teachers) to conduct health education should be included in the curriculum of the physical education studies.

Physical education teacher's competence useful in health education

Currently, the problem of a versatile preparation of the teacher for health education has been discussed, among others, by Woynarowska. She points out to the teacher's competences, which are important in the didactic and educational process. The competences should be acquired during the university studies leading to the bachelor's degree and other pre-master courses for future teachers and educationalists, as well as during teacher training courses held for already working teachers [21, p. 17]. According to the author, the teacher should have: *knowledge* about health and health education, but also *abilities* to organize and conduct health education (diagnosing, planning, conducting, monitoring and evaluating) and an *atittude* (e.g. convinction of health's significance, recognition of health as a value, readiness to perfect one's health, openness, creating a healthy environment) [21, p. 17]. Also Krawański underlines the significance of professional competence of the physical education teacher related to the health education, and he distinguishes its three layers:

1. Social (cultural):
- contributing to the formation of pro-social attitudes and abilities of the man by means of physical culture, as sport generates culture,
- active participation of local communities in the health education process, especially in promotion of human physical activity.
2. Utilitarian (educational)
- development of everyday life abilities by means of physical education,
- forming a habit of moving and of other healthy behaviours as a fundamental element of the human lifestyle.
3. Existential:
- stimulation of development and physical fitness of an organism,
- formation of a personality that cares about the body based on the pro-health reflections [18, p. 361].

The above mentioned competences show that there is a need to prepare students of physical education (still during the university studies), as well as to train teachers (already working) by providing them with knowledge and skills in the form of constant training courses and self-education.

Health education as a challenge for the physical education teacher

The new solution to the implementation of health education approved by the Ministry of Education enhances the status of the physical education teacher, whose role in this scope is fundamental and at the same time it makes him responsible for the school health education process.

The new curricular basis indicates clearly the scope of the **educational responsibility**.

According to the contents of the document the physical education teacher at school:

- is a coordinator and the main organizer and director of health education;
- cooperates with other teachers, parents and other people (institutions): e.g. hygienist, nurse, physician;
- holds lessons of health education in the classroom making use of activating and interactive methods, using a **learning by experience cycle**, arranges the learning orientated teaching process;
- **draws up his own curriculum**;
- is **a guide** (leader) of healthy lifestyle [8].

The tasks included in the curricular basis are a challange for the physical education teacher, as he is the person responsabile for the implementation of health education.

Responsibility – a basis for effectiveness of educational work

The teacher, due to the character of the profession, should be a credible undisputable model for his pupils. Certain priorities, such as: dignity, authority, high social status are ascribed to the profession of a teacher. The right attitude of the teacher is the key to success in moulding a pro-health attitude of pupils. The ethic and moral area is an important element of the teacher's attitude, as it is related to responsibility. As Rusiecki says "responsibility is a core of the moral experience, an important ethic category of a practical character (...), which is an 'indicator of the human's maturity'. It indicates readiness, obligation, and even the necessity of taking responsibility for his own thinking, desires, words, attitudes and actions" [22, p. 4]. While establishing various interactions with pupils, the teacher must be aware of the responsibility for himself, his actions, but also for others (pupils). The teacher is "an active responsible subject to be trusted and believed in, who is aware of the binding norms and the effects resulting from the assumed obligations, who takes actions freely; he is responsible, i.e. establishes the moral (and legal) relations with the people and tasks entrusted to him" [22, p. 4].

Karol Wojtyła, John Paul II, paid attention to the importance of responsibility in the process of bringing up the man. Discussing the anthropological issues, the author underlined the significance of responsibility in the human life. According to Wojtyła responsibility is "characteristic of accepting and realizing vital values" [23, p. 34], which is especially important in reference to health education. The pupil is to be responsible and take responsibility for such values as: health, physical fitness or beauty of his own body.

The man is his own master, uses the brain and is sensitive to the values which do not determine him, but are chosen by him in a free and responsible way [23, p. 34].

The teacher of physical education – creator of healthy lifestyle

In order to make the pupil take responsibility for the above mentioned values, he must get interested in the programme offered by the teacher. Therefore, the physical education teacher should become a creator of pupils' healthy lifestyle, i.e. a person who has an effect on others, who cares about other people, transmits the values (he embodies the values, follows them and realizes them), is able to make pupils follow him, who inspires and spurs them to work on themselves.

When can the teacher become a creator of the healthy lifestyle?

When he expresses readiness to carry out the undertaken tasks, but also when he is actually well prepared for them. Rusiecki says "on the position as highly exposed as the mission of the teacher it is out of the question not to know the curricular contents, principles of good behaviour, moral norms, or didactic and educational principles" [22, p. 34].

In the health education presently implemented, the teacher's attitude and coherence of the imparted knowledge with the preferred healthy behaviours become particularly important. It is not enough to impart the knowledge about health and healthy behaviours. If the teacher is not genuine, i.e. he says one thing, but he behaves in another way, the entire knowledge imparted

to pupils is useless and does not provide support for everyday actions.

Jeleńska notices and underlines that "in the process of bringing up we have to create situations which will result in making relations with what is true and good (...) such conducts only can mould an 'internally harmonized' man" [24, p. 17]. The man who will possess inside himself the values allowing him to live in accordance with his own "inside", will not be a man "controlled externally", submissive to others' influences. It is especially important while speaking about health care. The "internally harmonized" man is able to refuse, is aware of his responsibility for health [24, pp. 17–19]. He can be guided by the freedom understood properly, which is based on choices and decisions.

Therefore, the teacher should be credible in the pupil's eyes, only then he will be the role model and "will be followed by his pupils". However, if his behaviour does not reflect the knowledge he imparts, e.g. speaking about the harmfulness of smoking though he smokes, he is not a model to follow.

It is necessary to note that the efficiency and effectiveness of health education carried out at school depend on many factors; one of them is the teacher's atittude, the so-called role model of the educator, which is essential and has a direct influence on the pupil's behaviour. The genuity of the teacher's atittude was pointed out, among others, by Zamoyska, who underlined that "if we require certain conducts from a child, we must behave impeccably" [25, p. 172]. The teacher must bear testimony to the truth, good and beauty, and as Gogacz says "by means of good images you must evoke good feelings in the pupil" [26, p. 37].

Health education, as it is noticed by Demel, "does not have to be boring, it can be connected to the deepest motivations of behaviour, because it participates in the achievement of the overall educational objectives aimed at learning and understanding oneself as well as mastering the most difficult art, the art of living" [20, p. 115]. Therefore, it is necessary to convince pupils that healthy conducts are attractive, to point out the advantages resulting from leading the healthy life.

Observing the school reality, one notices that young people are attracted by **good examples from life**. Practical reference to the imparted knowledge can be best familiarized by the teacher-educator if he is able to attract and interest pupils. Youth (especially adolescence) is a very difficult period and requires from the teacher to be both delicate and consistent in actions. A young man (especially aged 12–15) wants to impress others and if he is not brought up well, he often chooses such conducts which do not favour health but damage it. Joining various informal peer groups, he yields under pressure exerted by others and starts using addictive substances, e.g. cigarettes, alcohol, drugs. Left alone, he gets addicted quickly and starts enhancing improper behaviours, i.e. unhealthy. If the teacher (who is close to his pupils) notices the problem and is able to help, for example, by involving the pupil in a chosen form of sports activity, the pupil can get back on the straight and narrow. Such situations, i.e. the teacher's influence and help, are a frequent method of educational work in Polish schools.

Young people, as John Paul II used to underline, need an example and model of behaviour, they are looking for directions, landmarks in their lives, they need help and support from parents and teachers. According to the Pope, bringing up a man is both a challenge and a responsible task; young people need examples and models of behaviours and they are looking for them in adults [27, p. 6]. It is good when they can find them in their parents' and teachers' behaviours, the persons who are significant in the up-bringing.

That is why, it is important for the teacher "to be" and "to want to be" an important person for his pupils, and to treat his educational work as a challange and not only a job. He should remember that the highest value for him is the child's good, where the development of his personality and not his knowledge comes first. While teaching and bringing up, the teacher provokes some intended changes and in this way, he helps parents. Together with them he is responsible for the pupil's health, hygiene and overall personal development. He must not only be an expert in the knowledge he imparts, but also help pupils discover in a wise manner the sense of life, a great adventure and a unique opportunity to become a real human [28, p. 11].

Conclusions

The above discussion raises a question: is / will / or can the physical education teacher be a creator of the healthy lifestyle? Certainly this is possible, however it is important for him to be not only a good trainer, but first of all, an animator, the model to follow for his pupils, somebody who will help to find the right track in life based on healthy choices.

Another question is: what does a success of health education in the reformed school depend on? To a great

extent on the teacher himself. In the health education carried out presently, the teacher's attitude is extremely important; "the teacher's personality teaches", therefore he has to be genuine and his principles must be reflected in his behaviour. Due to such attitude he becomes a creator of the healthy lifestyle and influences others' behaviours.

At the end, another question must be answered: what is the basis for the effectiveness of the health education carried out presently? It is the awareness that "I – teacher" am responsible for moulding the pupil's attitude. **A creative teacher of physical education is the guarantee of the effectiveness of health education.** As Nowak notices. "teachers, beside parents, take responsibility for bringing up children and young people, therefore they have to be characterized by maturity, openness to work with pupils; they should take care of all their pupils, because they take social responsibility for their education" [3, p. 476].

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MEDIEVAL RE-ENACTMENT GROUPS AS A NEW FORM OF RECREATION

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ABSTRACT

Purpose. Medieval re-enactment groups known also as modern knight societies or fraternities have been developing rapidly in Poland and all over the world, in particular, for the last decade. The following study aims to show that membership in medieval re-enactment groups can be regarded as a novel form of physical recreation. The study focuses on various dimensions of membership, members' motivations, and benefits of participation in such groups. **Basic procedures.** The study was conducted in 2006 with members of two modern knight societies: "Opole" and "Chorągiew Ziemi Lwowskiej Księcia Władysława II Opolczyka" from Poland. All in all, 63 subjects (44 men and 19 women) aged 14–52 years, with different levels of education took part in the study. **Main findings.** The results obtained showed that the main reason for joining medieval re-enactment groups for the majority of subjects was to pursue their hobbies. The main expectation concerning membership in such groups is having fun, which was declared by over 50% of subjects. Moreover, over 50% of subjects expected to improve their frame of mind and experience diversity in their daily life as side effects of their membership in modern knight societies. Additionally, 61% of members who specialized in medieval combat re-enactment noted an improvement of their fitness level. **Conclusions.** Participation in medieval re-enactment groups can be regarded as a new and attractive form of physical recreation as well as an intellectual activity.

Key words: free time, physical recreation, medieval re-enactment, knight society, questionnaire study

Introduction

Modern man frequently experiences maladjustments, lack of contact with nature and close and informal interpersonal relations and shortage of physical movement. An effective remedy to these problems can be physical recreation, which by stimulating physical development can improve one's quality of life and functioning in society [1–4]. Active physical recreation is more and more often perceived not only as a desired model of leisure pursuit but also as a way of life. This perception involves the benefits of all types of sports, tourism, movement games and other physical exercises as means of creative self-fulfillment and health improvement.

One of original and alternative forms of physical recreation are medieval re-enactment groups or modern knight societies, which have been enjoying a great popularity in Poland in recent years.

The modern revival of knight societies is deeply rooted in the Polish awareness of medieval culture. The popularity of such groups is additionally facilitated by the mythologization of the knightly ethos in Polish literature and songs, so much admired by the Poles [5].

The first medieval re-enactment groups appeared in Poland at the end of the 20th century (Fig. 1). There were only two such groups between 1986 and 1990. In 1998 Poland had twenty-four modern knight societies [6].

The medieval re-enactment groups form associations and are mostly active in Polish cities and towns with medieval traditions (castles, historical monuments, etc.). They take part in various recreational events inspired by medieval knight tournaments [7].

The present-day revival of the "knight movement" is a fairly recent phenomenon which has not yet been subject to any extensive research, unlike the Polish medieval knightly culture which can boast a rich historiography regarding the knightly ethos and code of honor [8–10]. Despite numerous differences between particular medieval re-enactment groups their main

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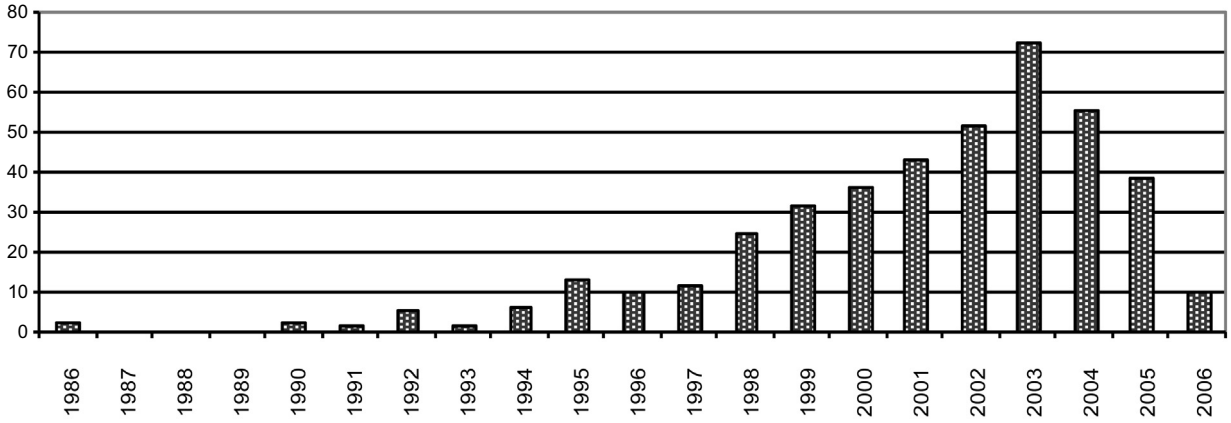

Figure 1. The growth of medieval re-enactment groups in Poland 1986–2000 [6]

aims and ideas remain the same. They are known by different names, e.g. knight brotherhoods, knight companies or knight movement and concentrate on medieval combat re-enactment or "living history" activities pursuing the knightly ideals, values and customs. The members of these groups share their interests in history and active (physical and intellectual) leisure pursuits. These communities are hobby, artistic and recreational groups in one [7, 8].

Recreational activities are of autotelic character. Participants in recreation pursue their own interests but also engage in activities as means of care of their health and physical fitness [11]. The activities of medieval re-enactment groups combine these two aspects. One of the most significant dimensions of these activities is the diversity of roles played by the group members. They are engaged in medieval combat tournaments, dances, archery or arts and crafts. The ludic and entertainment aspects of such activities are particularly emphasized, rather than attainment of set goals. The members learn from one another, preserve knightly values and pursue the ideals of fair play rather than achieving victory at all costs.

The present study aims to confirm empirically that different activities of medieval re-enactment groups as well as motivations to participate in such groups can be regarded as novel forms of physical recreation. The study attempts to identify the motives of participation in medieval re-enactment groups by examining their members' opinions about the benefits of participation in such activities. The following research questions were formulated:

1. What are the members' motivations and expectations before joining medieval re-enactment groups?
2. What, in the members' opinion, are the benefits of their participation in activities of medieval re-enactment groups?
3. What characteristics of physical recreation can be found in the activities of modern knight societies?

The adopted research hypothesis is that membership in a medieval re-enectment group meets the basic criteria of participation in physical recreation in terms of forms of activity and motives of participation in such groups.

Material and methods

The study was carried out between January and February 2006. The subjects were members of the Opolskie Bractwo Rycerskie (Opole Knight Brotherhood) and Chorągiew Ziemi Lwowskiej Księcia Władysława II Opolczyka (Company of the Lvov Land of Duke Vladislav II of Opole) from Poland. The subjects had been members of the groups for at least six months. They included 44 men and 19 women, aged from 14 to 52 years who expressed their consent to participate in the study. Such an age span is typical of medieval re-enactment groups which are composed of members of different generations.

The sample was divided into two study groups with regard to the members' preferred forms of activities:

- combat group (30 men, 1 woman) consisting of members for whom the main field of activity was medieval combat re-enactment involving intensive physical training;
- non-combat group (14 men, 18 women) consisting of members whose main activities included medieval archery, dancing, jugglery, and arts and crafts.

The method of questionnaire survey was used in the study. As the subjects could choose from one to three answers to each questionnaire item, in some cases the total of answers exceeded 100 percent.

Results

Determinants of physical recreation include development of interests and different preferences of movement activities. Within each medieval re-enactment group its members can specialize in different activities. In the present study 49.2% of subjects chose medieval combat as their main interest, while 50.8% were engaged in other non-combat activities. Among the combat members 19.3% combined medieval combat re-enactment with dancing, 3.2% with arts and crafts and with archery. In the non-combat group 56.2% subjects specialized in dancing and archery. More than one-fourth of subjects were also involved in arts and crafts and dancing (Fig. 2).

An important determinant of membership in a medieval re-enactment group is motivation which is related to the awareness of reasons for joining such groups and participating in their activities (Fig. 3).

The results obtained show that the main motivation to join a modern knight society for more than two-thirds of its members is indulging passions (pursuing hobbies). The distribution of other motives for joining was different in the combat and non-combat members. For 54.8% of the former learning new forms of activity was most significant, whereas for 50% of the latter it was making new acquaintances. For both groups of members fitness improvement was a fairly insignificant motive: 9.7% for the combat members and 6.2% for the non-combat members.

Motivations for undertaking activity are identified with one's expectations, and the knowledge of one's motivations for undertaking a new form of recreation can be helpful in estimation of fulfillment of one's expectations. Creating an opportunity in which at least a few

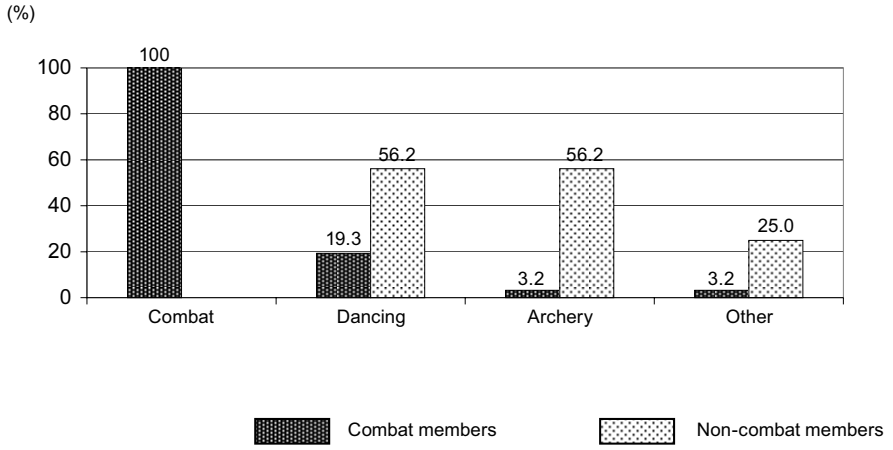

Figure 2. Preferred forms of activity of members of medieval re-enactment groups

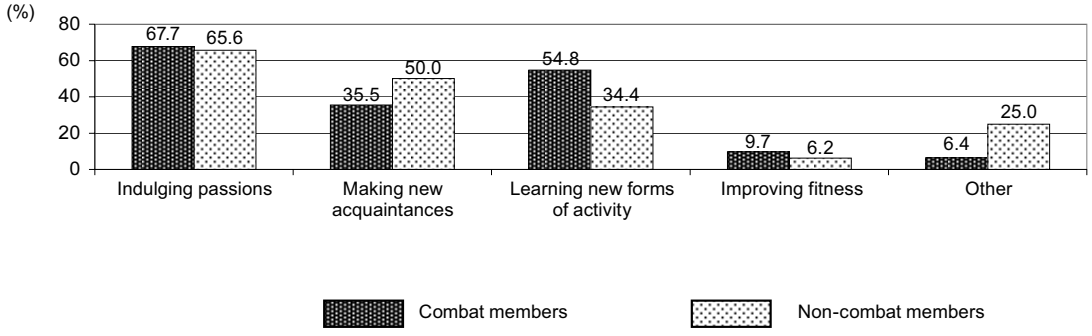

Figure 3. Reasons for joining a medieval re-enactment group

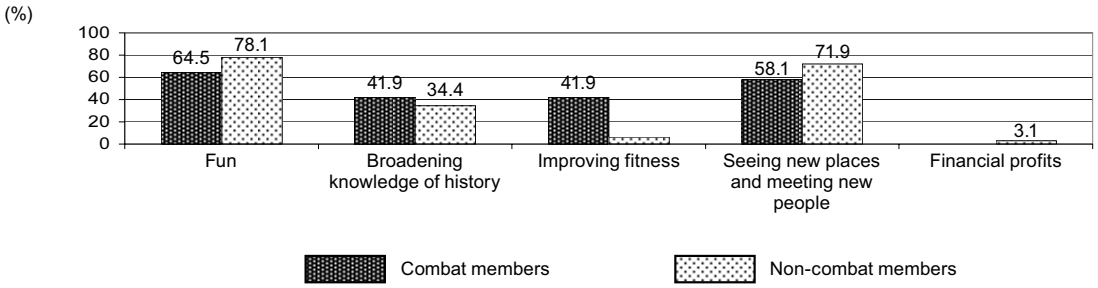

Figure 4. Subjects' expectations before joining a medieval re-enactment group

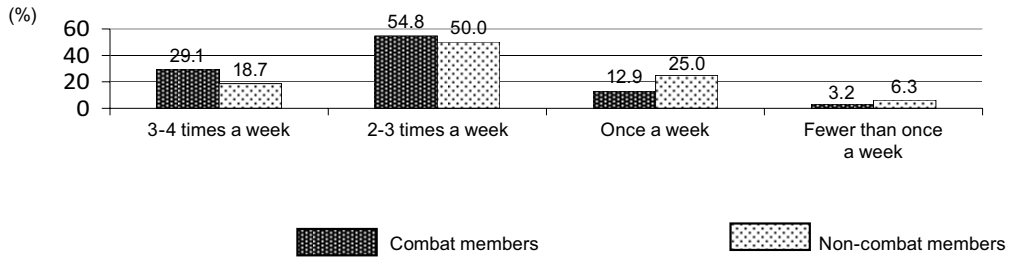

Figure 5. Frequency of members' participation in physical exercises

expectations are realized can be translated into satisfaction and continuation of this form of recreational activity (Fig. 4).

On joining their group the largest number of subjects (64.5% of combat members and 78.1% of non-combat members) expected good fun out of their participation in physical recreation. The second most important expectation in both groups of subjects was getting to know new people and seeing new places (58.1% of combat members and 71.9% of non-combat members, respectively) followed by broadening their knowledge of history (34.4% of combat members and 41.9% of non-combat members, respectively). In fact, propagation of the knowledge of history had been the primary goal of the founders of modern knight movement. Among the combat members only 41.9% mentioned fitness improvement as their expectation (6.2% in the non-combat group). Only one member expected financial profits from his/her membership in the group, which goes against the very idea of recreation.

A large part of subjects (64.4% of combat members and 53.0% of non-combat members) had practiced different forms of physical activity, e.g. team games, swimming, jogging, horse riding, etc., before they joined their knight societies. Many of them were active athletes and medieval re-enactors at the same time. This is an indication of a positive relationship between membership in medieval re-enactment groups and physical exercise, which is effective if practiced at the appropriate level of intensity.

Physical exercises in a knight society include preparatory training before tournaments and participation in combat shows. Figure 5 presents the frequency of members' participation in physical exercises in the two knight societies under study.

More than one half of subjects (50% of non-combat members, 54.8% of combat members) take part in physical exercises 2–3 times a week; 29.1% of combat members and 18.7% of non-combat members 3–4 times a week. 25% of the non-combat members and 12.9% of combat members engage in physical exercises only once a week. Only 4.76% of all subjects (3.2% of combat members and 6.3% of non-combat members) admitted they were taking part in physical exercises less than once a week.

The subjects were also asked how their membership in a medieval re-enactment group affected their current physical activity. The vast majority of society members noted an increase in their physical activity after joining the group (80% of combat members and 75% on non-combat members, respectively). 19.3% of combat members and 21.9% of non-combat members saw no change

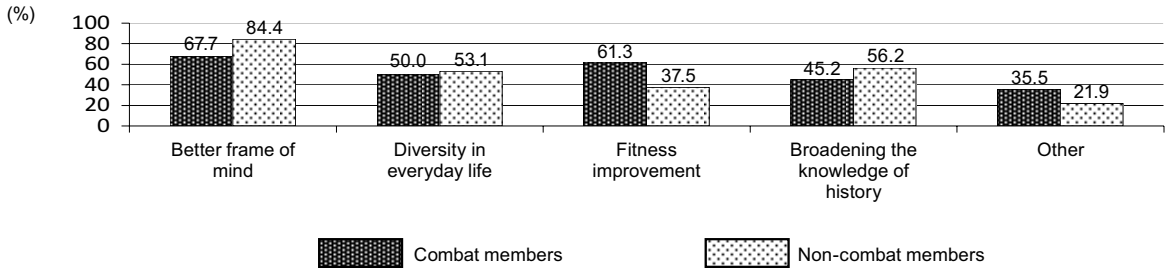

Figure 6. Benefits from membership in a medieval re-enactment group in subjects' opinion

in their level of physical activity after joining their group. Only one non-combat member declared a decrease in his level of physical activity after joining the modern knight society.

Physical exercises which are of appropriate intensity, duration and frequency fulfill the crucial needs of the human body and can stimulate further physical activity by providing satisfaction and developing active lifestyles [12]. If there are no expected results, however, a chosen form of physical activity can be changed or abandoned.

In the assessment of benefits from membership in medieval re-enactment groups the largest number of members declared improvement of their frame of mind as the most important benefit (Fig. 6; 84.4% of the non-combat members, 67.7% of combat members). More than 50% of all subjects stated diversity in their everyday life as the main benefit of their membership. 61.3% of combat members and 37.5% of non-combat members noted an improvement in their physical fitness; while 56.2% of non-combat members and 45.2% of combat members stressed the broadening of the knowledge of history. Other benefits, e.g. looking better, improving interpersonal relations, were indicated by 35.5% of combat members and almost 21.9% of non-combat members.

Discussion

Determinants (attributes) of physical recreation include activeness – active and creative attitude towards activities which provide enjoyment, satisfaction and good feelings; voluntariness – freedom of choice and pursuing one's own interests and passions; retreat from everyday life and social and professional roles; disinterestedness, i.e. lack of financial motives to undertake recreational activities; and fun and entertainment [13, 14]. The study results obtained can be used to validate the assumed hypothesis that the membership in a medieval re-enactment group meets the basic criteria of participation in physical recreation. The forms of activity within such groups are new and specific forms of active leisure.

The analysis of the questionnaire responses related to the forms of activity preferred by the members of medieval re-enactment groups reveals certain differences. The group members who are combat re-enactors are also engaged in dancing or, more seldom, archery, or tend to choose arts and crafts. This can be related to the specificity of knight tournament organization. Melee combat and archery contests are usually held at the same time, thus harmonization of both pursuits is impossible. The combat members prefer dancing as it is often part of festivities after tournaments. Medieval show performances such as juggling with fire and arts and crafts are immensely popular among the non-combat members. They demand however, great strength and endurance, coordination and courage.

Among the reasons for joining a medieval re-enactment group the least significant was the motive of physical fitness improvement; however, almost one half of combat re-enactors and only 6.2% of non-combat members indicated it as one of their most important expectations. The latter's expectations include first of all fun and making new acquaintances.

The study results obtained point to a diversity within the group. The combat members devoted more time to movement activities which is, of course, related to the specificity of combat re-enactment which requires great physical fitness and endurance. Most of the combat members are men, and almost half of them noted an improvement in their physical fitness level thanks to their membership in the group. It was not, however, their main motivation to join the group in the first place.

Conclusions

1. For the vast majority of 63 members of medieval re-enactment groups from Opole their motivation to join the group was pursuit of interests (hobbies). Among the members involved in medieval combat over one half were motivated by the opportunity to learn new forms of physical activity; among the non-combat members the main motivation was to make new acquaintances.
2. The most frequent expectation related to the membership in a medieval re-enactment group was good fun. Important expectations also included the opportunity to see new places and meet new people, and improvement of physical fitness among the combat re-enactors.
3. In the opinion of more than a half of subjects membership in a medieval re-enactment group offered the following benefits: better frame of mind and diversity in one's everyday life. In the group of combat re-enactors over one half of them indicated improvement of physical fitness as an important benefit.
4. Present-day medieval re-enactment groups offer their members a choice of various forms of activity, stimulate them to follow active leisure pursuits and are a great retreat from daily chores through organized fun and entertainment. Therefore they possess many characteristics of physical recreation.
5. Medieval re-enactment groups are novel and attractive forms of physical recreation with elements of intellectual recreation.

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THE IMPACT OF A SCHOOL-BASED ACTIVE VIDEO GAME PLAY INTERVENTION ON CHILDREN'S PHYSICAL ACTIVITY DURING RECESS

DOI: 10.2478/v10038-009-0023-1

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ABSTRACT

Purpose. To assess physical activity levels during active video game play over time and compare this to 'free play' associated with recess activity in a sample of British primary school children over a 6-week period. **Basic procedures.** Thirty children (ages 10–11, 12 boys, 18 girls) from central England were randomly selected to participate in a 6 week, recess based, active video gaming intervention (n = 15) or act as controls (n = 15). Repeated measures analysis of covariance (controlling for body fatness) was used to examine any differences in physical activity, determined by pedometry and heart rate monitoring over time and between intervention and control groups. **Main Findings.** Children in the intervention accumulated significantly greater steps/day than the control group during the first week of the intervention. This pattern was reversed at the mid and end points of the intervention (p = .03). Irrespective of time point, children engaging in active video game play spent a lesser percentage of time engaged in MVPA than the controls undertaking 'traditional' recess activity (p = .0001). **Conclusions.** Active video game play does not appear to be a sustainable means to enhance children's physical activity. Although physical activity (steps/min) was greater on initial presentation of active video games compared to 'traditional' recess activity, this appears to be an acute effect.

Key words: pedometer, heart rate monitoring, recess, steps, exergaming

Introduction

It has been accepted by scientists and health practitioners alike that media-based sedentary behaviours such as TV viewing and leisure time computer use compete for time that might otherwise be spent in physical activity, which might lead to obesity [1, 2]. One particular influence on children's health related behaviour that has received substantial media attention is computer and video game play. Moreover, children today have not only been described as fatter than previous generations, but also less active, less athletically skilled, less interested in physical activity, less self-disciplined (and therefore more likely to choose the 'easy' or 'soft' option, be it with respect to physical activity or food) and more addicted to technology [3]. This has subsequently led researchers to suggest that children's computer/video game behaviour should be the subject of further scrutiny when examining health behaviours [2].

Recently, technological advances have led to the development of active video gaming such as the Nintendo Wii, partly in an attempt to convert sedentary screen time to active screen time and to promote children's physical activity. However, evidence supporting this idea is scant and that which is available has tended to be laboratory based. Lannigham-Foster et al. [4] reported that active video game play was associated with increased energy expenditure (EE) compared to resting energy expenditure (REE) and EE during seated gaming. Active gaming, using the Sony eye toy, increased EE by 273 kj/h above REE whereas active gaming using a dance mat game increased EE 382 kj/h above REE in 25, 9 year old children. They concluded that activity promoting video games more than doubled the energy expenditure compared with chair-based equivalents and offer a potential approach for reversing sedintariness and reducing pediatric obesity. Likewise, a further laboratory study by Graves et al. [5] examined energy expenditure during active and sedentary game play in 11, 13–15 year old adolescents. They concluded, similar to Lannigham-Foster et al. [4] that, active video games use significantly greater energy than sedentary game play but are not of sufficient intensity to contribute towards the recommended daily amount of exercise in children. However, both these studies were laboratory based and examined the acute impact of active video game play on

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physical activity. Both authors have highlighted further research examining this issue in other settings and with varied age ranges as a priority.

More recently, McDougall and Duncan [6] reported that, in a sample of 12, 8–11 year old children who engaged in active video game play during school recess over one week, children accumulated approximately 10% of the recommended number of steps/day for health. They however, highlighted the short duration of their study as a limitation and suggested that future research examine the potential of active video game play as a means to enhance children's physical activity at recess over a longer period. Therefore, the purpose of this study was to assess physical activity levels during active video game play over time and compare this to 'free play' associated with recess activity in a sample of British primary school children over a 6-week period.

Material and methods

Participants

Following ethics approval and parental informed consent, 30 children (12 boys, 18 girls) from 2 primary schools in central England were randomly selected to participate in a 6 week, recess based, active video gaming intervention. Children were from school year 6 (ages 10–11) and the mean age (SD) of the children was 10.4 (0.5) years. Fifteen children from each school undertook twice weekly sessions of active video gaming during school lunch breaks with 15 children acting as controls. There was an equal gender split between groups and across schools with 6 boys and 9 girls in both the intervention and control groups. The schools were located in the same geographical area of England and did not differ in regard to indices of deprivation.

Procedures

The intervention group undertook twice weekly active video game play sessions instead of their regular recess activity for 6 weeks. The control group took part in their normal recess activity only. Active video game play sessions used the Nintendo Wii console and employed 3 game titles, Wii Sports (Tennis), Sonic and Mario at the Olympics (100 m, 110 m hurdles) and Celebrity Sports Showdown (Horse Racing). Game titles were rotated during each session in order to avoid children becoming bored by playing the same game. This ensured that the children played all of the active video games during each active game play session. The playground provision across both schools that participated in the study was similar in terms of area and equipment provided during recess ($p < .05$). In addition, the duration of school recess periods was identical across schools.

Physical activity was assessed at recess during the first, third and sixth weeks of the 6-week period for both groups using pedometry and heart rate monitoring. Physical activity was assessed using a sealed, piezoelectric pedometer (New Lifestyles, NL2000, Montana, USA) which was worn throughout the game play and recess periods. The physical activity monitoring/game play periods were set at 30 minutes across schools and across intervention and control groups. However, step counts were converted to steps/min in order to account for minor variations in the time engaged in recess activity between groups across the monitoring period and in accordance with recommended guidelines [7]. In addition, heart rate data was collected using Polar RS400 heart rate monitors (Polar Electro, OY, Finland), covered with a purpose built shield to prevent children gaining feedback during recess periods. Heart rate was recorded every 5 s. Resting heart rate was determined a priori by averaging the 5 lowest heart rate values recorded for each child [8] lying supine for a 10 minute period in a darkened room. These were determined 24 hours prior to the intervention beginning but following familiarisation sessions described below. Heart rate reserve (HRR) values of 50 (HRR_{50}) and 75 (HRR_{75}) percent were used as threshold values to represent moderate-to-vigorous physical activity (MVPA) and in agreement with prior studies of children's recess based activity [9]. In all cases monitors/pedometers were placed on the children prior to the start of their lunch recess period and the children consumed their lunches at the end of the recess period in order to ensure that heart rate measurements were not affected by dietary induced thermogenesis following lunch.

Prior to commencing the intervention or control periods measurement of stature (to the nearest 0.1 cm) was recorded using a Leicester Height Measure (Seca Ltd., Birmingham, UK). Body mass was assessed using calibrated scales (Seca Ltd., Birmingham, UK) and percent body fatness was determined using bioelectrical impedance analysis (Tanita BF305, Tanita Inc, Japan). This form of bioelectrical impedance analysis has previously been validated with pediatric populations and shows

Table 1. Mean (SD) of children's anthropometric characteristics

	Age (years)	Body Mass (kg)	Stature (m)	Body Fatness (%)
Group (n = 30)	10.4 (.50)	38.6 (8.2)	1.44 (.06)	20.1 (4.3)
Intervention (n = 15)	10.4 (.50)	38.7 (7.8)	1.44 (.07)	20.2 (4.6)
Control (n = 15)	10.4 (.51)	38.5 (8.9)	1.43 (.06)	19.9 (4.2)

Table 2. Mean (SD) of steps/min and percentage of recess time spent in MVPA across the monitoring period

	Steps/Min Week 1	Steps/Min Week 3	Steps/Min Week 6	MVPA Week 1 (% recess time)	MVPA Week 6 (% recess time)
Intervention (n = 15)	28.9 (8.6)	18.9 (8.5)	19.3 (5.6)	15.9 (8.3)	12.1 (6.0)
Control (n = 15)	27.0 (4.2)	25.1 (6.9)	25.1 (3.7)	23.1 (8.9)	25.2 (11.2)

good reliability and validity [10, 11]. The mean (SD) values for the children's anthropometric characteristics are shown in Tab. 1. In addition, children were familiarised with the physical activity monitoring equipment to be used in the study. The children undertaking the active video game play sessions were also familiarised with the Nintendo system to be used as part of the study. Brief focus group interviews (n = 6 approx per group) were also employed prior to any physical activity assessment/video game sessions in order to ascertain children's prior experience with video games in general and the Nintendo Wii specifically. These indicated that all the children possessed at least 1 video game console, 60% owned the same console that was used in the current study and 100% had experience of using/playing the same console that was used in the current study. Children who missed 2 scheduled sessions or more of the monitoring period were excluded from the data set. This resulted in 2 exclusions, both of whom were boys.

Statistical Analysis

Any differences in physical activity across the 6-week period and between intervention and control groups were examined using 3 (measurement period) by 2 (group) repeated measures Analysis of Covariance (ANCOVA) controlling for body fatness. The dependent variables were the percentage of time spent in MVPA and the steps/min taken at each measurement point. The statistical package for social sciences (Version 16) was used for all analysis and the alpha level was set at $p < 0.05$.

Results

In regard to pedometer data, repeated measures ANCOVA indicated significant steps by group interaction

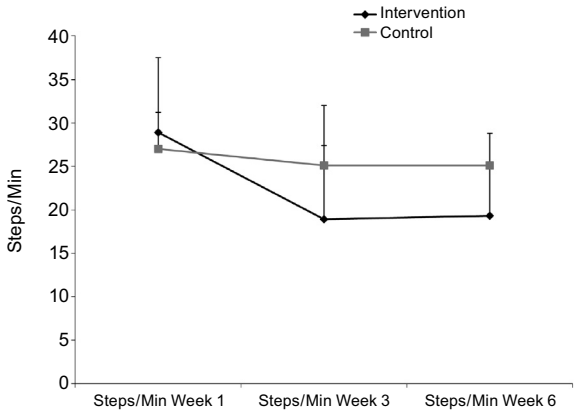

Figure 1. Mean (SD) of steps/min between intervention and control group during the first, third and final week of the intervention period

($F_{2, 54} = 3.74$, $p = .03$) with number of steps/min being greater for the intervention group in the first week of the intervention period but lower than the control group at the mid and end points of the 6-week period (see Fig. 1). Bonferroni post hoc pairwise comparisons indicated no significant differences between steps/min across tie periods for the control group (all $p < .05$) but significant differences between steps/min taken in the first week of the intervention and the mid point of the intervention (Mean Diff = 9.95, $p = .01$) and between the first week of the intervention and the last week of the intervention (Mean Diff = 9.56, $p = .01$). In regard to heart rate, a significant main effect for the percentage of time spent in MVPA ($F_{1, 28} = 15.6$, $p = .0001$) was evident and indicated that the percentage of time spent in MVPA was significantly lower in the intervention group, compared to the control group, across the intervention period. There were no other significant interactions or main effects (all $p < .05$). Mean (SD) of steps/

day and percentage of recess time spent in MVPA for both groups and across the intervention period are presented in Tab. 2. Analysis also indicated that there were no significant differences in variables across the two schools that participated in the study (all $p < .05$), confirming the similarity of recess conditions across the two participating schools.

Discussion

The purpose of this study was to assess physical activity levels during active video game play over a 6-week period and to compare this to 'free play' associated with recess activity in a sample of British primary school children. The results from this exploratory study suggest that there is an acute effect of participating in active video game play whereby physical activity (steps/min) during recess was greater for children engaging in active video game play compared to those engaging in regular recess. However, this was not sustained and physical activity at weeks 3 and 6 was lower for the video game group compared to the control group. Heart rate data also support these assertions as the percentage of time spent in MVPA during traditional recess was greater than the percentage of time spent in MVPA when playing active video games. These results are novel but add support to laboratory based research which has suggested that active video game play may not be sufficient to contribute to children's recommended daily levels of physical activity [5]. Prior authors have also suggested that active video game play might provide a stimulus for obesity treatment and prevention due to increases in energy expenditure measured in comparison to sedentary game play [4]. Certainly, active video game play results in greater energy expenditure than sedentary game play but, in the context of this study and school recess, traditional recess activities appear to offer a more sustainable way for children to meet physical activity targets or recommendations during school time.

As this study was school-based, recess physical activity was employed in order to provide a comparison for the physical activity undertaken during active video game play sessions. Prior research has reported that children can accumulate substantial portions of their daily-recommended physical activity levels during the free-play associated with recess periods [12] and clearly, the benefit of traditional recess free play in terms of encouraging physical activity make this a particularly opportune period where children can be physically active. The current study was only 6 weeks in duration and suggests that there is an acute impact of active video games when used as a substitute for traditional school recess. This may be a form of novelty effect and physical activity levels decline after initial presentation with this mode of physical activity. In this context the introduction of active video game play may have actually suppressed children's physical activity levels rather than enhanced them.

Additionally, prior research conducted by McDougall and Duncan [6] also suggested that active video game play during school recess could provide a stimulus to increase children's physical activity and reported that a substantial part of the recommended level of children's physical activity could be achieved through recess based game play. However, this study was conducted over a 1 week period and used a limited number of participants and, although the authors noted this as a limitation and suggested further research was needed to verify their results, clearly the duration of their study has limited the conclusions they could make to the acute effects of a school based active video game intervention. This study has attempted to fill the gap in some of the previously published studies examining this topic by exploring active video game play outside the laboratory environment, by comparing this to a control group and by assessing children over a longer period than the majority of prior studies.

Despite this, the current study is not without its limitations. Active video game play was engaged in twice weekly as this was considered to be a realistic frequency for this form of activity in schools. It is possible that different weekly frequencies of game play may have provided different results. Expertise may also be an issue that future research needs to consider. Practice of using the Nintendo Wii games and controllers may change the level of energy expenditure required to be successful within these games. Prior studies have noted this to be an important consideration [13]. It is possible that the reductions in physical activity seen as the children progressed through the 6-week intervention may have arisen because they actually become more successful at the games they were playing. Anecdotally, in order to be successful in many of the active video games used in the present study dynamic, gross movements are not always required. To some extent this may then negate the premise on which these gaming platforms are based but further research is needed to verify this suggestion.

Sample size is also an issue, these results are based on a relatively small sample of participants and further large scale studies are needed to verify these findings. Furthermore, as children were selected from one school year, resulting in a possible age difference between any two children in the study being 12 months. As prior authors [14] have reported that although children may be the same age chronologically, they may be a different age biologically which can then manifest itself in performance differences, this may be an issue future authors need to consider when examining physical activity in the school setting. The authors of the current study also acknowledge that the use of pedometry and heart rate monitoring to quantify physical activity in the current study may also be a limitation. In some cases, lower limb movement during the active video game play is not always needed but upper body movement is and therefore differences in pedometer counts between intervention and control groups may be a result of the games selected as part of the intervention. Accelerometers were not available for use in the current study but future researchers interested in this area may benefit from the use of accelerometry as a tool to quantify movement during active video gaming.

Conclusions

This study has added further data on children's physical activity responses to active video games. No study to date has examined the potential for active videogames to contribute to enhanced physical activity in the school setting. This study is novel in that it is the first to provide heart rate and step count data comparing a sustained period of active video game play to traditional recess physical activity in an ecologically valid setting (i.e. the school). In this case, physical activity was greater for active video games played during school recess compared to traditional recess during the first week of a 6-week intervention period. Thereafter, physical activity during active game play was significantly lower than physical activity during traditional recess. This suggests that although the premise of active video games has potential to enhance children's physical activity, this does not appear to be the case when applied to school recess over a 6-week period.

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RETRACTION NOTICE

THE STUDY OF LUNG FLOW LIMITATIONS IN AEROBICALLY TRAINED CHILDREN

DOI: 10.2478/v10038-009-0019-x

Mohsen Ghanbarzadeh[1]*, Abdolhamid Habibi[1], Masoud Nikbakhat[1], Gholamhosain Ebadi[2], Hossein Poursoltani[3]

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RETRACTION NOTICE

Refers to: RETRACTED "The study of lung flow limitations in aerobically trained children" *Human Movement*, Volume 10, Number 2, 2009, pages 96–108

The following article from *Human Movement* 2009, 10(2), 96–108, "The study of lung flow limitations in aerobically trained children" by Mohsen Ghanbarzadeh, Abdolhamid Habibi, Masoud Nikbakhat, Gholamhosain Ebadi, Hossein Poursoltani has been retracted at the request of authors and the American Physiological Society (APS).

Reason: The author has plagiarized a paper that had already appeared in *Journal of Applied Physiology* 2005, 99, 1912–1921, doi:10.1152/japplphysiol.00323.2005, "Exercise flow-volume loops in prepubescent aerobically trained children" by Cedric Nourry, Fabien Deruelle, Claudine Fabre, Georges Baquet, Frederic Bart, Jean-Marie Grosbois, Serge Berthoin, and Patrick Mucci. One of the conditions of submission of a paper for publication is that authors declare explicitly that their work is original and has not appeared in a publication elsewhere. As such, this article represents a severe abuse of the scientific publishing system. We apologize to the authors of the original article and editors of the *Journal of Applied Physiology* for this unfortunate occurrence, and thank the American Physiological Society for drawing the matter to our attention. We apologize also to readers of both journals that this was not detected earlier during the submission process and deeply regret any inconvenience caused due to this incident.

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CONFERENCE REPORTS

III CENTRAL EUROPEAN CONGRESS ON OSTEOPOROSIS AND OSTEOARTHRITIS Kraków, September 24–26, 2009

REPORT

III Central European Congress on Osteoporosis and Osteoarthritis was held in Kraków on 24–26 September 2009. The Congress was organized under the auspices of the International Osteoporosis Foundation. The Honorary Patron was Ewa Kopacz, the Minister of Health of the Republic of Poland. The Congress was officially opened by Prof. J.A. Kanis, the President of the International Osteoporosis Foundation.

750 doctors, including 80 from abroad, participated in the Congress, the biggest scientific event in this field in Central Europe. During 3 days of debates 55 lectures and 70 posters were presented. Lectures were simultaneously translated into English and Polish. Traditionally, abstracts of all presentations were published in a Polish journal *Ortopedia Traumatologia Rehabilitacja* vol. 11. suppl. 2, 2009.

The Congress forms an international platform where doctors and scientists from various fields of medicine can exchange experience. Osteoporosis and osteoarthritis were recognized as the most common illnesses of the contemporary society. Recent scientific achievements in the diagnosis and treatment of osteoporosis were presented, consistent with the WHO guidelines. Prominent scientists from Poland and abroad held presentations, among others.: Prof./Prof. P. Burckhardt, S. Epstein, G. Holzer, H. Johansson, J.A. Kanis, S. Kutilek, G. Maalouf, E. McCloskey, S.E. Papapoulos, J-Y. Reginster, F.J. Ring, R. Rizzoli, H. Resch, J. Stepan.

Opening lectures were presented by world recognized authorities in the field of osteoporosis, Prof. J.A. Kanis (United Kingdom): *Use of FRAX® in identification of persons who are at high fracture risk*, and Prof. S.E. Papapoulos (the Netherlands): *Treating osteoporosis beyond five years.*

One of the main Congress topics was developing guidelines for the diagnosis of osteoporosis. It was agreed on without all doubt that therapeutic decisions should be taken based on the assessment of fracture risk. It can be determined on the basis of the body mass index (BMI) and clinical fracture risk factors. The current WHO standard for calculation is the FRAX® method, presented by Prof. J.A. Kanis. The FRAX® calculator is available online at www.shef.ac.uk/FRAX. Being familiar with the realities of the work of a doctor in Polish clinics, Prof. E. Czerwiński with his Team, and in cooperation with Prof. J.A. Kanis, developed a hand held FRAX® calculator. It can be used to calculate fracture risk with or without BMD. The calculator was presented to all Congress participants. Reliability of fracture risk evaluation using FRAX® was documented on the basis of 11-year observation of patients from the Kraków region. Implementation of FRAX® was also discussed by Prof. J.E. Badurski, Prof. E. McCloskey (United Kingdom) and H. Johansson (Sweden). A round table discussion summarized a number of interesting presentations related to FRAX®. The minimum fracture threshold, which should initiate therapy and its refunding, was discussed.

It was pointed out in sessions devoted to the treatment of osteoporosis that Poland, resulting from its current refunding system, is the only country in Europe where only one medication is available – alendronate. The efficacy and safety of therapy with ibandronate, zolendronate and PTH was discussed in particular sessions. Prof. S. Epstein (USA) presented beneficial results of long-term treatment with ibandronate orally once monthly and intravenously once in 3 months. Prof. J-Y. Reginster (Belgium) summarized many year observation of the efficacy of strontium in the prevention of fractures, stressing that people treated with strontium had higher bone biomechanical parameters than patients treated with alendronate. The advantage of anabolic therapy, at present available in the form of PTH, was indicated in many discussions. This medication is used not only in the most serious stages of osteoporosis, but also in corticosteroid-induced osteoporosis.

Much hope arouses due to the awaited introduction of denosumabe administered subcutaneously once in

6 months to treatment in Poland. Prof. R. Rizzoli (Switzerland) and Prof. S. Kutilek (Czech Republic) showed the results of clinical trials of this medication documenting the antifracture efficacy and safety of therapy.

No explicit answer to the question about the sequential therapy or prolonged treatment with bisphosphonates above 5 years was given in the discussions.

Sessions on causes and results of osteoporotic fractures as well as prevention and clinical results of falls also met with much interest. Among the novelties were training sessions of Nordic Walking and Tai-Chi. Congress participants had opportunity to get familiar with these increasingly popular forms of physical activity, recommended in falls prevention programmes. Information materials were distributed as part of the "Don't Break" campaign.

Among main Congress topics there were mechanisms of bone regulation and turnover, osteoporosis in men, children and adolescents, and secondary osteoporosis. Prof. P. Burckhardt (Switzerland) convinced that the currently used supplementation of vitamin D is on a too low a level and 2000 jm. is recommended in persons not exposed to sun.

Standards of treatment were discussed in the session devoted to osteoarthritis. However, no progress was noted in the pharmacotherapy of osteoarthritis.

Members of the Scientific Committee as well as participants stressed the high scientific level of the Congress, recognizing it as the highest among congresses organized so far.

The general Assembly of the Polish Osteoarthrology Society decided that the forthcoming IV Central European Congress on Osteoporosis and Osteoarthritis will be held in Kraków on 29.09–01.10.2011.

All publications related to the last and previous congresses (organized since 1994) along with the photographic documentation are available on the Polish Portal of Osteoporosis (www.osteoporoza.pl). Materials from the "Don't Break" campaign as well as many other publications are also available on the portal.

On behalf of the Scientific Committee

Prof. med. Edward Czerwiński
President of the Organizing Committee
Head of Department of Bone and Joint Diseases
Medical College Jagiellonian University
Kraków, October 2009

COMPETITION

COMPETITION OF RESEARCH PAPERS
on
PHYSICAL EDUCATION TEACHING
for Prof. Bogdan Czabański's Award

Submission requirements:

- Only papers published in the year prior to the date of competition may be submitted
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- Independent academics must not take part in the competition
- Former award winners must not take part in the competition
- A research paper can be a team work effort, but the team of authors must not include an independent academic

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- All papers must be on the subject of physical education teaching

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Three independent academics, Professors of the University School of Physical Education in Wrocław, Poland:

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- Head of Chair of Physical Education Didactics
- Head of Chair of Swimming

The jury convenes annually on **April 24**. The jury's final decision will be made available to all participants.
Only one paper is awarded with the prize (diploma of merit and 1.000 PLN).
The award is presented each year during the inauguration ceremony of the academic year at the University School of Physical Education in Wrocław, Poland.

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