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Contents

CHANGES IN AEROBIC AND ANAEROBIC PERFORMANCE CAPABILITIES FOLLOWING DIFFERENT INTERVAL-TRAINING PROGRAMS

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Abstract The aim of the study was to compare the effect of an increasing-distance interval-training program and a decreasing-distance interval-training program, matched for total distance, on aerobic and anaerobic performance capabilities. Forty physical education students were randomly assigned to either increasing- or decreasing-distance interval-training group (ITG and DTG), and completed two similar sets of tests before and after six weeks of training. One training program consisted of 100 – 200 – 300 – 400 – 500 m running intervals, and the other 500 – 400 – 300 – 200 – 100 m. While both training programs led to a significant improvement in 2,000 m run (ES = 0.02–0.68), the improvement in the DTG was significantly greater than in the ITG (18.3 ±3.6 vs. 12.2 ±3.2%, $p < 0.05$). In addition, while both training programs led to a significant improvement in 300 m run (ES = 0.25–0.73), the improvement in the DTG was significantly greater than in the ITG (21.1 ±1.8 vs. 15.4 ±1.1%, $p < 0.05$). The findings indicate that beyond the significant positive effects of both training programs, the DTG showed significant superiority over the ITG in improving aerobic and anaerobic performance capabilities. Athletes should acknowledge that, in spite of identical total work, interval-training program might induce different physiological impacts if order of intervals is different.

Key words performance capabilities, training programs, interval training

Introduction

Interval-training is based on the premise that an intense activity can be performed if interspersed with periods of rest. Accordingly, an individual performs the activity at a relatively high intensity, for a number of repetitions, with appropriate recovery periods between repetitions. A major advantage of this training method, and a key reason for its popularity among athletes, is its ability to improve aerobic and anaerobic capabilities simultaneously (Billat, 2001; Hazell, MacPherson, Gravelle, Lemon, 2010; Meckel, Gefen, Nemet, Eliakim, 2012). This is possible due to the significant load put on the neuromuscular and cardiovascular systems in a typical interval-training session (Loursen, Jenkins, 2002; Rakobowchuk et al., 2008; Rodas, Ventura, Cadefau, Cussó, Parra, 2000). The specific training variables – distance, intensity, and rest time between intervals – are determined according to the athletes' event specialty and physiological requirements. An aerobic-type athlete usually performs a relatively low-intensity high-volume training protocol, whereas an anaerobic-type athlete usually performs a low-volume high-intensity training protocol (Billat, 2001; Loursen, Jenkins, 2002; MacDougall et al., 1998). Usually, the different variables in interval-training are constant throughout a single session. However, coaches sometimes deviate from this norm, creating incremental protocols. For example, "increasing-interval protocol" may include increasing running distance intervals in a *single* session. Conversely, a "decreasing-interval protocol" may include decreasing running distance intervals in a *single* session. Although the total work in both protocols may be similar, the physiological stress may vary between the two due to the different running order. Indeed, it was previously shown that the mean physiological responses (i.e. heart rate and blood lactate concentration) in a single decreasing protocol were significantly higher than in a single increasing protocol, although the total work was equal (Meckel, Grodjinovsky Ben-Sira, Rotstein, Sagiv, 1997). In line with that, it was found that growth hormone (GH) concentration was significantly higher during decreasing-distance compared to increasing-distance protocol (Meckel et al., 2011). It was speculated that these differences resulted from a higher physiological stress following the first long interval in the decreasing-distance protocol, compared with the low stress following the first short interval in the increasing-distance protocol. Most recently, in a relevant intervention study, it was found that 12 training sessions of decreasing order intervals improved maximal oxygen consumption (VO_2 max) and anaerobic indices (Peak power – PP, Mean power – MP and Fatigue index – FI) significantly more than 12 sessions of increasing order intervals (Sindiani, Eliakim, Segev, Meckel, 2017).

So far, only one study compared the influence of increasing and decreasing distances interval-training programs. This study used conventional laboratory procedures to identify aerobic and anaerobic physiological changes following the two training protocols. However, the question remains whether such differences in interval order apply to aerobic and anaerobic performance capabilities in the field. The aim of the present study, therefore, was to compare the effect of increasing- and a decreasing-distance interval-training program, matched for total distance, and rest periods on aerobic and anaerobic performance capabilities in the field. Given the higher physiological responses that were found following a single decreasing compared to a single increasing-interval protocol and the higher VO_2 max and anaerobic indices that were found following the decreasing-distance interval-training program, we hypothesized that the decreasing-distance program will lead to greater improvement in field aerobic and anaerobic performance capabilities.

Methods

Participants

Forty healthy young (age 22–25) physical education students volunteered to participate in the study. The participants general fitness status was some-what higher than average for their age group, as they were routinely active in practical classes (soccer, basketball, swimming etc.) required for their academic program (Table 1). The participants performed an average of about 8 hours of physical activity every week, mostly playing ball games and some aerobic work. Standard calibrated scales and stadiometers were used to determine height and body mass. Skinfold measurement at four sites (triceps, biceps, sub-scapular and supra-iliac) was used to calculate percent body fat using standard equations. The Institutional Review Board of the Hillel-Yafe Medical

Center approved the study. The participants were informed of the experimental procedures and risks and signed an informed consent prior to the investigation.

Training Procedure

Participants were randomly assigned to one of two interval training groups – an increasing training group (ITG, n = 20) and a decreasing training group (DTG, n = 20) – after matching for aerobic (2,000 m running times) and anaerobic (100 m sprint times) scores. A week after the completion of the pre-training set of testing, each group started a-six weeks, twice a week (non-consecutive days), training program. Participants maintained their other usual weekly routine with minor changes to balance total physical activity between groups. At the end of the six weeks, participants performed a second – post-training – set of testing to evaluate training effects and fitness improvement.

Throughout each session of the six weeks interval training program, both groups performed the same work matched by total volume, intensity and recovery times. However, while one group performed an increased interval protocol in which running distances were increased by 100 m in each interval, the other group performed a decreased protocol in which running distances were decreased by 100 m in each interval throughout the training session. Specifically, the ITG performed an increased running distances starting from 100 m in the first interval and then increased by a 100 m in each interval (100 – 200 – 300 – 400 and 500 m) until 500 m in the last interval. In contrast, the DTG performed a decreased running distances starting from 500 m in the first interval and then decreased by a 100 m in each interval (500 – 400 – 300 – 200 – 100 m) until 100 m in the last interval. Resting times between intervals were increased from 3 to 9 min in the increased protocol, and decreased from 9 to 3 min in the decreased protocol. Running speed in each interval was performed at 75% of each participant 100 m best running time. Overall, the two training groups performed the same total volume of work (1,500 m) and were given the same total recovery time (24 min) in each session over the 6 weeks of training. A description of the two interval training programs, including work and rest periods, is presented in Figure 1. Participants performed an active recovery between runs (walking at a comfortable pace). In order to get familiar with the necessary running paces, participants practice two special "pace sessions" before the beginning of the program. All training sessions were performed on

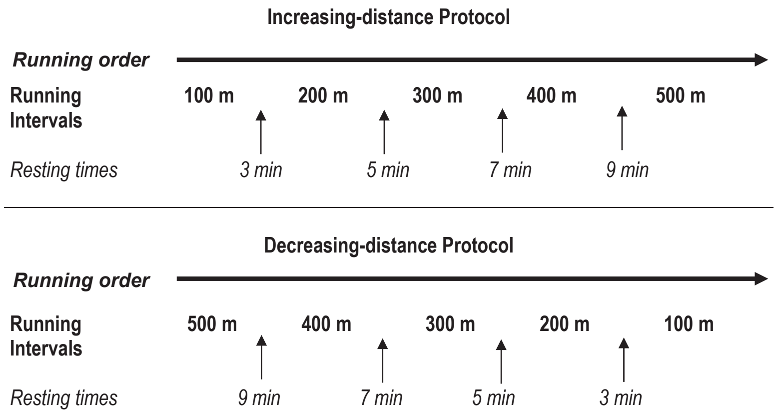


Figure 1. The training protocol for the increasing-distance and decreasing-distance groups

a 400 m lap rubber (Recortan) made track. Worm up before each training session included about 8 min of jogging, 10 min of stretching exercises and 3–4 40–60 m sub-maximal runs at 70–80% of maximal sprint speed. Training sessions were performed during the late afternoon, 3–4 hours after lunch, with an air temperature of 24–26°C. Participants were instructed to drink 500 ml of water 30 min before each training session. None of the participants was taking any food supplements.

Testing Procedures

In order to evaluate field performance capabilities changes, participants performed two field tests on non-consecutive days, during the two weeks prior to the beginning and the two weeks after completing the six weeks training programs. Both tests were performed at the same time of the day, under the same environmental conditions, and with the same technician who was blinded to the training-group affiliation. Due to the great sensitivity of environmental conditions on scores during the field test, the technicians stuff made shore that weather conditions were similar for the pre and the post treatment testing sessions. The performance evaluation, in each set of tests, included an aerobic- and an anaerobic-type field tests.

Aerobic Test – 2,000 m Run: The 2,000 m running test was used to evaluate the participants' aerobic performance capability. In order to complete the run the participants were required to complete five laps on a 400 m track. Running times were taken by hand using a standard stopwatch, and were rounded off to the nearest 0.1 sec. The run was performed in homogenous sub-groups of 8–10 participants each according to their personal records. Although each participant ran as fast as he could, each had the liberty to use his own running tactics to produce the best possible result.

Anaerobic Test – 300 m Run: The 300 m running test was used to evaluate the participants' anaerobic endurance capability. The run was performed on a 400 m lap track. Running times were taken by hand using a standard stopwatch, and were rounded off to the nearest 0.1 sec. The participants ran the 300 m in small homogenous sub-groups of 5–6 participants with similar capabilities. Each participant used his own running tactics to produce the best possible result.

Environmental conditions in the two field tests were comfortable and similar (morning: 8:30am, temperature: 24–26ºC, wind: 0.1–0.3 m/sec, humidity: 40–50%) for all groups. All the participants were familiar with the two runs – the 2,000 and the 300 m – as they ran them before during fitness and track and field practical classes. Before each tests, participants performed a standard warm-up including 8 min of jogging, followed by a 10 min stretching exercise and two 30 m sub-maximal runs (at approximately 90% of maximal sprint speed). In order to eliminate unnecessary fatigue, participants were instructed to avoid any intense physical activity 48 hr before each test.

Statistical analyses

A two-way repeated measure analysis of variance was used to compare performance capabilities, with time serving as the within-group and training protocol as the between-group factor. In addition, we used an unpaired t-test to compare the percent change differences in 2,000 m and 300 m running time scores between the two training protocols. A Cohen's d-effect size (ES) was also performed to demonstrate the magnitude of training effect in each group. Data are presented as mean ± s. Significant level was set at $p \leq 0.05$.

Results

There were no baseline differences in body mass (72 ±2.4 and 74.2 ±3.3 kg), height (1.74 ±0.1 and 1.75 ±0.1 cm), body fat percentage (12.6 ±3.1 and 12.9 ±2.9), or lean body mass (59.6 ±4.3 and 61.3 ±6.7 kg) between the groups prior to the training programs.

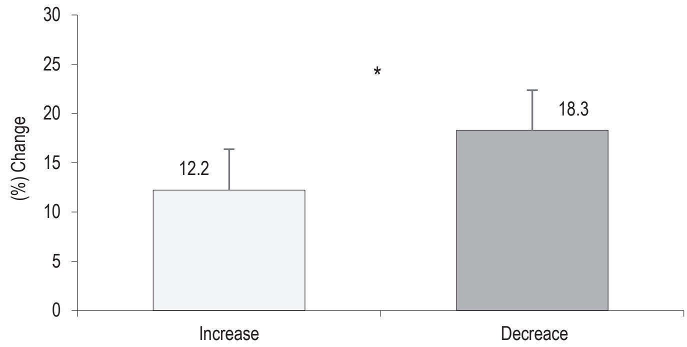
Changes in aerobic capability (as measured by the 2,000 m running times) are presented in Table 1. There were no baseline differences in 2,000 m running times between the groups prior to the training. Both training programs led to a significant improvement in 2,000 m running times [F (1, 38) = 383.30; P < 0.000; ES = 0.91], with a significant group interaction [F (1, 38) = 14.41; P < 0.001; ES = 0.52]. In addition, the percent change in 2,000 m running time was significantly greater in the DTG compared to the ITG program (Figure 2).

Table 1. The effect of the different training programs on aerobic and anaerobic performance capabilities (Means ± s)

	Increasing-distance group (n = 20)			Decreasing-distance group (n = 20)		
Variables	Pre	Post	ES	Pre	Post	ES
2,000 (min/sec)	9:33 ±1:02	8:55 ±0:50*	0.02	9:27 ±1.01	7:58 ±0:48**	0.68
300 (sec)	52.8 ±3.6	44.6 ±3.8*	0.25	53.6 ±2.7	42.2 ±2.8 **	0.73

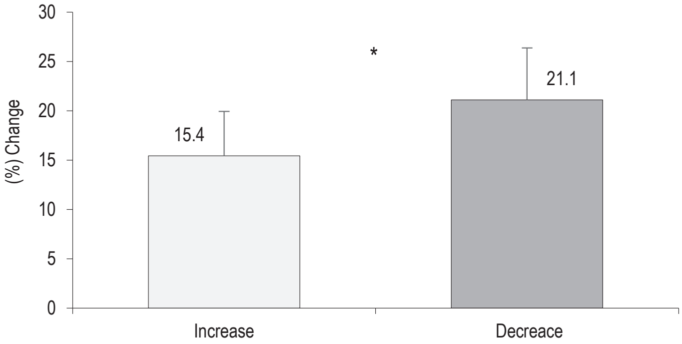
*p < 0.05; **p < 0.01 for within group changes; ES: effect size.

Changes in anaerobic capability (as measured by the 300 m running times) are presented in Table 1. There were no baseline differences between the groups in the 300 m running times prior to training. Both training programs led to a significant improvement in 300 m running times [F (1, 38) = 479.90; P < 0.000; ES = 0.93], with a significant group interaction [F (1, 38) = 12.92; P < 0.001; ES = 1.02]. In addition, the percent change in the 300 m running time was significantly greater in the DTG compared to the ITG program (Figure 3).



*p < 0.05 for between group change.

Figure 2. The effect of the two training programs on percent changes of 2,000 m run time



*p < 0.05 for between group change.

Figure 3. The effect of the two training programs on percent changes of 300 m run time

Discussion

The findings of the present study indicate that both training programs significantly improved aerobic and anaerobic performance capabilities measured by the 2,000 m and 300 m running times. More importantly, it was found that the improvement in both the aerobic and anaerobic capabilities was significantly greater in the DTG compared to the ITG.

These findings are agreement with previous relevant studies. Systematic reviews and reports have indicated that interval-training in recreationally active individuals significantly improves aerobic fitness and endurance performance (Garcia-Hermoso et al., 2016; Gist, Fedewa, Dishman, Cureton, 2014; Lindsay et al., 1996; Sloth, Sloth, Overgaard, Dalgas, 2013). An improved capacity of aerobic metabolism, as evidenced by an increased expression of type I fibers, capillarization, and oxidative enzyme activity (Gibala et al., 2006; Harmer et al., 2000; Helgerud et al., 2007), is the most common response to interval-training in active individuals. The improvement in interval-training was found to be significantly greater than the improvement following continuous sub-maximal training (Burgomaster et al., 2008; Milanovic, Sporiš, Weston, 2015; Stepto, Hawley, Dennis, Hopkins, 1999; Weston, Taylor, Batterham, Hopkins, 2014). In addition, when compared to continuous sub-maximal endurance training, interval-training presents an effective alternative, with a much lower volume of activity and potentially reduced time commitment (Foster et al., 2014). Low-volume high-intensity interval-training may also have the potential to improve anaerobic performance, as it enhances anaerobic metabolism (Laursen, Blanchard, Jenkins, 2002; Meckel et al., 2011; Spriet, 1995). In meta-analyses of Sloth et al. (2013) and Gist et al. (2014), low-volume high-intensity interval training was shown to consistently improve anaerobic peak and mean power. This improvement was expected, given that these trainings were found to induce glycolytic enzymes activity, muscle buffering capability, and ionic regulation related to anaerobic metabolism (Billat, 2001; Weston et al., 1996).

The main finding of the present study demonstrated that the improvement in the aerobic (2,000 m run time) and anaerobic (300 m run time) performance capabilities was significantly greater in the DTG compared to the ITG (Figure 2 and 3). This is in agreement with a recent study by Sindiani et al. (2017) who demonstrated that DTG showed significant superiority over ITG in improving aerobic (VO_2 max) and anaerobic indices (PP, MP, FI in the Wingate anaerobic test). These findings are also in line with the acute higher cardiovascular (heart rate), metabolic (lactate) and hormonal (GH) stimulus that were found in a single decreasing-distance compared to a single increasing-distance training protocol in trained athletes (Meckel et al., 1997; Meckel et al., 2011). The results of these studies may reflect the physiological load resulting from the differences in the length of intervals as well as from the duration of rest periods between intervals at the different stages of each training protocol. It is therefore suggested that the decreasing interval protocol creates a stronger physiological impact, and apparently presents a more efficient training tool than the increasing interval protocol. The superior efficiency of the decreasing training protocol is even strengthened, because significant greater improvement of the DTG compared to the ITG was seen in both the aerobic and anaerobic performances simultaneously (Figures 2 and 3). On the other hand, since the decreasing-distance training protocol is more physiologically and hormonally demanding, athletes and coaches should keep in mind that this type of interval training probably deserves longer and more efficient recovery modalities.

Conclusions

The present study demonstrated that six weeks of both an increasing-distance and a decreasing-distance interval-training program significantly improved aerobic and anaerobic performance capabilities. More importantly, the study's findings revealed that the decreasing-distance interval-training program induced greater improvement than the increasing-distance interval-training program in both aerobic and anaerobic fitness of young active participants.

Given the varying impacts of the two interval-training protocols in our study, coaches and athletes should be aware of the different recovery times or modes of training sessions required following each of these protocols. These may be considered when designing a micro- or a macro-cycle training period of aerobic- or anaerobic-type young athletes.

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EFFECT OF AQUA AEROBICS ON SELECTED SOMATIC, PHYSIOLOGICAL AND AEROBIC CAPACITY PARAMETERS IN POSTMENOPAUSAL WOMEN

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Abstract The world's population is aging. Aquatic exercises can improve the physical function in humans and raise the quality of their lives in middle and older age. The study aimed to determine the effect of aqua aerobics on the selected somatic, physiological and aerobic capacity parameters in postmenopausal women. 11 purposively selected women that were confirmed overweight or obese by 20% and had Body Mass Index of 30 ±5 (the first stage of obesity) took part in aqua aerobics classes three times a week for 14 weeks. Their mean age was 56.18 ±3.19 years and mean height was 166.5 ±7.41 cm. The value of LBM and muscle mass (p = 0.04 in both cases) were statistically significantly higher at study end compared with their baseline values, likewise haemoglobin concentration (p = 0.001), haematocrit (p = 0.03) and blood cell count (p = 0.01), whereas BMI (p = 0.02) and percentage body fat (p = 0.04) were significantly lower. The lactate analysis revealed significant changes in LA_{max} (p = 0.04), LAres9' (p = 0.02), $Delta_{LAmax-LAsp}$ (p = 0.02) and $Delta_{LAres9'-LAres3'}$ (p = 0.0004). After 14 weeks of aqua aerobic workout, significant changes were noted in the selected somatic, morphological and aerobic capacity parameters in postmenopausal women, but the differences between the lipid profiles were insignificant.

Key words body composition, lipid profile, blood count parameters, aerobic capacity, aqua aerobics, postmenopausal female

Introduction

According to international reports, the world's population of people aged 65 will double to 1 billion by 2030 raising the overall proportion of those aged 65 and older (National Institute on Aging..., 2007, pp. 6–7). At the same time, the number and proportion of the oldest-old (persons aged 80 years or over) is rising. By 2050, this segment of the population is expected to reach 392 million or 4.1 per cent of the world population and by 2100 it would ascend to 830 million or 7.6 per cent of the population (UN, 2013).

Aging reduces and impairs tissue and organ function in the human body. Studies point out that the most common, negative effects of aging are the loss of skeletal muscle mass and strength (sarcopenia) (Adamo, Ferrar, 2006, pp. 310–331), bone density reduction and weakening bone structure (Humphries et al., 1999, pp. 364–374), and increasing body fat mass (Adams, O'Shea, O'Shea, 1999, pp. 65–77). The nervous system (Bellew, 2002, pp. 60–62) and metabolism have also been observed to function less efficiently as people age. These degenerative changes lead to various health and well-being problems affecting the everyday life of people. Researchers have established, however, that physical exercise can significantly contribute to the maintenance of the functional capacity in older persons (Hagberg et al., 1989; Hirvensalo, Rantanen, Heikkinen, 2000; Struck, Ross, 2006; Torlaković, Radjo, Dautbašić, Gec, 2010). According to the WHO guidelines of 2002, people should exercise at least 30 minutes a day. Interestingly, the physical activity standards are the same for people aged 65+ and younger and healthy adults. As far as older people are concerned, the special role of strength training and exercises improving motor coordination, and thus reducing the risk of falling, are emphasised. Research has shown that resistance (strength) training can effectively sustain the well-being of elderly people (Roubenoff, 2007, pp. 208–212). However, gym exercises are frequently too straining on the body, so in the case of older persons all kinds of water exercises (aqua fat-burner, aqua step, aqua senior, aqua dance, aqua yoga) are recommended as particularly suitable. Exercising in water is safer than on land because the human body appears to lose 90% of its weight when immersed in water; with decreased load on the joints and the spine a greater range of motions is possible and the risk of injury to the locomotor system is reduced (Sheldahl, Buskirk, Loomis, Hodgson, Mendez, 1982, pp. 29–42). Further, because exercising in water (with or without accessories) involves greater energy output because the resistance of water must be overcome, aquatic exercises are more effective in increasing lean body mass and decreasing fat mass (Sonati, Modeneze, Vilarta, Maciel, Boccaletto, 2011, pp. 378–381) or BMI (Carrasco, Vaquero, 2012; Sonati et al., 2011) than if they were performed on land (Bergamin et al., 2013; Bocalini, Serra, Murad, Levy, 2008). Water resistance training is also reported to increase muscle mass and strength (Carrasco, Vaquero, 2012; Hansen, Allen, 2002; Raguso et al., 2006). In elderly persons doing aquatic training improves walking ability (Sato et al., 2011, pp. 331–335), balance and posture (Kaneda, Sato, Wakabayashi, Hanai, Nomura, 2008; Katsura et al., 2010; Simmons, Hansen, 1996) have been observed to improve. Rotstein, Harush, Vaisman (2008, pp. 352–359) have demonstrated that seven months of aquatic training improved bone mineral density (BMD) in post-menopausal women and Kamijo and Murakami (2009, pp. 55–62) have reported significantly lower blood triglyceride content in women that exercised in water for two years.

Research has provided interesting observations on people exercising in warm water and cold water. Regular exercises in thermal swimming pools and the use of rating of perceived exertion as a method of exercise monitoring have been found potentially useful tools for enhancing physical performance and body composition in healthy elderly (Bergamin et al., 2013). In the study by Sheldahl et al. (1982), cold water exercises (17–22^{o} C) did not significantly change body weight, body fat, and fat-free body weight in seven obese women (fat mass >30%, a mean of 43%) who exercised at moderate intensity (30–40% of maximal oxygen uptake) five times per week for 90 minutes over a period of eight weeks. It is very probable, though, that in cold water people exercise at greater intensity to maintain thermal comfort.

There is also evidence that exercising in water can improve aerobic capacity. Bocalini et al. (2008) have reported that in a group of women aged 61+ who exercised at 70% VO_2max three times a week for 60 min over a period of 3 months maximal oxygen uptake increased by 42%. The results of other authors (Broman, Quintana, Lindberg, Jansson, Kaijser, 2006; Takeshima et al., 2002) from studies with elderly women were also statistically significant.

The conclusion that can be drawn from all these studies is that aquatic exercises can improve the physical function and raise the quality of human life (Devereux, Robertson, Briffa, 2005, pp. 102–108).

This study was undertaken to make up for insufficiency of information about morphological changes induced in humans by aquatic exercises and to determine the influence of 14 weeks of such exercises on the selected somatic, physiological and aerobic capacity parameters in postmenopausal women.

Methods

The study protocol was approved by the Bioethics Commission at the Jerzy Kukuczka Academy of Physical Education in Katowice by its decision no. 14 of 9 December 2008.

Subjects

The study was conducted with 11 purposively selected women that were confirmed overweight or obese by 20%, and had the Body Mass Index of 30 ±5 (the first stage of obesity). Their mean age was 56.18 ±3.19 years and the mean height was 166.5 ±7.41 cm.

All women screened for the study were examined by the attending physician to see if they could do exercises in water. Other inclusion criteria were the postmenopausal stage of the life cycle and age between 50 and 60 years. Seven women were excluded because they failed to meet the inclusion criteria.

Procedures

The selected women participated in 45-minute aqua-aerobic sessions that were held three times a week over a period of 3 months.

All exercises were performed in a swimming pool that was 60–160 cm deep, in a water temperature of 26–28°C. They were selected to match the participants' age and capabilities. Exercise intensity was controlled to remain between 128–137 heart rate per minute. Heart rate (HR) was constantly recorded during the sessions (the device was S810i, Polar Electro, Finland).

A single session consisted of three parts. It started with a 10–15 minute warm-up during which exercise intensity was around 128 ±5 HR/min. The warm-up exercises mostly involved arm swings in different planes and directions and were done by the participants while jogging. An important objective of a warm-up for aqua aerobics is to rise the participants' body temperature so that the water they initially feel as cold be felt as warm.

The main part of a session lasted 25–30 minutes. Exercises were performed according to the principles of aqua aerobics at an intensity of ca. 132 ±5 HR/min (it was higher than during the warm-up). They were selected in such a way as to engage the whole body of the participants and involved the use of different accessories (aqua discs, noodles, swimming boards).

The third part lasted 5 minutes and included exercises the intensity of which was set to around 120 HR/min. Participants exercised to slow music to allow them to stretch different muscle groups and relax psychologically and physiologically.

Participants exercised three times per week over a period of 14 weeks. A total of 42 sessions were held, with participants attending an average of 40 sessions. None of them dropped out before the end of the study.

To find out how aquatic exercises influenced the participants' body composition and selected blood cell count parameters they were assessed at baseline (assessment 1) and after intervention (assessment 2).

The participants' body composition was analysed using an eight-electrode Biospace InBody 220 body composition analyser utilising bioelectrical impedance. The analyser was operated by a trained person certified by MEDfitness, the sole distributor of the device in Poland. Participants were weighed in the morning between 9 and 10 am, two hours after breakfast and after they had used the toilet, in the ambient temperature of 21°C. They did not exercise or take any drugs before they were weighed. The weighing procedure was conducted twice, one day before the study and one day after they ended.

The Intraclass Correlation for the body composition analysis varied from 0.88 to 0.99. The following parameters were measured:

- body mass (BM),
- body height,
- body mass index (BMI),
- total body water (TBW),
- fat free mass (FFM),
- body fat mass (BFM),
- skeletal muscle mass (SMM),
- percentage body fat (PBF).

Before breakfast, resting blood samples were drawn from the participants' antecubital veins using Advia 2120, Siemens, Germany, to determine haematological variables (haemoglobin concentration (HGB), haematocrit value (HCT), the number of erythrocytes (RBC) and the lipid profile (total cholesterol (TC), high-density lipoprotein-cholesterol (HDL-C), low-density lipoprotein-cholesterol (LDL-C), and triglycerides (TG)). The following blood morphotic elements were tested:

- white blood cells (WBC),
- red blood cells (RBC),
- haemoglobin (HGB),
- haematocrit (HCT).

The lipoprotein profile:

- cholesterol (Ch-T),
- cholesterol (HDL-C),
- cholesterol (LDL-C),
- triglycerides (TG).

Maximal oxygen uptake (VO_2max) was measured in the participants during a ramp test. Exercise intensity was increased by 15 W/1min (0.25 W/1 sek). The ramp test was selected in order to prevent local fatigue that may arise in untrained persons doing a progressive exercise test.

The participants' nutritional intake was limited to 2,000 kcal over the length of the study. The main sources of energy were carbohydrates, fats and proteins, which accounted for 50–60%, ca 25%, and 15–20% of daily energy requirement, respectively.

Statistical analysis

Data were analysed statistically with the use of Statistica 10.0 (StatSoft). Basic descriptive statistics were calculated and all variables were tested for normal distribution. Differences between the values of the investigated variables obtained during assessments 1 and 2 were tested for significance using the T-test for dependent variables. The level of statistical significance was set to $p < 0.05$.

Results

The analysis of results obtained during assessment 2 showed that the participants' LBM and muscle mass ($p = 0.04$ in both cases) were statistically significantly higher compared with their baseline values, but BMI ($p = 0.02$) and percentage body fat ($p = 0.04$) were significantly lower.

Table 1. Somatic parameters

Variable	Assessment 1		Assessment 2		Difference	p
	mean	std. dev.	mean	std. dev.		
Body mass	78.30	12.35	77.70	9.88	0.6	0.13
TBW	35.64	4.41	36.16	4.02	–0.52	0.17
FatFM	**48.49**	**6.01**	**49.81**	**5.25**	**–1.32**	**0.04**
BodyFM	29.93	6.28	28.85	5.75	1.08	0.14
SMM	**26.55**	**3.52**	**28.23**	**4.07**	**–0.83**	**0.04**
BMI	**29.05**	**3.48**	**28.62**	3.30	0.43	0.02
PBF	37.78	4.66	36.28	4.09	1.50	0.04

It was also found that exercises in water significantly increased haemoglobin concentration ($p = 0.001$), haematocrit ($p = 0.03$) and blood cell count ($p = 0.01$) in the participants.

Table 2. Morphological parameters

Variable	Assessment 1		Assessment 2		Difference	p
	mean	std. dev.	mean	std. dev.		
Wbc	5.77	1.19	6.01	1.39	–0.24	0.52
Rbc	**4.58**	**0.33**	**4.72**	**0.28**	**–0.14**	**0.01**
Hgb	**13.60**	**0.57**	**14.28**	0.46	–0.68	0.001
Hct	40.13	1.19	41.20	1.01	–1.07	0.03

The analysis of the lipid profiles did not show the results of assessments 1 and 2 to be statistically significantly different.

Table 3. Lipid parameters

Variable	Test 1		Test 2		Difference	p
	mean	std. dev.	mean	std. dev.		
Cholesterol	6.07	1.47	5.81	1.25	0.26	0.24
CholHDL	1.75	0.36	1.82	0.47	–0.07	0.26
CholLDL	3.76	1.12	3.56	1.00	0.20	0.25
Triglic	1.18	0.48	1.02	0.39	0.16	0.10

The only variable that the second ramp test showed to be significantly different (higher) than at baseline was WR_{max} (p = 0.01); HR_{max}, VO_2max and VE_{max} did not change statistically significantly compared with their initial values. The lactate analysis revealed significant changes in LA_{max} (p = 0.04), $LA_{res9'}$ (p = 0.02), $Delta_{LAmax-LAsp}$ (p = 0.02) and $Delta_{LAres9'-LAres3'}$ (p = 0.0004).

Table 4. VO_2max – Ramp test 15W/1 min

Variables	Test 1		Test 2		Difference	p
	mean	std. dev.	mean	std. dev.		
HR_{max}	156.55	20.32	159.00	19.19	–2.45	0.25
WR_{max}	**154.18**	**14.34**	**160.27**	**14.87**	**–6.09**	**0.01**
$VO2_{max}$	22.00	4.20	22.64	4.13	–0.63	0.13
VE_{max}	65.55	14.59	67.12	11.99	–1.57	0.37
LA_{sp}	1.50	0.24	1.25	0.24	0.25	0.06
LA_{max}	**5.04**	**1.02**	**5.95**	**1.15**	**–0.91**	**0.04**
$LA_{res3'}$	6.00	1.35	6.4	1.15	–0.39	0.31
$LA_{res6'}$	5.77	1.34	5.44	1.09	0.33	0.38
$LA_{res9'}$	5.53	1.36	4.56	0.86	1.17	0.02
$Delta_{LAmax-LAsp}$	3.54	1.03	4.71	1.25	–1.16	0.02
$Delta_{LAres9'-LAres3'}$	–0.53	0.40	–1.17	0.52	1.36	0.0004

Discussion

In sedentary people taking up regular physical activity, the exercise stimulus triggers adaptive changes in different organs and systems of the body, particularly in the muscular, cardiorespiratory, circulatory, and hormonal systems. In this study, 14 weeks of aerobic workout had a significant effect on the participants' somatic characteristics. Statistical analysis conducted after the intervention showed significant changes in body lean mass (increase; p = 0.04), muscle mass (increase; p = 0.04), BMI (decrease; p = 0.02) and percentage body fat (decrease; p = 0.04) compared with their baseline values. That water exercises can improve the body composition has been reported by many authors (Bergamin et al., 2013; Fernández-Lao et al., 2013; Kim, O'sullivan, 2013; Taunton et al., 1996; Takeshima et al., 2002). The results of this study are consistent with those obtained by Sonati et al. (2011), who has demonstrated that regular aquatic exercises decrease body fat mass and increase fat-free mass (FFM) in physically active women. In contrast, Speakment and Westerterp (2010, 826–834) failed to find a relationship between increased physical activity and higher FFM in elderly persons.

Bergamin et al. (2013) had a group of 59 healthy elderly exercise in geothermal spring water (36°C) for 24 weeks in order to assess the effectiveness of such exercises in improving the general fitness and muscle mass of the study participants and to compare the results of exercises performed in water and on land. The sample was randomised into three groups: an aquatic group (AG), a land group (LG), and a control group (CG). The AG and LG groups followed a 6-month, twice-weekly, multimodality exercise intervention. The AG group underwent a protocol in hot-spring water (36°C), while the LG group exercised in a land-based environment. The authors of the study established that in the AG group fat mass (FM) and forearm fat decreased by 4% ($p < 0.05$) and 9.2% ($p < 0.05$), respectively, and calf muscle density increased by 1.8% ($p < 0.05$); no changes in FFM were noted, though. Carrasco, Vaquero (2012) obtained similar results in a study involving a group of 38 postmenopausal women randomised into an exercise group (EG; n = 21) and a control group (CG; n = 17) The EG group exercised in a shallow pool twice a week for 45 min over a period of 12 months. The results show that workout in a shallow pool had significant implications for total body weight of participants in the EG group because their BMI decreased by an average of -2.75% ($p \leq 0.05$). The results provide strong evidence that people exercising in a shallow pool can reduce their BMI. Ruoti, Troup, Berger (1994, pp. 140–145) have reported different results from a study on the effect of non-swimming exercises on muscle endurance, body fat, and aerobic work capacity in an older adult population. After 12 weeks of training, the values of all variables except for body composition were significantly different ($p < 0.05$).

In this study, the typically aerobic exercises induced adaptive changes in the participants' circulatory systems because of statistically significant increases in the levels of haemoglobin ($p = 0.001$) and haematocrit ($p = 0.03$), and in blood cell count ($p = 0.01$). The increases should be attributed to adaptive responses to exercising over a long period and the rising volumes of blood plasma. Physical activity enhanced the function of circulatory systems in the participants, thus improving their whole body function. However, the literature lacks evidence that various forms of aerobics have effect on blood parameters in people who regularly participate in such activities.

The lipid profiles of the women participating in this study were not significantly different after intervention from those established at baseline. This contrasts with the results obtained by Kamijo and Murakami (2009), according to which regular physical workout significantly reduced the blood levels of triglycerides in elderly females. The results of the LeMura et al. (2000, 451–458) study were similar in that they implied that aerobic exercises could improve the lipid-lipoprotein profile, endurance and body build in women. LeMura has reported that 16 weeks of training significantly reduced blood concentration of triglycerides ($p < 0.05$) and significantly increased blood concentration of high density lipoproteins (HDL-C) in the exercise group.

The only variable that the second ramp test in this study showed to have changed statistically significantly (increased) was WR_{max} ($p = 0.01$). The values of Hu_{max}, VO_2max and VE_{max} were not significantly different from those recorded at baseline. The lactate analysis revealed significant changes in LA_{max} ($p = 0.04$), $LA_{res9'}$ ($p = 0.02$), $Delta_{LAmax-LAsp}$ ($p = 0.02$) and $Delta_{LAres9'-LAres3'}$ ($p = 0.0004$) after intervention.

In the study by Broman et al. (2006), elderly women (aged 69 ±4 years) did high-intensity interval exercises in deep water twice a week over a period of 8 weeks. The authors have noted a significant decrease in the participants' heart rate during submaximal exercises (by 3%), as well as increased maximal oxygen uptake and maximal ventilation levels ($p < 0.01$). Bocalini et al. (2008) have reported that because of 12 weeks of workout maximal oxygen uptake increased in the intervention group (women aged 62–75 years who exercised 60 minutes 3 times per week) by 42%.

In the study by Tsourlou, Benik, Zafeiridis, Kellis, (2006, pp. 811–19) a significant improvement in the maximal isometric torque of knee extensors (10.5%) and knee flexors (13.4%) was noted in women aged 60+ who exercised in shallow water (three 60-minute sessions per week over a period of 24 weeks). Poyatos and Abellán (2011, pp. 17–30) have reported that resistance exercises performed by postmenopausal women (aged 55.4 ±6.5 years) in shallow water for 45 minutes twice a week significantly improved the mean power of their upper limbs (9.08%, $p \leq 0.05$). Maximal strength did not improve, though, probably due to insufficient training loads. According to Elliott (1978, pp. 2408–2410) depending on the type of physical exercises individual's fitness may improve at the cost of speed and maximal power. In this study, aquatic exercises improved participants' maximal power statistically significantly, but the improvement in aerobic threshold was statistically insignificant. This seems to indicate that aqua aerobic exercises can be selected to influence these somatic and physiological characteristics that need strengthening.

It should be noted, however, that in addition to describing the benefits of water exercises the literature provides evidence that physical activity in a swimming pool may have negative effects too. For instance, long and frequent exposure to chlorinated water may lead to the development of upper and lower respiratory symptoms such as asthma (Angione, McClenaghan, LaPlante, 2010; Bernard, Nickmilder, Voisin, 2008; Bougault, Turmel, Levesque, Boulet, 2009).

Conclusions

After 14 weeks of aqua aerobic workout, the following changes were noted in the participants:

- higher levels of haemoglobin blood concentration, haematocrit, and blood cell count,
- significantly greater fat-free mass and muscle mass and significantly smaller BMI and percentage body fat,
- insignificant differences between lipid profiles recorded at baseline and after intervention,
- significantly higher WR_{max} shown by the second ramp test data.

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THE ASSESSMENT OF THE OCCURRENCE OF BENIGN HYPERMOBILITY JOINT SYNDROME IN PHYSIOTHERAPY STUDENTS

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Abstract The occurrence of connective tissue disorders is an important factor for development of occupational diseases in professions requiring a non-ergonomic and often static load of the musculoskeletal system. Symptoms of the connective tissue disorders appear at different ages. The diagnosis of hypermobility is an important problem due to the lack of uniform diagnostic criteria.
The aim of this paper is to evaluate the incidence of joint hypermobility and its relation with a history of injuries and the level of physical activity in Physiotherapy students.
The study involved 143 students (69% female, 31% male) aged 18 to 27 years (M = 20.7; SD = 1.43). The assessment of the occurrence of Benign Hypermobility Joint Syndrome (BHJS) syndrome was performed using the Beighton and Brighton scale.
Among the surveyed students almost 82% of the women and just over 18% of the men fulfilled the diagnostic criteria for the diagnosis of hypermobility. A significant difference was also observed in the physical activity of the students. Among those who showed no signs of hypermobility exactly half of the participants trained sports as amateurs, while in the group of people with hypermobility the proportion was lower by nearly half. BHJS was not related to injuries and operations in the study group.

Key words hypermobility, joint, Beighton score, score Brighton, sports, physiotherapy

Introduction

Hypermobility of the joints, also known as “double-jointedness” is characterized by bigger than normal range of motion in the joints (Seçkin et al., 2005; Yazgan, Geyikli, Zeyrek, Baktiroglu, Kurcer, 2008). The mobility of the joints changes with age. These changes do not occur simultaneously and with the same intensity in each joint. The largest mobility of the joints is in infants and decreases with time at varying rates. The joint mobility decreases very rapidly during childhood and more slowly in adolescents and adults (Malfait, Hakim, De Paepe, Grahame, 2006).

Hypermobility is a symptom of disorder in the structure of the connective tissue associated with a number of genetic diseases for example Osteogenesis Imperfecta, Down's syndrome, Marfan's syndrome, Ehler-Danlos syndrome and BHJS. Originally BHJS was named the hypermobility syndrome (HMS), first described by Kirk, Ansell, Bywaters (1967) as a pathological condition characterized by excessive joint mobility along with additional symptoms from the musculoskeletal system. In adults the symptoms of musculo – skeletal disorders resulting from excessive mobility of joints were described as the Hypermobility Syndrome (HS).

In the scientific reports the terms Joint Hipermobility Syndrome (JHS) and BHJS are used interchangeably (Simmonds, Keer, 2007). The term constitutional hypermobility (CM) is also sometimes used referring to a generalized and innate connective tissue deficiency of the whole body assessed by the Brighton scale.

The major manifestations of CM include increased joint mobility, softness of joint capsules and ligaments (Iomdina et al., 2015). Other symptoms including ease of dislocations and joint sprains, muscle and joint pain, hyperelastic skin, vision disorders, disorders of the gut, problems with body stabilization and other Brighton criteria indicate the presence of BHJS. CM is mainly observed in the developmental and in young adults. With age the joint mobility decreases, however, it is related to the aging process of the body and not to the disappearance of abnormal connective tissue.

Excessive joint mobility is observed in approximately 10% of "healthy" people, especially among Asians, is present more often in women than in men (Larsson, Baum, Mudholkar, 1987; Moraes, Louzada, 2007). Excessive joint mobility often predisposes to choose a profession where it can be useful. This applies to acrobats, ballet dancers and musicians playing various instruments such as the violin and the piano (Grahame, Jenkins, 1997; Larsson, Baum, Mudholkar, Kollia, 1993).

The occurrence of connective tissue disorders is an important factor in occupational diseases in groups of professions requiring a non-ergonomic and often static load. It is the cause of micro-injuries and later the cause of disorders of the musculoskeletal system in office workers, IT specialists, dentists, drivers, athletes etc. The presence of dysfunction resulting from the occurrence of benign joint hypermobility syndrome can be used to take preventive measures for vulnerable occupational groups.

In the available medical literature, a large role is assigned to health prevention (Pate et al., 1995; Penedo, Dahn, 2005). Particular attention is given to physical activity as an important factor in maintaining health (Warburton, Nicol, Bredin, 2006). This includes, but is not limited to, people with evidence of constitutional hypermobility (CM). Although exercise will not help to achieve better "stiffness" in stretched tendons or ligaments, it is advisable to strengthen the muscle strength and proprioception. Improperly dosed movement is a cause of musculoskeletal and other ailments. It should be noted that the treatment of people with CM is exclusively symptomatic. Personalized exercises can strengthen weakened muscles by improving the stabilization of excessively moving joints, thereby reducing their soreness. In order to improve stability, mainly exercises in closed kinematic chains should be implemented (Gębska, Weber-Nowakowska, Żółtowska, Żyżniewska-Banaszak, Woitas-Ślubowska, 2017). Due to the consequences that hypermobility can cause, the assessment of the predispositions that point out existing BHMJ allows targeted therapy of people with hypermobility. It is important to inform students of medical and related fields of possibilities of counteracting the symptoms of HS and to present methods of rehabilitation in situations where there is risk of injury, specially that the dysfunction of the musculoskeletal system caused by the presence of hypermobility significantly increases the risk of many diseases within the musculoskeletal system.

The aim of the study was to assess the prevalence of joint hypermobility and its relation with a history of injuries and the level of physical activity in physiotherapy students.

Materials and methods

The research was conducted among physiotherapy students at the Faculty of Health Sciences of the Pomeranian Medical University in Szczecin. The study involved 143 students (69% of women, 31% of men) aged 18–27 years (M = 20.7, SD = 1.43). Body weight and body height of all of the participants was measured using an electronic scales.

Subjective examination

The subjective examination included a questionnaire containing questions about personal factors, social factors, current health, level of physical activity and details about past injuries.

Assessment of Benign Hypermobility Joint Syndrome incidence

In order to determine the occurrence of joint hypermobility in the participants of this study a 9-point Beighton test was performed. It consists of: a passive extension of the fifth finger above 90°, passive thumb adduction to the inner surface of the forearm, elbow joint overextension above 10°, overextension of the knee above 10°, placing the whole surface of the hands on the ground while standing with straight knee joints (Table 1).Obtaining a minimum of 4 points in the test is the basis for the diagnosis of HS. Subsequently, the Brighton test was conducted in order to diagnose BHJS.

Table 1. Beighton test

No.	Joint movement examined	Right side (0–1 points)	Left side (0–1 points)
1.	The ability to position your hand flat on the floor during the while standing with straight knees.		
2.	Passive hyperextension of the fifth finger above 90°		
3.	Passive adduction of the thumb to the surface of the forearm.		
4.	Hyperextension of the elbow		
5.	Hyperextension of the knee joint		
SUM			

The Beighton test result included the results of the Brighton test and symptoms such as arthralgia, degenerative spine conditions, joint subluxation, skin symptoms, eyesight disorders, hernias, varicose veins, anal fissures, and body type. The criteria were divided into "large criteria" and "small criteria" (Table 2). The basis for the diagnosis of BHJS is: the presence of at least two "high criteria", a "big" and two "small" or four "small" (Bisaralli, Kanti Dutta, Flora Marak, Naorem, 2017; Pacey, Nicholson, Adams, Munn, Munns, 2010).

Table 2. Brighton criteria

I	LARGE CRITERIA	Yes	No
1.	4 or more points on the Beighton scale (currently or in the past)		
2.	Pain in at least 4 joints that lasts at least 3 months		
II	SMALL CRITERIA		
1.	Result = 1, 2, 3 in the Beighton scale		
2.	Pain in 1 to 3 joints lasting longer than 3 months, or back pain lasting 3 or more months, spondylosis, spondylolysis /spondylolisthesis		
3.	History of joint displacement or subluxations in more than 1 joint or more than 1 time		
4.	Soft tissue rheumatism (3 months or more) (e.g. Epicondylitis,tenosynovitis, bursitis)		
5.	Marfanoid appearance, Arachnodactyly (+ Steinberg symptom)		
6.	Irregularities affecting the skin - stretch marks, hyperelastic skin, thin skin		
7.	Ocular symptoms: ptosis, myopia, antimongoloid slant		
8.	Varicose veins of the lower limbs, hernias, anal or vaginal/ uterus prolapse		
Benign Hypermobility Joint Syndrome: – at least two “big” criteria – one “big” and two “small” criteria – four „small” criteria		BHJS Score:	

All participants have signed a consent to participate in this study. The study was approved by the Bioethical Committee of the Regional Medical Chamber in Szczecin (KB-0012/104/15).

Statistical analysis

The statistical analysis was done in the IBM SPSS V.21 packet. The Pearson Chi-square test, the non-parametric Mann-Whiteney test and the binary logistics regression analysis were used. The value of $p < 0.05$ was assumed to be significant and the value of $p < 0.1$ was assumed to be an indicator of a non-significant statistical trend.

Results

Among the examined students almost 82% of women and only slightly over 18% of men met the diagnostic criteria for the diagnosis of hypermobility. A significant difference was also observed in the physical activity of the students. A significant difference was also observed in the physical activity of the students. Among those who showed no signs of hypermobility exactly half of the participants trained sports as amateurs, while in the group of people with hypermobility the proportion was lower by nearly half. BHJS was not related to injuries and operations in the study group (Table 3).

Comparative analysis of examined students with BHJS and without BHJS revealed significant differences in body weight, body height and BMI between these groups (Table 4).

In the next step, all the variables that coexisted with hypermobility were collected in one regression model to determine whether estimating the risk of hypermobility by the gender, BMI and additional physical activity of young adults was possible (Table 5).

Table 3. Characteristics of the group by selected dichotomous variables including hypermobility; N (%)

	The whole group, n = 143	Hypermobility		Chi-square Test	
		YES, n = 103	NO, n = 40	X^2	df
Sex					
Female	99 (69.2%)	84 (81.6%)	15 (37.5%)	26.248	1
Male	44 (30.8%)	19 (18.4%)	25 (62.5%)		
Injuries	78 (55.7%)	56 (54.4%)	22 (55.%)	0.012	1
Operations	33 (23.0%)	24 (23.3%)	9 (22.5%)	0.010	1
Recreational sport	47 (32.9%)	27 (26.2%)	20 (50.0%)	7.388	1

Table 4. Characteristics of the group by selected quantitative variables including hypermobility; M (SD)

	The whole group, n = 143	Hypermobility		Mann-Whiteney U Test
		YES, n = 103	NO, n = 40	Z
Age	20.70 (1.43)	20.56 (1.35)	21.08 (1.60)	–1.740
Body mass	65.86 (13.15)	62.10 (11.22)	75.55 (12.89)	–4.444
Height	172.28 (8.99)	169.95 (8,33)	178.26 (7.87)	–4.965
BMI	22.03 (2.97)	21.39 (2,79)	23.65 (2.82)	–4.156

Table 5. Binary logistics regression analysis of hypermobility predictors

	B	S.E.	Wald	df	p	Exp(B)	95% C.I	
							Lower	Upper
Sex	1.463	0.452	10.491	1	0.001	4.320	1.782	10.473
Physical activity	–0.786	0.441	3.183	1	0.074	0.455	0.192	1.081
BMI	–0.188	0.078	5.772	1	0.016	0.829	0.711	0.966
Constant	4.566	1.910	5.718	1	0.017	96.189		

The most important of the hypermobility predictors was the sex – the likelihood of finding hypermobility among women is 4.3 times higher than in men. A significant relationship also exists with BMI which is also related to the gender. The exp value (B) indicates that with the decrease of BMI by 1 compartmental point, the probability that the participant meets the criteria for hypermobility increased by about 0.8%.

There is an incomplete relation with the physical activity of the participants. Those practicing amateur sport are in the risk of hypermobility of almost 46% greater than those not practicing sports.

Discussion

The diagnosis of hypermobility is an important problem due to the lack of uniform diagnostic criteria. Symptoms of hypermobility appear at different ages (3–55 years). Most cases occur before the age of 15. Symptoms of hypermobility are more common in females and concern the lower limbs more often, which manifests itself, for example, with proneness to ankle and knee sprains (Seçkin et al., 2005). Joint hypermobility decreases with age, and it seems to be related to gender and race (Beighton, Grahame, Bird, 1989). The authors research has shown that in as many as 82% of students of physiotherapy symptoms of BHJS can be found using the Beighton and Brighton tests. In men this percentage was about 18%. In medical literature there are many studies that show that sex is one of the main factors predisposing to the development of BHJS (Larsson et al., 1987; Moraes, Louzada, 2007).

By analyzing the results from the interview card, it is clear that 55.02% of students do not know whether they are hypermobile, and only 9.46% recognize the ailment in themselves. This fact proves that there is a lack of knowledge of hypermobility of joints and the risks that it carries in future physiotherapists. Hypermobile joints are always overloaded, leading to adverse biomechanical changes in the body's motion such as faster wear of joint surfaces, overloads, and pain.

Among the participants, the diagnosed group with BHJS differed significantly in body weight and height compared to those without BHJS. The fact is confirmed by numerous scientific reports, where people with BJHS are overweight, suffer from chronic joint pain and other neuromusculoskeletal symptoms associated with collagen defects (Everman, Robin, 1998; Finsterbush, Pogrund, 1982).

The purpose of increased physical activity with a clear predominance of exercises focusing on suppleness is to increase the mobility and flexibility in the joints. It contributes to reducing the intensity and incidence of injuries and is one of the main factors protecting against joint damage. Depending on needs, suppleness is interchangeable named as flexibility or elasticity. Its basic measure is the amplitude or the range of movement of the selected joints, which depend on the structure of passive joint structures such as the joint surfaces, joint capsules and ligaments, and the active joint structures – the muscles (Cromie, Robertson, Best, 2000). The biggest diagnostic problem concerns people who have an increased range of motion in the joints as the result of many years of training (gymnastics, dance) and persons subjected to heavy physical loads (professional athletes) (McCormack, Briggs, Hakim, Grahame, 2004; Pacey et al., 2010). Excessive flexibility may seem to be an advantage in sports such as gymnastics, dance, acrobatics, and a potential risk in such disciplines as rugby, judo (and other martial arts) where athletes have significantly different sensitivity to pain compared to non-athletes (Stewart, Burden, 2004; Leźnicka, Pawlak, Białecka, Safranow, Cięszczyk, 2017). Many authors suggest that frequent sports injuries are caused by excessive motion in the joints (Smith, Damodaran, Swaminathan, Campbell, Barnsley, 2005). In people with BHJS who do not suffer from pain Simmonds, Keer (2007) recommend a non-contact sport, such as swimming, Pilates and tai chi, while Murray (2006) recommends full involvement in sport. In a study performed on rowers and swimmers, the percentage of athletes with hypermobility in rowers who in training rely on performing repetitive movements in closedkinematic chains is smaller than in swimmers (Gębska et al., 2016). In ourstudy, among the students who have no symptoms of hypermobility, exactly half of the practiced sports recreationally, while in the group of people with hypermobility only 26.2% undertook physical activity. This observation confirms the association of BHJS with motor activity. People with hypermobility are much more likely to drop out of physical activity most likely because of the pain that occurs during or after exercise. Physiotherapists should be physically fit because the nature of the work requires high quality motor features such as strength, power, coordination, balance and endurance. Assuming long lasting, monotonous, non-ergonomic and uncomfortable positions while performing rehabilitation treatments such as massage, lifting and verticalization leads to the occurrence of dysfunctions and disorders of the musculoskeletal system (Bash, Farber, 1999; Passier, McPhail, 2011). In the case of hypermobility of the joints, the physiotherapist's physical strain can lead to traumas and overload of the locomotor system, resulting in degenerative changes and disability.

Conclusion

In the study group hypermobility was not related to injuries and operations. The knowledge of physiotherapy students with the characteristics of hypermobility is insufficient, which should be taken into account when training future physiotherapists. The eligibility criteria to become a physiotherapist should include the diagnosis for benign joint hypermobility syndrome.

Special training programs for people with hypermobility should be developed and implemented to protect joints from overload. The implementation of prevention and rehabilitation in the early stages of the dysfunction will help prevent the occurrence of locomotor disorders in the medical profession.

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THE INFLUENCE OF THE 6-MONTH COURSE OF NORDIC WALKING ON PATIENT WITH PARKINSON'S DISEASE – A CASE REPORT

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Abstract A person with Parkinson's disease has bigger problems with maintaining the stability than the healthy person. Nordic Walking is a safe kind of physical activity for elderly people.

The aim of this study is to present the influence of a 6-month therapy of the Nordic Walking on the imbalance and the risk of falls for 66-years-old patient with Parkinson's disease.

On the basis of results of 4 tests, performed both at the beginning and at the end of the Nordic Walking therapy, we have made a comparison of patient's changes before and after 6 months of rehabilitation.

the DGI test, the PD patient received 18 points. After he got 22 points. In the Functional Reach Test (FR), while attempting to reach forward, reached out for 23 cm before the therapy, and 31 cm after the therapy. In the test and go up the patient got a time of 63 seconds, after therapy the time was reduced to 45 s.

Nordic Walking is a safe kind of physical activity for people with Parkinson's disease. It reduces muscle tension, and improves joint function.

Key words physiotherapy, Parkinson's disease, Nordic Walking

Introduction

Parkinson's Disease

Parkinson's disease is caused by chronic, progressive degeneration of the central nervous system. It occurs twice as often for men than for women, mostly in the age group of 40–50 y/o (Struensee, 2010). Symptoms occur when the level of dopamine, the striatal neurotransmitter drops below 60%. The disease causes losses of substantia nigra (Krygowska-Wajs, 2006). New treatment strategies are always being developed, like gene therapy and usage of nanotechnology, a new therapeutic method using molecules that can contribute to the regeneration of damaged neurons and drugs transfer through the blood-brain barrier (Maguire-Zeiss, 2008). Characteristic symptoms of the disease are primarily resting tremor, muscles' hypertonia stiffness, slowness of movement (bradykinesia), and abnormal posture. Early detection of the disease allows patients to longer maintain the motor skills, which affects the extension of the period of independence. Physiotherapy, individually adjusted for each patient, should complement the pharmacological fight against the disease. An integral part of the physical activity for each patient should be physiotherapy and physical therapy. In determining the severity of the disease patient assessment scales might be helpful, like Hoehn and Yahr Unified Parkinson's Disease Rating Scale (UPDRS called. Unified Parkinson's Disease Rating Scale) or functional scales (Struensee, 2010).

Disorder of Core Stability for a Patient with Parkinson's Disease

Core stability depends heavily on the correct functioning of the nervous system. For your body to react properly, the nervous system must quickly respond to the loss of balance (Dyszkiewicz, 2006). Studies, for example those conducted by (Kłoda, 2013), show that patients with PD risk of falls and losing balance is much higher. They performed studies on a group of 43 patients with PD and 46 healthy people and studied their balance maintaining. The research team concluded that increased deviation of the center of gravity makes it more difficult to maintain a balance for sick patients (Zawadka, 2013). Problems with balance show up already in the early stages of the disease. Imbalance can be seen (detected) after balance tests, but they show only the qualitative nature of the disorder, like Tinneti test (Kłoda, 2008). Stiffness and slowness of movement cause loss of balance and increase risk of falls.

Figure of a human suffering from PD becomes inclined, head and torso slide forward, shoulders start hanging. Knees, hips and elbows are flexed in (Petit, Allan, Vermersch, 1997; Samii, 2008). Such a posture can increase the number of falls – retropulsion or propulsion (Kłoda, 2013). Using the physiotherapy, we can decrease the risk of falls and increase the quality of life of patients (Skalska, 2014).

Nordic Walking as a Form of a „Drug" for Elderly

Nordic Walking is a safe form of physical activity for people with Parkinson's disease. It reduces muscle tension, and improves joint function and motor coordination (Chęcińska-Hyra, 2012). It combines march with pushing back using specially designed poles (Morsø, Hartvigsen, Puggaard, Manniche, 2006). Patient adjusts walking speed according to his abilities. This technique of walking involves 90% of the body muscles, many of which are not used during normal walking. As a result, the patients does not feel too much fatigued. Using sticks as a support, reduces load on the articular surfaces while walking. This form of movement engages upper and lower limbs and, as a result, improves the asymmetric movements.

Material and methods

Material

Patient: male, age 66, 10 years ago diagnosed with Parkinson's disease. 3rd stage of the disease, according to the Hoehn-Yahra-scale. BMI equals 25, which means a slight overweight. In the early stages of Parkinson's disease patients experienced troubles with writing, micrographia, and degradation of movement.

In addition, conducted examination found hypomimia (impaired facial expressions) and lack of balance of the upper limbs while walking. MRI of the head and UDP were also performed. The MRI scan noticed a single, non-specific foci of demyelination in the white matter around the front corner of the left lateral ventricle and subcortical parietal lobes. UDP showed an asymmetry flow in the vertebral arteries (L > R), but without asymmetry in the flow in the carotid and intracranial. In the early stage of disease symptoms touched a right side of the body. At the beginning the man has experienced a tremor of right arm, which was intensifying in stressful situations. Increased tension of gearwheel type in upper limbs and "lead pipe" stiffness in lower limbs were observed. For all his daily activities, patient is forced to dedicate much more time than a healthy person. We observed also a typical for Parkinson's disease stiffened posture – head and torso are inclined forward, arms and legs are slightly bent and arms leaned forward, patient is lacking of counter-rotation of trunk. Very often, while performing ordered tasks, there was a symptom of "frozen" motion. Throughout many years of dealing with the disease there were, according to the patient, alternating periods of higher and lower mobility. What is more, a phenomenon of retropulsion appears very often.

It occurs in both direction gait, and during a steady, uniform march. The doctor conducting the neurological treatment of the patient since 2007 has noticed periodic worsening of mood. Parkinson's disease did not exist in family interview. Along with the progress of the disease, new symptoms may appear.

The medical treatment causes side-effects, like among others dyskinesia (uncoordinated movements of the various parts of the body, unwilling movements). The health condition of the patient may deteriorate with time which is associated with aging and worsening symptoms of Parkinson's disease (Struensee, 2010). Others disorders occurring in Parkinson's disease are: problems with swallowing, difficulties with changing the body position while sleeping, eyelids movements problems. The patient can manifest also psychological symptoms like: depression, cognitive disorders, memory disorders, dementia, sleep disorders. Parkinson's disease is also accompanied by the pain caused by contractures and stiffness (Janocha, Zawilska, 2007). Autonomous system is also later negatively affected, what is associated with the occurrence of orthostatic hypotension. Other problem appearing during the subsequent stages is randomness of "on" and "off" phase – as one of the effects of long-term medical treatment. With time kyphosis may deepen, which will reduce the respiratory function and increase vulnerability to infections (Kwolek, 2009).

Methods

Patient participated in NW activities from December 2014 for six months. Classes were held once a week. The time of one therapy session was 1.5 h. At the beginning of the 6-months participation period, fitness tests were organized to verify effects of the therapy. A question was posed: how patient will be influenced by such a form of physical activity, in particular in the area of maintaining balance and coordination improvement. In addition, the goal was to learnt the patient of correct alternating motion of upper and lower limbs and to learnt correct technique of walking with poles. Tests that were conducted at the beginning of the treatment for later verification included:

1. Dynamic Gait Index (DGI) assessing gait, balance, and the likelihood of falling. Patient was able to get 18 points.
2. Functional Reach Test (FR) is a clinical test, which allows to assess the balance in a standing position . The patient has lean forward with feet and pelvis fixed (not taking them from the ground) 1. Results of the test are given in centimeters. Patient obtained 23 cm of reach.

3. Test up and go is a test designed especially for the elderly after a stroke with spinal injuries and Parkinson's disease . It allows to evaluate gait and balance. The patient obtained a time of 63 seconds.
4. The patient underwent the Tinetti test, part of the balance examination; Sum of points before evaluating the balance part was 11/16.

After verifying these results, the activities of Nordic Walking started.

At first, the respiratory physiotherapy started. Patient was taught of calm and rhythmic breathing: breathing in through the nose and a long, quiet exhaling through the mouth.

During developing of a rehabilitation program, a guidance on respiratory physiotherapy developed by A. Patel and others was used (Duncan, Weiner, Chandler, Studensld, 1990). Workout lasted about 10 minutes.

The following is a schematic description of the individual classes:

1. Initially, the number of repetitions breaths wasn't exceeding 6–8 in order to avoid hyperventilation of the patient. Stop of breathing was introduced to the exercises as following: patient was taking a 5-seconds-long breath in, then 3 seconds of holding the breath and then 5-seconds-long exhaling. During the exhalation phase, patient tried to remove as much air from the lungs as he could. Over the time, a number of repetitions was increased even to 20. After demonstrating the exercise, observing its performance by the patient and necessary correction made by authorized medical staff, the patient was able to perform these exercises alone.
2. Patient was taught different breathing tracks: upper-ribbed and abdominal (diaphragmatic). First one was demonstrated by laying the therapist's hands on the upper ribs, pressing them during patient's exhalation, and then releasing when he was exhaling.
3. Diaphragm track was turning on during the exercise in which patient put one hand on a stomach, and the other one on the chest. The latter one was to be kept level, and the first one to move up and down. Successively: breath in through the nose – the hand goes up, exhale through the mouth, the hand goes down. Then the patient blew a lighted candle from 15 cm, and the flame was needed to heave. The distance was increased with each passing day.
4. It was tried to reduce the muscle tension of the chest by lifting the upper limbs, straight at the elbows. This movement was synchronized with inhaling through the nose. The patient lowered upper limbs along the torso during exhaling through the mouth.
5. The patient lifted his arms as high as possible – a movement of shrugging his shoulders. Countdown to three and arms were being lowered.

Scapula were pulled tight, chest pushed out to the front, countdown to three and relaxation.

Then the height of sticks was adjusted. Properly chosen, they should allow 90 degrees flexion at the elbow. Warming up lasted 20 minutes:

- with feet slightly apart, poles were passed from the right to the left hand – 10 reps,
- front, rear and alternately arms circling – 8 reps,
- in standing position, lean on the poles, and do forward and backward swings with right and left lower limb – 10 reps,
- position of the patient as above, make the hips circulations, first from the left then from the right – 5 repetitions on each side,
- knees circulation, inside and outside,

– then lift one of your heels and make circular movements of your ankle, first the right one, then the left – 5 reps on one side,
– fold your toes alternately with standing on toes – 10 repetitions.

After the warm-up we proceeded to walking with sticks. At the beginning, several principles of correct walking were reminded:

– the body works in rotation with the supportive lower limb, so when the right lower limb is as a support, then the left part of the torso moves forward,
– the pivotal movement of the upper limbs synchronized with the movement of the torso,
– rolling the foot starts from heel to toes,
– during the march is an active movement of the upper limbs happens, what affects the rhythm of the march,
– the head looking forward with straight back,
– steps must be alternating, forward and harmonious,
– you should push back from the big toe,
– upper limbs must be kept closely to the body.

The march started with a 10 minute easy gait. Then it was changing from slower to faster movements, longer to shorter steps, walking sideways, starting from the right foot, then from the left. When the patient's gait was economical and alternating the task was made more difficult, by an addition obstacles on the road, e.g. a ball or a tape. Direction of the march was also modified. The therapy for disorder of patient's facial expressions was conducted later. Using the concept of C. Morales, shoulder girdle of the patient was relaxed with the massage. Then there was a return to marching with poles as before, when the pace and direction were being changed and some exercises aimed at improving the quality of gait performed. The final march lasted 10 minutes .

At the end of the session we performed stretching and calming exercises . Each muscle was kept stretched for 20–30 seconds. The aim of this was to reduce the tonicity and calm down the patient, like also increase the range of joints mobility. Those exercises included:

– stretching of the muscles of the lower limbs, mostly sciatic tibial, quadriceps, gluteal,
– stretching of the muscles of the upper limbs,
– limb movements combined with calm breathing at the end,
– free falls of torso.

With time passing, the exercises were refined, the walking speed and level of difficulty of the exercises were also increased.

Results

After 6 months of practice 4 tests were performed again: Dynamic Gait Index, Functional Reach Test, test and go up and part of evaluating the balance from Tinetti test. Improvement was found in all 4 results (see Table 1). In the case of the DGI before training patient got 18 points and after 6 months 22 points. FR before was 23 cm, and after 31 cm. The time of test up and go before was 63 seconds, and 45 seconds after the therapy. Tinetti test 11/16 and after 13/16.

Table 1. The results of the influence before and after Course of Nordic Walking on Patient with Parkinson's Disease

Type of the test	Results	
	before the test	after the test
Dynamic Gait Index (points)	18	22
Functional Reach Test (cm)	23	31
Up and go (s)	63	45
Tinetti test (points)	11/16	13/16

Discussion

Results presented in this work indicate an alleviation of the symptoms for a patient with Parkinson's disease. Similar results of studies while using Nordic Walking training were published by I. Reuter and others. As they notice, persons who supervise the exercises, should pay an additional attention to technique of gait with poles.

One of symptoms of the Parkinson's is pain. Regular physical activity along with the walking exercises decrease the pains of back, of sacroiliac joints and of joints of the upper limb. I. Reuter and others compared effectiveness of walking training with Nordic Walking training. After examinations it was stated that gait pattern and stability was much better for those who were training Nordic Walking. After 6 months of Nordic Walking, the gait was longer, which is very important for reducing the risk of falling. Reuter and others stated also positive changes in cognitive functions, concentration and memory for patients taking part in Nordic Walking group training. Regular physical activity decreases negative effects of Parkinson's, including „freezing" of the movement. Rehabilitation supplements pharmacological treatment. Reuter and others showed also that walking training and Nordic Walking training gives better results than using only relaxation and tensile exercises (Reuter et al., 2011).

Studies conducted by J. Szefler-Derela and others point out improvement of gait, dynamical balance and static mobility. After 6 weeks of Nordic Walking training, patients with Parkinson's were better at performing physiotherapist's orders. Improvement of gait pattern for the 66 years old patient were confirmed among others by Dynamic Gait Index test and Up and go test. Those tests were used to grade results in studies by J. Szefler-Derela and others, where the significant influence on the speed of gait was concluded (Szefler-Derela, 2014).

Positive effects of Nordic Walking training is also a general improvement of physical fitness. P. Kocur and others conducted studies on a group of 80 men after acute coronary syndrome. It was proved that even a short-term Nordic Walking training increases endurance and dynamical balance. Gait training with poles increases autonomy and life quality (Kocur, Deskur-Śmielecka, Wilk, Dylewicz, 2009).

For patients with Parkinson's gait pattern is the most important in everyday life. De Dreu and others used elements of music therapy to increase locomotive functions. Physical and rhythmical exercises combined decrease „frozen" movement (De Dreu, Van der Wilk, Poppe, Kwakkel, Van Wegen, 2012). Studies of De Dreu and others may be a hint of how to conduct Nordic Walking classes. Music during the training will influence the speed of gait and make the sessions more diverse.

While treating patients with Parkinson's, physiotherapy must play an essential role during the therapy. Studies conducted by M. Strunsee proved that a proper kinesiotherapy program may decrease various kind of tremors. UPDRS questionnaire defines severity of symptoms for Parkinson's disease. This scale allows to grade for example: manual skills, mimics, tremor, gait pattern and posture stability. Results coined by M. Struensee on the basis of

UPDRS questionnaire shows that it is possible to soothe symptoms of Parkinson's by regular physical activity (Struensee, 2010).

Aside of the Nordic Walking training, we used also various other exercises (breathing, coordination and flexing exercises). Therapeutic success is guaranteed by the proper choice of exercises, including all rules of kinesiotherapy. Non-weight bearing exercises and weight-bearing exercises with resistance added to the improvement program made by M. Struensee contribute on, among others, to improve manual movements of hands and alternate movements (Struensee, 2010).

During the six month cycle of Nordic Walking training we used also other physiotherapeutic methods, like classic massage. Thanks to the laxity of shoulder girdle, patient could correct his body posture. M. Hernandez-Reif and others point out positive effects of massage. They were comparing effects of the massage and Jacobson's training onto the Parkinson's symptoms. Patients attending the massage sessions got better results of UPDRS. Among those, authors noted also lowered level of stress hormones (norepinephrine and epinephrine). Aside of eliminating stiffness, massage decreased also sleep disorder (Hernandez-Reif, Field, Largie, 2002).

Walking with poles affects physical and mental health of patients. Taking part in group session of Nordic Walking helps fighting with the routine and improves emotional state of patients. Confirmation comes from the studies conducted on the group of 20 patients older than 70 years. Results obtained by Hank Suk and Jeung Hung prove that walking training strengthens patients' leg muscles as well as their cognitive functions. Patients performing only general exercises didn't get that good results as the group using Nordic Walking. Contact with others and fresh air activity decreased depression symptoms for seniors (Han Suk, Jeung Hun, 2015). During Parkinson's development patient may suffer from cognitive disorder. Patients complain on lowered level of mental comfort, including depression (Janocha, Zawilska, 2007). Participation in Nordic Walking training will not only improve the gait pattern but also will affect declines of humor.

Diverse therapy program and physical activity affects positively symptoms for patients with Parkinson's. Complex perceiving of a patient and, noticing his physical and mental needs will affect positively his autonomy and social life. Everyday life comfort comes from working on the gait pattern and manipulative skills. Rehabilitation program must be individualized, but participation in the group sessions also plays a crucial role in the process of improvement.

Consclusions

6-months long exercises of Nordic Walking significantly improved balance and reduced the risk of fall for the patient. Exercises with NW poles contributed to improving the quality of gait for patients with Parkinson's disease, reducing sense of anxiety associated with the acceleration of walking. In addition, an improvement of joint mobility was confirmed. The posture has become more upright and muscles less tensed. Patient's movement became smoother and faster, so the march with sticks positively influenced the symptom of bradykinesia.

Summary

Regular physical activity reduces severity of symptoms of people suffering from Parkinson's disease. Group exercises also contribute to the integration of patients who are struggling with the same condition. Cessation of exercise can exacerbate symptoms for given patient, thus worsening the quality of life and sense of independence.

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DESIGN, VALIDATION, AND RELIABILITY OF SURVEY TO MEASURE KNOWLEDGE OF NUTRITION, WEIGHT CONTROL AND ITS RISKS

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Abstract The purpose of this study was to design, validate, and test the reliability of an instrument to evaluate knowledge of nutrition, weight control and its risk. The instrument collects information regarding: socio-demographics and athletic status; basic knowledge of nutrition (the diet they follow, nutrients, supplements, energy balance, myths, hydration and habits); and weight control and risks (weight control, eating behaviors, and weight control habits). The design, validation, and testing of the reliability of the questionnaire were done in four phases: a) design and development of the instrument, b) content validation, c) instrument reliability, and d) concurrent validity. The results show that the instrument is suitable for measuring nutrition, weight control and risk knowledge in athletes. The instrument that was developed and validated in this paper can contribute to assessing how the athletes evolve through their different formation stages.

Key words sport, health, prevention, evaluation

Introduction

Athletes train to achieve success in competition. Ideally, sport practice should involve improving or maintaining the physical, psychological, and social wellbeing of the athletes. However, this is not always true (Sundgot-Borgen, 2002). For example, in sports where the aesthetics or weight control is important (e.g. gymnastics or combat sports), many athletes try to reduce their weight with the theoretical goal of being more successful (Sundgot-Borgen, 2002; Steen, Brownell, 1990). These weight control cycles risk affecting athletes' self-perception and health. Additionally, numerous studies have reported the use of inadequate weight control techniques (Artioli et al., 2010a; Ubeda et al., 2010; Valliant, Emplaincourt, Wenzel, Garner, 2012). There are several possible reasons for the use of these unhealthy procedures in athletes, such as stress, social and environmental factors, or stereotypes.

Prevention is widely regarded as the key to combating the risks related to weight control (Rust, 2002; Beals, Brey, Gonyou, 1999; Joy et al., 1997). Coaches focus their efforts on increasing their players' knowledge and skill in the sport, but they should also provide information regarding reducing the risks of their athletes being unhealthy. In order to measure their athletes' needs and the effects of specific continuing education about this topic, an instrument to measure their knowledge and habits is needed. The information about the athletes' knowledge or their nutrition and weight control habits will provide useful information for coaches, federations, and managers to ensure healthy habits in their players and emphasize these aspects in the life of athletes. Ideally, monitoring the health of the athletes and the aspects that affect it should be as important as monitoring the physical or technical aspects. In the bibliography review carried out, several instruments that measure the knowledge and habits of athletes with regard to nutrition or weight control risk have been found (Artioli et al., 2010b; Bonci et al., 2008; Brito et al., 2012; Juzwiak, Ancora-Lopez, 2004; Zawila, Steib, Hoogenboom, 2003). However, those instruments were focused on specific aspects such as knowledge of nutrition or nutritional habits. In order to provide useful tools to coaches and researchers to measure how athletes are evolving or the effect of a specific educational programming, a comprehensive instrument is needed. This instrument must provide information from different perspectives or approaches due to the multi-dimensional aspects that are involved. This information should help coaches, dietitians, sport psychologists, athletes' families, etc. in the process of maintaining the athletes' health. The purpose of this study was to design, validate, and test the reliability of an instrument to evaluate athletes' knowledge about nutrition, weight control and its risks.

Method

The design, validation, and testing of the reliability of the questionnaire were done in four stages: a) design and development of the instrument, b) content validation, c) instrument reliability, and d) concurrent validity (Trochim, Donnelly, 2007). The design and development of the instrument involved the use of specific literature about sport nutrition, weight control and its risks. Reviews in the following databases were done: ISI Web of Knowledge, Medline, SPORTDiscus, Google Scholar, EBSCO, and Dialnet. The key word searches included: "nutrition", "knowledge", "weight control", "eating disorders", "athletes", "survey" (as well as their equivalents in Portuguese and Spanish for the Scielo and Dialnet databases, respectively). A review of abstracts was done to select the papers related to the instrument topic. Questionnaires found in the literature (Artioli et al., 2010b; Bonci et al., 2008; Brito et al., 2012; Juzwiak, Ancora-Lopez, 2004; Zawila, Steib, Hoogenboom, 2003), specific literature (Bean, 2010; Bonci, 2009), and literature about creating an original instrument (Hague, Hague, Morgan, 2004; Thomas, 2004) were used as guides. Some of the questions were translated to Spanish and adapted to be used in different sports such as combat sports, gymnastics, or athletes in general. In the process of designing the first draft of the survey, the researchers, a dietician, two coaches of combat sports, two combat sport athletes, and a former gymnast participated in the process of selecting the questions, adapting or wording the questions, and clarifying them.

From this review, a list of key aspects about the female athlete triad was established. Questions were grouped into: a) athletes' characteristics (10 questions), nutrition knowledge (23 questions), nutrition habits (2 frequency charts), knowledge of weight control and its risks (12 questions), habits and perceptions regarding weight control and its risks (19 questions). For the questions related to socio-demographics of the athletes, open and closed questions were used. For the questions related to nutrition knowledge and weight control and knowledge about it, true/false were used. For questions related to nutrition habits, open questions were used. For habits and perceptions regarding weight control and its risks, open questions and multiple choice items were used.

In the second stage, the instrument was sent to four experts in fields related to at least one of the components of the survey, nutrition or weight control. The experts were asked to evaluate qualitative (open questions) and quantitative questions (scale from 1 to 10) from the survey regarding: degree of understanding of the survey's questions; degree of adequacy of the survey's questions, and the need to reduce or include more questions in the survey. The collective suggestions from the experts were considered, and the appropriate changes were made. A descriptive analysis of their answers (i.e. mean, median, and mode) was also done. Following Bulger and Housner (2007), questions with values lower than 7.0 were eliminated, questions with values between 7.1 and 8.0 were modified, and questions with values greater than 8.1 were accepted or accepted with modifications. With the values from the quantitative evaluation done by the experts, the Aiken's V was calculated (Penfield, Giacobbi, 2004).

In the third stage, the reliability of the instrument was calculated. The questionnaire was completed by Spanish wrestlers and rhythmic gymnasts. The four week test-retest procedure was completed by 12 wrestlers (24.16 ±4.87, national level) and 11 gymnasts (16 ±1.16, international level). A final section allowing for comments took into consideration their understanding of the questionnaire, the time taken to complete the survey, and questions or concerns they had with the instrument. Reliability of each item was calculated using the Kappa Index for each of the questions (categorical variables) using the SPSS software.

In the fourth stage, the ability of the instrument to differentiate between athletes of different age groups was measured (Trochim, Donnelly, 2007). Twenty-one under-16 wrestlers and 20 senior wrestlers who participated in the Spanish National Championship were analyzed (2012–2013 season). An inferential analysis of the data (one-factor ANOVA) was done to establish the existence of differences between wrestlers of both ages using the SPSS 21.0 software, with a level of statistical significance set at $p < 0.05$.

Results

The draft of the survey had 63 questions after the first stage. Sub-scales with 23 points and 12 points were established with regard to the questions pertaining to nutrition knowledge and weight control and its risks, respectively. After reviewing the experts' evaluation of the draft of the survey, vocabulary for four questions were changed. The experts' observations were related to the terms used, the need to clarify the terminology or questions, etc. At this stage, all questions from the draft of the survey had an average score >7.0. The Aiken's V was pertinent (>0.81 for the lowest value).

Table 1. Knowledge scores of nutrition and of weight control and its risks for under-16 wrestlers and senior wrestlers

	Nutrition knowledge		Weight control knowledge	
Type of sport	average	percentage	average	percentage
Under-16 wrestlers	18.24*	68.48	3.15*	78.70
Senior wrestlers	12.93*	76.07	2.68*	67.12

* *p*<.000 (One-factor ANOVA).

From the score of the test-retest carried out with wrestlers and gymnasts, the total reliability of the questionnaire was calculated (the smallest of these calculations). Intra-class correlation coefficients of 0.615 and 0.609 were found for male wrestlers and female gymnasts, respectively. Regarding the ability of the instrument to differentiate theoretically different age groups of wrestlers (Table 1), significant differences were found in the nutrition knowledge score ($p < 0.001$) and weight control and its risks score ($p<.001$) for the wrestlers of different age groups. The final Spanish and English versions of the survey can be found after the references.

Discussion

This paper describes the process done to design and validate a survey to measure knowledge of nutrition, weight control and its risks. In the first stage, the review of the available literature and similar questionnaires was the basis for developing the survey. The information from different sources was translated and adapted to ease understanding and pertinence for athletes from different environments and sports. The combination of internal reviews, mini-pilot studies with athletes and coaches, and the experts' opinions contributed to increasing the clarity, understanding, and proper terminology of the survey. The quantitative evaluation done by experts allowed for the establishment of the pertinence of the sections and questions of the survey (Bulger, Housner, 2007; Escurra, 1989; Padilla, Gómez, Hidalgo, Muñiz, 2007; Zhu, Ennis, Chen, 1998). The levels of content validity found are higher than the proposed minimum (Penfield, Giacobbi, 2004). The level of reliability of the instrument in the test-retest procedure carried out with male wrestlers and female gymnasts was "substantial" (Landis, Koch, 1977). The values showed that it is pertinent at this level (intra-rater reliability). The results show that the survey that was developed has the ability to measure differences between groups that, in theory, are different.

These data show that the instrument can be useful to measure the knowledge of nutrition and weight control and its risks in athletes. The survey has a structure that allows for dividing it into several parts, so it can be used as a whole survey or different parts, depending on the goals and needs. The combination of information related to knowledge and habits allows us to determine what the needs of the athletes are. Future studies are needed about reference values and normative profiles for different sports, genders, and levels of competition in order to properly understand and apply the information provided by the survey.

Conclusions

The process that was followed and the data that were found show that this instrument is suitable for measuring athletes' knowledge of nutrition as well as of weight control and its risks. This instrument can be useful to evaluate the need for specific education and the effect of educational training. Performance sport can involve the risk of developing unhealthy behaviours. Coaches, clubs, institutions, etc. must be proactive to avoid these problems. Prevention is a key aspect to prevent these health problems, and measuring the states and needs of the athletes is part of preventive and proactive actions. More research and specific normative profiles are needed to reduce the risk of inadequate eating and weight control behaviors.

CUESTIONARIO SOBRE NUTRICIÓN, CONTROL DEL PESO Y SUS POSIBLES RIESGOS

El presente cuestionario forma parte de un trabajo de investigación que se está realizando en la Universidad de ________. **El estudio pretende conocer los conocimientos sobre nutrición, control del peso y posibles riesgos que el control del peso puede generar.** Dado que el cuestionario es anónimo, **te rogamos contestes con la mayor sinceridad**, pues los datos obtenidos son de relevancia para el conocimiento de nuestro deporte. Para cumplimentarlo marca los cuadros de las opciones que se plantean en cada pregunta, teniendo en cuenta que, **excepto cuando se indique**, **sólo deberás marcar una respuesta**. Cuando sea necesario, escribe sobre las líneas con letra clara.

Club: ________________ Género: ( ) Femenino ( ) Masculino F. Nacimiento: ______/_____/______ Altura: __________

CUESTIONES SOCIO-DEMOGRAFICAS

1. ¿A qué edad comenzaste a practicar este deporte?____ años
2. ¿A qué edad comenzaste a competir federada? _____años
3. ¿Cuánto pesas? periodo de entrenamiento___ Kg / periodo de competición ___ Kg / vacaciones ___ Kg.
4. ¿Cuál ha sido tu máximo nivel de competición?
   ( ) Regional ( ) Nacional ( ) Europeo ( ) Intercontinental (ej. Campeonato del mundo)
5. ¿Cuántas veces competiste el año pasado en competiciones oficiales? ___ veces
6. ¿Cuántas horas semanales y sesiones entrenas este deporte? Horas semanales _______ Sesiones semanales _______

CUESTIONES SOBRE NUTRICION

A continuación se presentan una serie de afirmaciones sobre conocimientos en nutrición. Señala en la columna si estás de acuerdo o no con cada una de ellas.

	Si	No
7. Son los cereales, el yogurt y la leche desnatada buenas opciones para tomar en el desayuno.		
8. Las nueces y la fruta no son consideradas como un buen tentempié para tomar en competición.		
9. El arroz, la pasta, las patatas y el pan son buenos alimentos para la semana previa a la competición.		
10. Los deportistas necesitan constantemente más proteínas que las personas sedentarias.		
11. Una dieta adecuada tiene aproximadamente una proporción de 20-35% de hidratos, 45-65% de grasas y 10-15% de proteínas.		
12. Tras el entrenamiento, se debe evitar comer alimentos salados (patatas), cereales y sándwich.		
13. La última comida previa a la competición debe realizarse 3-4 horas antes de su inicio.		
14. Antes de los entrenamientos matutinos se recomienda hacer un desayuno ligero.		
15. Es recomendable tomar entre 3-5 piezas de fruta al día.		
16. Cien gramos de ternera contienen menos proteínas que cien gramos de merluza.		
17. Las grasas son los nutrientes que contienen más calorías (por cantidad de peso).		
18. El azúcar y la fruta aportan hidratos a la dieta y favorecen la recuperación.		
19. La ingesta de fruta en nuestra dieta es importante porque es fuente natural de azúcar, vitaminas, minerales, antioxidantes y fibra.		
20. En el proceso de recuperación de un deportista, la hidratación no es importante.		
21. La ingesta de suplementos de vitaminas y minerales no es necesaria para un deportista de alto nivel si se realiza una dieta equilibrada (completa).		
22. Al realizar una actividad intensa y de corta duración (1-2 min) nuestro cuerpo obtiene principalmente la energía a través de los hidratos de carbono.		
23. El uso excesivo de laxantes y/o diuréticos naturales disminuye el estrés que sufre el organismo.		
24. Las vitaminas y minerales nos aportan energía.		
25. En un día normal de entrenamiento se debe beber entre 1 litro y 2 litros (entre 4 y 7 vasos de agua).		
26. En competición no es importante hidratarse constantemente (al menos cada 15-30 minutos).		
27. Síntomas de la deshidratación son perdida repentina de energía, temprana fatiga, dolor de cabeza, etc.		
28. Por cada kilo perdido tras entrenamiento o competición, se debe beber entre 1 y un 1,5 litros.		
29. En entrenamientos previos a la competición, es aconsejable beber únicamente antes de entrenar.		
30. En los días previos a la competición, se recomienda aumentar la ingesta de grasas.		
31. Consumir alimentos ricos en fibra producen la sensación de estar lleno.		

32. ¿Con qué frecuencia tomas algunos de los siguientes alimentos en periodo de entrenamiento (en la presente temporada)? (Pon una cruz en las casillas correspondientes)

	Varios o varias veces al día	Una vez al día	3 a 5 veces por semana	1 a 2 veces por semana	Algunas veces al mes	Rara vez o nunca
Leche						
Yogur						
Queso						
Mantequilla y/o margarina						
Carne						
Embutidos (chorizo, morcilla...)						
Hamburguesas o salchichas						
Pescado						
Huevos o tortilla						
Frutas						
Verduras y hortalizas						
Legumbres (garbanzos, lentejas...)						
Cereales (pasta, arroz, trigo, maíz…)						
Pan						
Galletas, bizcochos, bollería…						
Precocinados (comida rápida)						
Frutos secos						
Aperitivos de bolsa, gusanitos...						
Golosinas						
Otros (__________________)						

CUESTIONES SOBRE CONTROL DEL PESO Y LOS RIESGOS QUE IMPLICA ESTE

A continuación se presentan una serie de afirmaciones sobre control del peso y sus respectivos riesgos. Señala en la columna si estás de acuerdo o no con cada una de ellas.

	Si	No
33. Los cambios bruscos de peso no afectan a la salud física ni a la salud mental.		
34. Aumentar los entrenamientos y disminuir la ingesta, aumenta el estrés que sufre el organismo.		
35. Saltarse las comidas es justificable cuando se necesita lograr una rápida bajada de peso.		
36. La pérdida de peso hace que las reservas de energía y los fluidos corporales estén en desequilibrio.		
37. La bulimia nerviosa se caracteriza por fuertes atracones de comida, seguido de vómitos.		
38. Un atleta que sufre un trastorno de la conducta alimenticia o se encuentra en riesgo de padecerlo, tiene un aumento de su rendimiento.		
39. La triada atlética femenina se compone de amenorrea, osteoporosis y un trastorno de la conducta alimenticia.		
40. Los trastornos de la conducta alimenticia pueden ser fatales.		
41. La combinación de una excesiva práctica deportiva y una disminución prolongada de ingesta de alimento, puede causar la perdida de densidad mineral de los huesos (osteoporosis).		
42. La anorexia nerviosa incluye el fracaso de mantener un peso corporal normal, para la edad y altura de una persona; y el miedo intenso a ganar peso.		
43. Las demandas energéticas de un deportista varían en función del momento de la temporada.		
44. El organismo necesita unos niveles mínimos de grasas para su correcto funcionamiento (6-13% para hombres y 12-18% para mujeres).		
45. Controlar el peso es una manera adecuada de monitorizar el efecto de un cambio en tu alimentación.		
46. Cuando uno pierde peso, únicamente pierde la grasa acumulada en su cuerpo.		
47. Una persona en crecimiento (normalmente hasta 18-20 años de edad) tiene unas demandas diferentes que una persona que ha finalizado su crecimiento.		
48. La composición corporal de una persona se puede reducir a través de la reducción de la ingesta y/o el incremento de ejercicio físico.		
49. El color de la orina es una buen método para controlar nuestro nivel de hidratación.		
50. En caso de trastornos alimenticios, el rol del entrenador y familia es detectar la posible existencia de un problema, derivar al deportista a un especialista, y ayudar en el proceso de tratamiento.		

51. ¿Controlas tu peso con regularidad?
( ) A diario ( ) Semanalmente ( ) Mensualmente ( ) Con menos frecuencia ( ) Nunca

52. ¿Cuántas comidas haces al día? (ej. desayuno, tentempié a media mañana, comida, merienda y cena)
( ) Una ( ) Dos ( ) Tres ( ) Cuatro ( ) Cinco ( ) Seis o más

53. ¿Has modificado alguna vez tu peso para competir?. En caso de responder “NO" pasa directamente a la pregunta 58.
( ) Sí, he perdido ( ) No, nunca he cambiado de peso para competir

54. ¿Has tenido alguna supervisión o recomendación en este proceso de pérdida de peso? Señala todas las que correspondan
( ) Ninguno ( ) Entrenador ( ) Otros deportistas
( ) Familiares ( ) Amigos ( ) Directivos club
( ) Nutricionista ( ) Medico ( ) Otros (________________________)

55. Marca el grado de influencia que tiene cada persona que aparece a continuación cuando cambias tu peso (ej. persona de referencia en tu deporte, persona que te presta información, da consejos...). (0 ▯ no influye / 10 ▯ máxima influencia)

Yo mismo	0 1 2 3 4 5 6 7 8 9 10
Compañeros	0 1 2 3 4 5 6 7 8 9 10
Entrenador	0 1 2 3 4 5 6 7 8 9 10
Fisioterapeuta	0 1 2 3 4 5 6 7 8 9 10
Psicólogo	0 1 2 3 4 5 6 7 8 9 10
Padres/familiares	0 1 2 3 4 5 6 7 8 9 10
Amigos	0 1 2 3 4 5 6 7 8 9 10
Medico	0 1 2 3 4 5 6 7 8 9 10
Internet/ foros	0 1 2 3 4 5 6 7 8 9 10
Dietista	0 1 2 3 4 5 6 7 8 9 10
Otros (_____________)	0 1 2 3 4 5 6 7 8 9 10

56. ¿Te han diagnosticado clínicamente un trastorno de la conducta alimenticia alguna vez? (marca todas las que corresponda)
( ) No ( ) Anorexia ( ) Bulimia ( ) Otros (indica cual) __________________

57. Indica empleando la siguiente tabla, ¿Has usado alguno de los siguientes métodos para perder peso?

	Siempre	A veces	Casi nunca	Nunca lo he usado
Comer menos				
Restricción de hidratos de carbono				
Restricción de grasas				
Saltarse comidas				
Ayunar (no comer en todo el día)				
Reducir la ingesta de líquidos				
No beber				
Incrementar el ejercicio				
Saunas				
Tomar laxantes, diuréticos…				
Vomitar				
Otros (______________________)				

58. Señala el grado de satisfacción con tu imagen (responde en una escala de 0 a 10)_________
59. Señala el grado de satisfacción con tu peso (responde en una escala de 0 a 10)_________
60. ¿Cuál es tu peso ideal? _________
61. ¿Crees que tienes conocimiento suficiente sobre…? (responde de 0 a 10).
Nutrición y alimentación ______
Control del peso ______
Riesgos que entrañan el control peso (anorexia, bulimia…) ______

62. ¿Has recibido alguna vez información sobre…? (marca las que corresponda e indica por parte de quien has recibido la información)
( ) Nutrición y alimentación (He recibido información por parte de ___________________________)
( ) Control del peso (He recibido información por parte de ___________________________)
( ) Riesgos control del peso (anorexia, bulimia…) (He recibido información por parte de ___________________________)
( ) Otros (_________________________) (He recibido información por parte de ___________________________)

63. ¿Qué logras cuando pierdes o ganas peso? (marca todas las que corresponda)

Mi rendimiento	( ) Empeora	( ) No varia	( ) Mejora
Mi estado de salud	( ) Empeora	( ) No varia	( ) Mejora
Mi apariencia	( ) Empeora	( ) No varia	( ) Mejora

64. ¿Crees que hay un problema relacionado con el control del peso en tu deporte (ej. falta de conocimiento, hábitos, entorno…)?
( ) No ( ) Sí (Si respondes "SI", indica cual) ____

65. ¿Crees que hay un problema relacionado con los trastornos de la conducta alimenticia (anorexia, bulimia,…) en tu deporte (ej. falta de conocimiento, hábitos, entorno…)?
( ) No ( ) Sí (Si respondes "SI", indica cual) ____

¡GRACIAS POR TU COLABORACIÓN!

Observaciones (usa este espacio para realizar cualquier observación o comentario con los aspectos abordados en este cuestionario):

QUESTIONNAIRE ABOUT NUTRITION, WEIGHT CONTROL AND ITS POSSIBLE RISKS

This questionnaire is part of a research study being carried out at the University of ________. **The study is an attempt to assess your knowledge of nutrition**, **weight control and the possible risks involved with weight control**. Since the questionnaire is anonymous, **we ask that you respond as sincerely as possible**. The data you provide are very important for the knowledge of our sport. To complete the questionnaire, mark an X under the response that best corresponds to your answer, keeping in mind that **unless otherwise indicated**, **there should only be one answer**. When necessary, print clearly on the lines provided.

Club: ________________ Gender: ( ) Female ( ) Male Birthdate: ______/_____/______ Height: __________

SOCIO-DEMOGRAPHIC QUESTIONS

1. At what age did you begin to practice this sport?____years
2. At what age did you begin to compete with your club? _____years
3. How much do you weigh? during training ___ Kg / during competition ___ Kg / in the off-season ___ Kg.
4. What is the highest competitive level you have reached?
   ( ) Regionals ( ) Nationals ( ) European competition ( ) Intercontinental (e.g. World Championship)
5. How many times have you competed this year in official competitions? ___ times
6. How many weekly hours and training sessions do you train for this sport? Weekly hours _______ Weekly sessions _______

NUTRITION QUESTIONS

Next there is a series of statements about nutrition knowledge. Mark in the corresponding column whether or not you agree with each of these statements.

	Yes	No
7. Cereal, yogurt, and skim milk are good options for breakfast.		
8. Nuts and fruit are not considered to be a good snack to have during a competition.		
9. Rice, pasta, potatoes, and bread are good foods for the week before the competition.		
10. Athletes always need more protein than sedentary people.		
11. An appropriate diet has an approximate proportion of 20-35% of carbohydrates, 45-65% of fats, and 10-15% of proteins.		
12. After training, you should avoid eating salty foods (chips), cereal, and sandwiches.		
13. The last meal before competition should be eaten 3-4 hours before the start.		
14. Before morning training sessions, a light breakfast is recommended.		
15. It is recommended that you eat 3-5 pieces of fruit per day.		
16. One hundred grams of beef has less protein than one hundred grams of fish.		
17. Fats are the nutrients with the most calories (by weight).		
18. Sugar and fruit provide carbohydrates to the diet and promote recovery.		
19. Fruit intake is important in your diet, because it is a natural source of sugar, vitamins, minerals, antioxidants, and fiber.		
20. In an athlete's recovery process, hydration is not important.		
21. Taking vitamin supplements and minerals is necessary for athletes, even when they eat a well-balanced diet.		
22. When executing an intense, short (1-2 mins) activity, our body primarily obtains energy through carbohydrates.		
23. Excessive use of laxatives and/or natural diuretics decrease the stress that the body suffers.		
24. Vitamins and minerals provide the body with energy.		
25. On a normal training day, an athlete should drink between one and two liters (4-7 glasses) of water.		
26. In competition, it is important to constantly hydrate oneself (at least each 15-30 minutes).		
27. Dehydration symptoms include sudden lack of energy, premature fatigue, headache, etc.		
28. For each kilogram of weight lost after training or competition, an athlete should drink one and one and a half liters.		
29. In training sessions before competition, it is recommended that you drink only before training.		
30. In the days leading up to a competition, it is recommended that you increase your fat intake.		
31. Consuming fiber-rich foods produces satiety (feeling of fullness).		

32. How often do you consume these foods when you are training for your sport (in the current season)? (Mark an X in the corresponding box)

	Several times per day	Once per day	3-5 times per week	1 - 2 times per week	Several times per month	Rarely or never
Milk						
Yogurt						
Cheese						
Butter and/or margarine						
Meat						
Cold meat (sausage)						
Hamburgers or hotdogs						
Fish						
Eggs						
Fruit						
Vegetables						
Legumes (garbanzos, lentils...)						
Grains (pasta, rice, wheat, corn…)						
Bread						
Cookies, cakes, pastries…						
Precooked (fast food)						
Nuts						
Bagged snacks, chips….						
Candy						
Other (__________________)						

QUESTIONS ABOUT WEIGHT CONTROL AND THE RISKS INVOLVED WITH IT

Next, there are a series of statements about weight control and its risks. Mark in the column whether or not you agree with each statement.

	Yes	No
33. Sudden changes in weight do not affect one's physical or mental health.		
34. Increasing training sessions and decreasing intake increases the stress that is put on the body.		
35. Skipping meals is justifiable when you need to achieve rapid weight loss.		
36. Weight loss causes an imbalance in energy reserves and body fluids.		
37. Bulimia nervosa is characterized by large binges followed by self-induced vomiting.		
38. An athlete who suffers an eating disorder or who is at risk of suffering one has an increase in performance.		
39. The female athlete triad is made up of amenorrhea, osteoporosis, and an eating disorder.		
40. Eating disorders can be fatal.		
41. The combination of excessive sports practice and a prolonged decrease in food intake can cause bone mineral density loss (osteoporosis).		
42. Anorexia nervosa includes the failure to maintain a normal body weight for one's age and height as well as the intense fear of gaining weight.		
43. The energetic demands of an athlete vary according to the point in the season.		
44. The body needs a minimum level of fat to function correctly (6-13% for men and 12-18% for women).		
45. Monitoring your weight is an adequate way to monitor the effect of a change in your diet.		
46. When you lose weight, you only lose body fat.		
47. A growing person (normally until 18-20 years of age) has different demands than a person who has finished growing.		
48. Body composition can change through reduced intake and/or increased exercise.		
49. Monitoring urine color is a good method to monitor your level of hydration.		
50. When an athlete suffers from an eating disorder, the role of coaches and family is to detect the possible existence of a problem, to refer the athlete to a specialist, and to provide support in the treatment process.		

51. Do you regularly weigh yourself?
( ) Daily ( ) Weekly ( ) Monthly ( ) Less frequently ( ) Never

52. How many meals do you eat per day? (e.g. breakfast, mid-morning snack, lunch, afternoon snack, and dinner)
( ) One ( ) Two ( ) Three ( ) Four ( ) Five ( ) Six or more

53. Have you ever modified your weight to compete? If you respond NO, skip to question number 58.
( ) Yes, I have lost weight ( ) No, I have never changed my weight to compete

54. Have you had any supervision or recommendations in this weight loss process? From whom? Mark all that apply:
( ) No one ( ) Coach ( ) Other athlete
( ) Family member ( ) Friend ( ) Club manager
( ) Dietician ( ) Doctor ( ) Other (_________________________)

55. Mark the degree of influence that each person listed below has had when you have tried to change your weight (e.g. reference person in your sport, person who provides information, gives you advice, etc.). (0 ▯ no influence / 10 ▯ maximum influence)

Yourself	0 1 2 3 4 5 6 7 8 9 10
Teammates	0 1 2 3 4 5 6 7 8 9 10
Coach	0 1 2 3 4 5 6 7 8 9 10
Physical therapist	0 1 2 3 4 5 6 7 8 9 10
Psychologist	0 1 2 3 4 5 6 7 8 9 10
Parents/family members	0 1 2 3 4 5 6 7 8 9 10
Friends	0 1 2 3 4 5 6 7 8 9 10
Doctor	0 1 2 3 4 5 6 7 8 9 10
Internet/ forum	0 1 2 3 4 5 6 7 8 9 10
Dietician	0 1 2 3 4 5 6 7 8 9 10
Other (_____________)	0 1 2 3 4 5 6 7 8 9 10

56. Have you ever been clinically diagnosed with an eating disorder? (mark all that correspond)
( ) No ( ) Anorexia ( ) Bulimia ( ) Other (which?) __________________

57. Indicate whether you have ever used the following methods to lose weight. Mark the corresponding box.

	Always	Sometimes	Rarely	Never
Eat less				
Restrict carbohydrates				
Restrict fats				
Skip meals				
Fast (refrain from eating all day long)				
Reduce liquid intake				
Refrain from drinking				
Increase exercise				
Sauna				
Use laxatives, diuretics…				
Vomit				
Other (_______________________)				

58. Indicate the degree of satisfaction you have with your body on a scale from 0 to 10, with 10 being very satisfied _________
59. Indicate the degree of satisfaction you have with your weight on a scale from 0 to 10, with 10 being very satisfied _________
60. What is your ideal weight? _________
61. Do you think you have sufficient knowledge of the following? Respond using a scale from 0 to 10, with 10 being the most knowledge)
Nutrition and diet ______
Weight control ______
Risks involving weight control (anorexia, bulimia…..)______

62. Have you ever received information about the following? (mark any that apply and fill in from whom you received the information)
( ) Nutrition and diet (I've received information from _________________________)
( ) Weight control (I've received information from _________________________)
( ) Weight control risks (anorexia, bulimia…) (I've received information from _________________________)
( ) Other (_________________________) (I've received information from _________________________)

63. What results do you find when you lose weight? (mark any that apply)
My performance ( ) Worsens ( ) Does not vary ( ) Improves
My health ( ) Worsens ( ) Does not vary ( ) Improves
My appearance ( ) Worsens ( ) Does not vary ( ) Improves

64. Do you think there is a problem related to weight control in your sport? (e.g. lack of knowledge, habits, environment, etc.)
( ) No ( ) Yes (If yes, what?) ____

65. Do you think there is a problem related to eating disorders (anorexia, bulimia,…) in your sport? (e.g. lack of knowledge, habits, environment, etc.)
66. ( ) No ( ) Yes (If yes, what?) ____

THANK YOU FOR YOUR COLLABORATION!

Comments (use this space to make any observations or comments regarding any aspect touched on in this questionnaire):

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ASSESSMENT OF THE PROGRESS OF TREATMENT REHABILITATION OF PATIENTS WITH SHOULDER JOINT DISEASES

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Abstract Introduction: Damage to soft tissue in the shoulder area causes significant impairment in the biomechanics of the joint, causing severe pain, inflammation and consequently leading to restricted mobility and functional capacity. The shoulder impingement syndrome is a multifaceted disease entity of diverse etiology. It is assumed that this syndrome is responsible for 44–60% of all ailments in the area of the pectoral girdle. Pathologies of soft tissues in the area of the glenohumeral joint affect 1/3 of the population. The aim of this study was to evaluate the functional capacity of patients with the shoulder area disorder undergoing sanatorium treatment.

Materials and Methods: In the study 30 patients were diagnosed with diseases within the shoulder joint before and after rehabilitation treatment. The clinical examination included kinematic measurement of the range of motion (ROM) and the muscle strength of the shoulder joint. Furthermore, the pain intensity was assessed using the VAS.

Results: The examination of the range of motion of the affected upper limb demonstrated considerable limitations and statistically significant differences before and after rehabilitation treatment for all the assessed movements. Moreover, the difference between the level of pain according to the VAS before (mean = 6.2) and after physiotherapeutic treatment (mean = 3.7) was demonstrated. The evaluation of linear relationships showed a significant correlation between the VAS and shoulder abduction, shoulder horizontal abduction and muscle strength for internal and external rotation after sanatorium treatment.

Conclusions: Progressive changes in the soft tissues of the shoulder joint cause a significant limitation of functional capacity of patients and severe pain. Rehabilitation treatment significantly increases active participation in daily life and improve patient quality of life.

Key words shoulder joint, shoulder impingement syndrome, soft tissue damage, rehabilitation, manual therapy

Introduction

Dysfunctions within the shoulder joint are one of the most common causes of pain in the musculoskeletal system. It is estimated that the diseases in the shoulder area affect 21% of older people. In the United States, rotator cuff tendinopathy accounts for approximately 4.5 million annual physician visits, with treatment and management reaching an estimated USD 3 billion annually. If we include indirect costs, such as lost time from work, this number is even larger (Judge, Murphy, Maxwell, Arden, Car, 2014). Pain and impaired motor function may have a significant impact on coping with activities of daily living and consequently lead to disability and reduced quality of life. Therefore, maintaining the independence and efficiency of older people should be the primary objective in planning effective physiotherapy (Bennell et al., 2010; Romero et al., 2015).

Shoulder impingement syndrome is a multifaceted disease entity of diverse etiology (Rotter, Mosiejczuk, Żugaj, Ptak, Lubińska, 2015). Its most common causes are injuries of the rotator cuff, occurring in 4% of adults aged 40–60 years to as much as 54% of people above 60 years of age (Chen, Peng, Zhang, Peng, Xing, 2015). Subsequently, there is synovitis, tendonitis, joint instability, pressure overload and micro trauma to soft tissues and fractures, degenerative changes (Haik, Albuquerque-Sendin, Moreira, Pires, Camargo, 2016). Other causes can include damage to the brachial plexus, discopathy and spondylosis, compression neuropathies and thoracic outlet syndrome (Piskorz, Iłżecka, Wójcik, Kozak-Putowska, 2014). The first symptom appearing in the damaged shoulder area is pain radiating to the outside of the shoulder in the direction of the neck and shoulders. In addition, there are disorders of proprioception and a reduction in joint movement, particularly in abduction, rotation movements and bending. Muscle strength is weakening, causing muscular atrophy within the arm and shoulder. Disorders occurring in proper functioning of the shoulder area result in taking pain relief positions. Due to the circumstances mentioned above, patients often report limiting of activities of daily living and reduced participation in social life (Gutierrez, Thompson, Kemp, Mulroy, 2007; Kuciel-Lewandowska, Wierzchowska, Paprocka-Borowicz, Kierzak, Pozowski, 2010).

According to recent studies that evaluated the efficacy of exercise or manual therapy in the setting of rotator cuff disease, and concluded that no clinical benefit exists for such interventions over placebo or other treatments (Khan, Warner, 2017). In our opinion further investigations are needed because it is very difficult and important topic to discuss. An effective therapy is based on the understanding of aging and major age-related changes both in the joints and muscles. The intervention of physiotherapy is often the first choice solution in the conservative treatment. The terminology of the shoulder impingement syndrome is imprecise and cannot provide a definitive diagnosis and therefore, it is extremely important to make a detailed diagnosis based on a careful history and physical examination in order to ascertain the actual cause of discomfort within the shoulder joint. This will result in selecting appropriate therapeutic methods in order to target at the damaged structure and thus completely restore lost functions (Chester, Shepstone, Lewis, Jerosch-Herold, 2013; Koh, Jae-Young, 2013; Romero et al., 2015).

To the best of our knowledge, ours is the first study investigating functional assessment of shoulder girdle. The aim of the study was to assess the change in the functional capacity of patients undergoing sanatorium treatment for shoulder pain.

Material and methods

The study involved 30 patients diagnosed with the shoulder impingement syndrome before and after a rehabilitation treatment. The study was performed according to the Helsinki declaration. A group of women comprised 20 patients (66.7%) at the age of 63.1 years (SD = 10.6), while a group of men consisted of 10 patients (33.3%) at the age of 61.7 years (SD = 6.6). The characteristics of the studied groups are presented in Table 1.

Table 1. Characteristics of the studied group

Variable		n	%
Gender	female	20	66.7
	male	10	33.3
Age	≤60	10	33.3
	>60	20	66.7

The inclusion criteria comprised pain and disease diagnosis (diagnosed by general practitioner, considering x-ray pictures and physical examination) within one shoulder joint, as well as participation in a 3-week rehabilitation including targeted manual therapy. The examination of the second upper limb should reveal advanced lesions. The exclusion criterion was the shoulder joint pain as a secondary symptom of pain caused by structures not directly in the shoulder. We excluded patients with previous surgeries, cancer, rheumatoid arthritis and fibromyalgia. The subjects gave their conscious and voluntary consent to participate in the research.

There is a large number of instruments that assess symptoms and function of the shoulder. More than 30 different tools can be found by entering “shoulder” and “assessment” into MEDLINE and conducting a review of the ≥3,000 retrieved references. We decided to use the most widespread and best-tested and characterized instrument for shoulder assessment. Diagnostic labels are commonly applied to patients with shoulder pain, such as capsulitis, bursitis and subacromial impingement syndrome (May, Chance-Larsen, Littlewood, Lomas, Saad, 2010). Our approach is to analyse the patient’s current state not focusing on labels. The rehabilitation protocol was set up individually for each patient and was adapted to its current state. The therapist used PNF techniques, deep tissue massage, as well as selected mobilization techniques for the shoulder joint. One session with the therapist lasted from 45 to 60 minutes. The clinical examination included the measurement of kinematic range of motion (ROM) and strength of shoulder joint muscles. In order to record the results the SFTR method (*S – sagittal, F – frontal, T – transverse, R – rotation*), developed by ISOM (*International Standard Orthopedic Measurements*), was used. The muscle strength for shoulder abduction, external and internal rotation were examined using the MRC modified scale (*Medical Research Council*), in which 0 is no muscle contraction, 1 – perceptible movement when attempting to contract, 2 – ability to move only if the resistance of gravity is removed, 3 – ability to perform a movement in the current scope against the force of gravity, 4 – the ability to perform an active movement with extra resistance, 5 – correct muscle strength. The scale of the MRC is the preferred research tool because of the high rate of compatibility assessment and strong relevancy (Paternostro-Sluga, Grim-Stieger, Posch, Schuhfried, Vacariu, 2008). Furthermore, the degree of pain was measured using the VAS. The Visual Analogue Scale pain assessment is a tool to determine the intensity of pain. The scale consists of a 10 cm horizontal line. The respondent indicates a point on the line, where 0 – means no pain, and 10 – the strongest pain imaginable (Hawker, Mian, Kendzerska, French, 2011).

The results were subjected to a statistical analysis in Statistica 12 PL. The level of statistical significance was set at $\alpha = 0.05$. Average values with standard deviation were used in order to describe the statistical analyses of the examined quantitative variables. The differences between variables before and after rehabilitation treatment: the VAS, range of motion and muscle strength were compared using the Wilcoxon test. The dimensional relationship between the study variables was examined using the Spearman's rank correlation.

Results

More than half of the study group (56.7%) experience shoulder joint pain lasting for less than two years. On the other hand, among 16.7% of patients the pain lasts from two to five years. The diagnosis on the medical examination referral was the shoulder impingement syndrome. The most common location of pain among the patients was shoulder pain radiating to the elbow (33.3%) and arm (30%), as well as the pain located at the top of the shoulder (23.3%) (Table 2).

Table 2. Characteristics of the examined variables

Variable		n	%
Location of pain	shoulder pain radiating to elbow	10	33.3
	upper back-of-shoulder	4	13.3
	top of shoulder	7	23.3
	shoulder pain radiating to elbow	9	30.0
When pain began	<2 years	17	56.7
	from 2 to 5 years	5	16.7
	from 5 to10 years	4	13.3
	>10years	4	13.3

The average value of the VAS before treatment and rehabilitation was 6.2 (SD = 2.1), and after treatment decreased almost twice – 3.7 (SD = 2.3). Statistical analysis of the distribution of the VAS in the group of subjects showed significant differences before and after a manual therapy ($p < 0.001$) (Table 3).

Table 3. Results of the VAS before and after rehabilitation therapy

Variable	Visual Analogue Scale						
	N	mean	SD	Q1	Me	Q3	p
Before rehabilitation therapy	30	6.2	2.1	4	6	8	<0.001*
After rehabilitation therapy	30	3.7	2.3	2	3	5	

* p < 0.05 statistically significant value compared with the score after treatment and rehabilitation; the Wilcoxon for paired samples.

The examination of mobility of the upper limb with lesions around the shoulder joint showed significant differences before and after treatment for movements of extension ($p = 0.001$), flexion ($p < 0.001$) abduction ($p < 0.001$), horizontal abduction ($p = 0.003$), horizontal adduction ($p = 0.011$), external rotation ($p = 0.005$) and internal rotation (p = 0.04). The biggest differences in the ranges could be seen for flexion. Before the treatment, the mean range of flexion was 139.5°; after the treatment it was increased to 154.8°. In the case of abduction the difference is more than 18°. For horizontal adduction the average value of the range before the rehabilitation was over 105 degrees, but after three weeks, the mean range of motion, which the patients achieved, was 114° (Table 4).

Table 4. The results of the measurement range of motion of the upper limb before and after rehabilitation treatment

Movement (°)	Before rehabilitation						After rehabilitation						p
	N	mean	SD	Q1	Me	Q3	N	mean	SD	Q1	Me	Q3	
Extension	30	41.20	11.6	40	45.0	50	30	46.3	8.3	50	50	50	0.001*
Flexion	30	139.50	38.6	120	155.0	170	30	154.8	27.4	155	170	170	<0.001*
Abduction	30	115.00	44.9	80	120.0	150	30	133.3	39.3	100	150	170	<0.001*
Horizontal abduction	30	18.17	11.3	10	20.0	30	30	22.8	10.2	20	30	30	0.003*
Horizontal adduction	30	105.80	45.0	100	127.5	135	30	114.2	40.4	110	135	135	0.011*
External rotation	30	50.50	13.5	45	60.0	60	30	54.7	10.7	50	60	60	0.005*
Internal rotation	30	59.00	23.5	70	70.0	70	30	60.5	20.8	70	70	70	0.040*

* p < 0.05 statistically significant value compared with the score after treatment and rehabilitation; the Wilcoxon for paired samples.

The test of muscle strength according to the MRC scale showed significant differences before and after rehabilitation for abduction movements (p = 0.012), external rotation (p = 0.018) and internal rotation (p = 0.012). The difference between the average values of muscle strength in the six level scale (0–5) was small – 0.2. The lowest strength was observed for the abduction movement both before (mean = 3.6), and after rehabilitation (mean = 3.8). For external rotation the average muscle strength was 4.1 before the treatment and 4.3 after it. The largest muscle strength was demonstrated for internal rotation – 4.4 during the first test and 4.6 at the end of the treatment. The MRC scale results indicate that most patients had the ability to move actively under the load (Table 5).

Table 5. The results of the measurement of muscle strength (MRC) of the upper limb before and after a rehabilitation treatment

Muscle strength	Before rehabilitation						After rehabilitation						p
	N	Mean	SD	Q1	Me	Q3	N	Mean	SD	Q1	Me	Q3	
Abduction	30	3.6	0.65	3	3.5	4	30	3.8	0.75	3	4	4	0.012*
External rotation	30	4.1	0.58	4	4.0	4	30	4.3	0.70	4	4	5	0.018*
Internal rotation	30	4.4	0.76	4	5.0	5	30	4.6	0.72	5	5	5	0.012*

* p < 0.05 statistically significant value compared with the score after treatment and rehabilitation; the Wilcoxon for paired samples.

Table 6. Spearman correlation between two variables

After rehabilitation treatment			
Variable	N	rho	p
VAS vs. abduction	30	–0.39	0.003*
VAS vs. horizontal abduction	30	–0.43	0.019*
VAS vs. muscle strength for internal rotation	30	–0.47	0.008*
VAS vs. muscle strength for external rotation	30	–0.37	0.045*
Internal rotation vs. muscle strength for internal rotation	30	0.53	0.003*

* p < 0.05 statistically significant value.

A negative correlation was observed for mean score after a therapy between the VAS, abduction (rho = –0.39, p = 0.003) and horizontal abduction (rho = –0.43, p = 0.019), and between the VAS scale and MRC for the movement of external rotation (rho = –0.47, p = 0.008) and internal rotation (rho = –0.37, p = 0.045) (Table 6).

Moreover, the relationship between one-dimensional range of motion and muscle strength was assessed. A significant positive correlation was found between the rotation and the inner muscle strength corresponding to this movement after a rehabilitation treatment (rho = 0.53, p = 0.003) (Table 6).

Discussion

The shoulder impingement syndrome is still the most common diagnosis with which the patient comes to the therapist. This vague terminology, which refers to joint diseases, causes numerous inaccuracies and therapeutic problems. The shoulder joint is a fundamental part of the kinematic chain of the upper limb, and the pain within it is often long-lasting and difficult to treat. We confirmed our hypothesis. Our results compiled with data known from the literature. The search for effective forms of physiotherapy is based on the correct diagnosis, the use of targeted therapies and thereby accelerating the regeneration of damaged structures and improving patients' quality of life (Kuciel-Lewandowska et al., 2010).

In the self-examination the symptoms of each patients were diagnosed as the shoulder impingement syndrome. The survey showed, however, the diversity in the location of the pain, suggesting damage to the shoulder within a few structures and the need for further investigation in order to ascertain the cause of the ailment.

The absence of a diagnosis or its inaccuracy often results in implementing schematic and general rehabilitation, which does not produce the desired results and, consequently, also can worsen the current condition of the patient. A reliable and proper diagnosis is the basis of effective physiotherapy (Kuciel-Lewandowska et al., 2010).

Pain is the dominant symptom in damage to the structures of the shoulder joint, limiting the activities of daily living (combing hair, reaching behind the back, dressing) (Wroński, 2013). Our study showed significant differences before and after the treatment in the level of pain. The average degree of the VAS was 6 degrees and decreased almost twice following the treatment. Chronic pain has a serious impact on the functional abilities of patients. There was a significant correlation between the VAS and range of abduction and horizontal abduction as well as muscle strength in the MRC scale for rotary movements.

Park, Choi, Lee, Kim (2013) showed a reduction in pain in the VAS for patients with shoulder impingement who had undergone stabilization exercises compared to the patients who had been treated with basic forms of physiotherapy. Shakeri, Keshavarz, Arab, Ebrahimi (2013) in their study used the Kinesio ® Taping Method in the research group and neutral application (placebo) in the control group. Significant differences between in the level of night pain and when moving were observed in the research group. The authors suggest that the application of the Kinesio ® Taping Method causes an immediate reduction in movement pain in patients with the shoulder impingement syndrome. The reduction of pain was also observed by Garrido, Vas, Lopez (2016) who used the research group acupuncture for shoulder impingement, paying attention to the safety and clinical efficacy of the method. The effectiveness of these therapies proves that the source of emerging problems within the shoulder is soft tissue damage and thus eliminates the suspected causes of joint.

Damage to structures within the shoulder joint causes severe pain. As a result, patients take a pain relief position, disrupting the normal biomechanics of the upper limb. The consequence of this is a reduction in range of motion, muscle weakness and atrophy of muscles around the arm and shoulder (Rotter et al., 2015).

The average range of motion in the shoulder joint was below the standards adopted by the ISOM. The study of mobility of the upper limb with lesions showed significant differences before and after a treatment for all movements. Similar results have been shown for muscle strength in the MRC scale for abduction, external rotation, and internal rotation. The analysed parameters were higher after an individual treatment.

Similar results were obtained by Rotter et al. (2015), showing an improvement in the range of motion and muscle strength after the rehabilitation. The group who underwent the PNF treatment achieved better results. The PNF method was also used by Sipko, Mraz, Demchuk-Wlodarczyk, Miażdżyk (2005), reaching comparable results in patients with the shoulder impingement syndrome. On the other hand, Kokosz, Sodel, Saulicz, Wolny, Knapik (2009) compared the standard method of kinesiotherapy with the Mulligan concept. The research group obtained better results in the ROM and in relieving pain. Galace de Freitas, Marcondes, Monteiro, Rosa, de Moraes Baros Fucs, Fukunda (2014) assessed the function of the shoulder joint and the degree of pain comparing the effectiveness of exercise for the patients with a 3-week session of low-frequency magnetic field and in the patients who received placebo. It has been shown that a combination of kinesiotherapy with physiotherapy effectively increases the function and strength of rotation movement as well as pain relief.

These results support the use of physiotherapy with particular emphasis on individually adjusted manual techniques supplemented with physiotherapy that will effectively improve the biological functions of the shoulder joint. The diagnosis which is too general significantly prolongs effective physiotherapy and recovery (Rotter et al., 2015).

A limitation of our study is certainly too small number of subjects and the lack of a control group. Perhaps it is also worth to use a more detailed diagnostic based on the analysis of the activity of weakened muscles using surface electromyography (sEMG). Further studies are needed to assess the effectiveness of various physiotherapeutic methods, including combination with pharmacological treatment. This would allow us to evaluate the benefits of taking therapy to improve function of the joint and moreover reduce pain in the various stages of symptoms.

Conclusions

1. Changes in the soft tissues of the shoulder joint and pain significantly impairs patients' functioning.
2. The individually adjusted rehabilitation has a significant impact on improving the condition of patients and their quality of life.
3. The results support taking action towards the implementation of a detailed history and physical examination to identify the real cause of ailments.

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COUNTERACTING SOCIAL EXCLUSION OF PEOPLE WITH MOTOR DYSFUNCTIONS THROUGH PHYSICAL CULTURE – OPINIONS OF PEOPLE WITH AND WITHOUT PHYSICAL DISABILITIES

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Abstract In the years 2010–2012, the research survey was carried out on 480 people with or without physical disabilities. The aim of the research was to obtain information on attitudes and opinions of people with physical disabilities towards the possibility of reducing social marginalization through participation in physical culture. The research confirmed that the respondents' attitudes towards participation of those people in physical culture were, in majority, positive. Participants of the research expressed the opinion that the feeling of marginalization of physically disabled persons would not have been so strong if there had been the possibility of an active participation in sport, recreation and tourism as well as in active rehabilitation. The possibilities of an active participation in physical activity should be inexpensive and widely accessible regardless of the year season and with providing volunteer assistance and transport facilitations.

Key words physical culture, marginalization and social exclusion, people with physical disability

Introduction

The quality of life of excluded and marginalized people with motor disabilities constitutes an important social problem (Abramowska, 2005; Pluym, Keur, Gerritsen, Post, 1997). The motive for the research was a social need to obtain some useful data in order to improve disabled people's life quality (Błażejewski, Cynarski, 2014; Simeonsson, Carison, Huntington, McMillen, Brent, 2001.) Widespread disabilities and their consequences such as marginalization and social exclusion fully explain the purpose of the research (Koperski, 2012). Integration with the society can be seen on many levels. One of them is physical culture, which is a part of global culture. That part of a man's activity influences the development of emotional, volitional, intellectual and motor spheres and covers some multiple needs of the modern society (Ślężyński, 1997).

Subjects and methods

The subject of the research included attitudes, declared knowledge, opinions, behavior, and emotions of healthy and disabled people towards the reduction of social marginalisation through physical culture such as sport, physical activity, rehabilitation and active forms of tourism.

The survey was carried out in the years 2010–2012 on 480 persons: 240 physically healthy and 240 physically disabled from Podkarpckie and Kujawsko-Pomorskie provinces. People in the age 20–45 were deliberately chosen for the research, proportionally men and women. The education level of the respondents was similar. Professional and basic education prevailed: physically healthy 180 persons (75%), disabled 177 persons (73,7%), high school education: healthy 60 persons (25%) disabled 63 persons (26,3%). The reason for the selective choice of volunteers was the conviction that participation consent was the key factor to obtain relatively full, honest and credible opinions.

Research questions

The following research questions were raised:

1. What is the opinion of persons with different psycho-physical condition on the possibilities and the necessity to counteract social marginalization of physically disabled persons through physical culture?
2. What forms of physical culture activities can effectively support the reduction of social marginalization of disabled people?
3. What benefits, according to respondents, do people with physical disability expect from participation in physical culture?

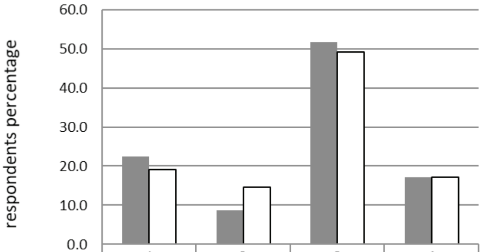
Results

The research showed that the knowledge of the needs and possibilities of physically disabled people's participation in different forms of physical activity is unsatisfactory, which proves that information, education and promotion is insufficient. Half of the respondents (52 and 49%) admit their low knowledge about the entities organizing and supporting disabled persons, and some even admit (9 and 15%) that they do not possess such knowledge at all (Figure 1). None of the respondents chose the option that their knowledge is very good.

The majority of the respondents assess their knowledge about health benefits of sport, tourism and recreation as moderate (41 and 32%) or insufficient (20 and 39%), and part of them admits they do not possess such knowledge (17 and 14%) (Figure 2). Just few of them think their knowledge is very good (15 and 12%).

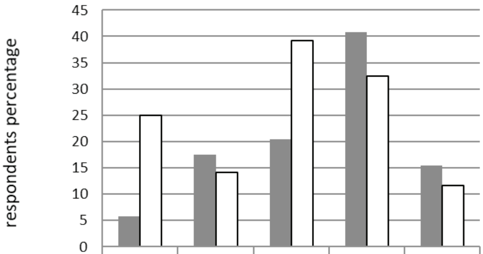
Assessment of the conditions created for disabled people for their participation in physical culture through recreation is mostly negative (Figure 3). Those conditions – according to most respondents – are insufficient (63 and 42%) or bad (6 and 12%). Only few consider them as good (7 and 17%). No one assessed them as very good.

Asked about the impact of the lack of possibilities for participation in physical culture on disabled people's life quality (Figure 4), the majority of respondents said that it is rather negative (33 and 34%), definitely negative (20 and 30%) or moderately negative (30 and 24%). It proves respondents' high awareness of the significance of physical activity in disabled people's lives.



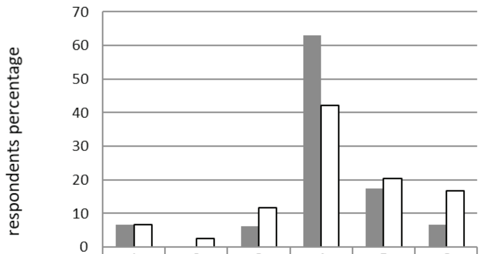
	1	2	3	4
physically disabled	22.5	8.8	51.7	17.1
healthy	19.2	14.6	49.2	17.1

Figure 1. Assessment of the subjective knowledge about the entities supporting the participation of disabled persons in physical culture 1 – cannot be assessed, 2 – do not possess such knowledge, 3 – incomplete knowledge, 4 – sufficient knowledge (χ^2 = 4,289)



	1	2	3	4	5
physically disabled	5.8	17.5	20.4	40.8	15.4
healthy	25	14.2	39.2	32.5	11.7

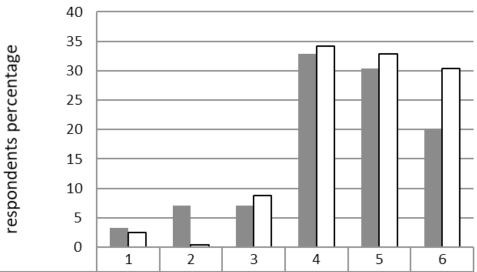
Figure 2. Subjective assessment of the knowledge about health benefits of sport, tourism and recreation: 1 – not able to assess, 2 – no such knowledge, 3 – incomplete knowledge, 4 – moderate knowledge, 5 – very good knowledge (χ^2 = **21,722**)[1]



	1	2	3	4	5	6
physically disabled	6.7	0	6.3	62.9	17.5	6.7
healthy	6.7	2.5	11.7	42.1	20.4	16.7

Figure 3. Assessment of the conditions created for disabled people for their participation in physical culture through recreation: 1 – not able to assess, 2 – lack of conditions, 3 – bad conditions, 4 – insufficient conditions, 5 – sufficient conditions, 6 – good conditions (χ^2 = **30,675**)

[1] χ^2 value p < 0,01 is marked **bold**, p > 0,05 is marked ***bold italic***

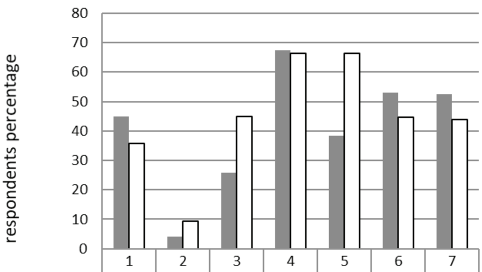


	1	2	3	4	5	6
physically disabled	3.3	7.1	7.1	32.9	30.4	20
healthy	2.5	0.4	8.8	34.2	32.8	30.4

Figure 4. The impact of the lack of the possibility of participation in physical culture on disabled people's life quality: 1 – no answer, 2 – do not have any influence, 3 – not able to assess, 4 – rather positive, 5 – moderately negative, 6) definitely negative (χ^2 = 22,221)

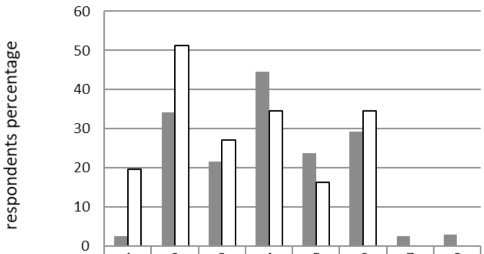
Expectations related to participation in physical culture of disabled people are carefully and in a balanced manner expressed by the respondents. They are limited to usually one or two expected benefits – to strengthen psycho-physical condition (67 and 66%), overcome various fears and insecurities (45 and 36%), establish attractive relationships with people (53 and 45%), enrich their everyday life (52 and 44%), and also to strengthen their self-confidence (34 and 51%) and improve their self-reliance (45 and 35%) (Figures 5, 6). That indicates great expectations of disabled people which they place in physical culture.

There are divergent opinions as to the chances of disabled people's participation in physical culture through sport and tourism to reduce their social marginalization. Approximately half of the respondent believes that they have such possibilities – as such conditions are sufficiently created – accordingly to Polish economic realities – while the other half expresses just the opposite opinion (Figures 7, 8).



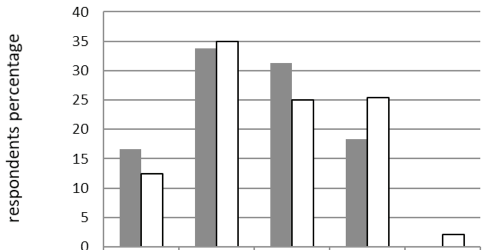
	1	2	3	4	5	6	7
physically disabled	45	4.2	25.8	67.5	38.3	52.9	52.5
healthy	35.8	9.2	45	66.3	66.3	44.6	43.8

Figure 5. Benefits expected from participation in physical culture: 1 – lack of insecurity, frustration, and stress, 2 – material benefits, 3 – optimism, 4 – better psycho-physical condition, 5 – self-realisation and life satisfaction, 6 – new relationships, 7 – breaking life monotony (χ^2 = **38,609**)



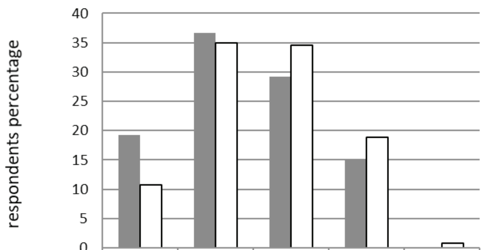
	1	2	3	4	5	6	7	8
■ physically disabled	2.5	34.2	21.7	44.6	23.8	29.2	2.5	2.9
□ healthy	19.6	51.3	27.1	34.6	16.3	34.6	0	0

Figure 6. Additional benefits expected from participation in physical culture: 1 – trust in people, 2 – self-confidence, 2 – discovering own possibilities, 4 – self-reliance, 5 – enhancing employability, 6 – experiencing life, world and people, 7 – other benefits, 8 – not able to assess (χ^2 = **58,717**)



	1	2	3	4	5
■ physically disabled	16.6	33.8	31.3	18.3	0
□ healthy	12.5	35	25	25.4	2.1

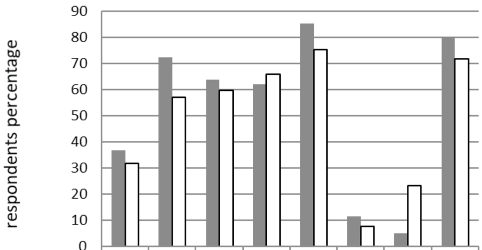
Figure 7. Assessment of the chances for satisfactory participation of disabled people in physical culture through sport: 1 – very little, 2 – little, 3 – sufficient, 4 – very good, 5 – not able to assess (χ^2 = ***10,902***)



	1	2	3	4	5
■ physically disabled	19.2	36.7	29.2	15	0
□ healthy	10.8	35	34.6	18.8	0.8

Figure 8. Assessment of the chances for satisfactory participation of disabled people in physical culture through tourism: 1 – very little, 2 – little, 3 – sufficient, 4 – very good, 5 – not able to assess (χ^2 = ***9,753***)

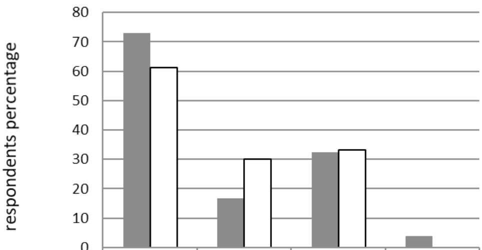
When answering the question about expected offers of participation in physical culture, the most frequent choice was their availability regardless of the year season (85 and 75%), free or partly paid (discounts) (92 and 79%), with provided volunteers' assistance (72 and 57%), means of transport to the place of the event (64 and 60%) convenient individual transport (62 and 66%) (Figure 9). It may prove a great motivation of both healthy and physically disabled persons to participate in physical activity.



	1	2	3	4	5	6	7	8
■ physically disabled	36.7	72.5	63.8	62.1	85.4	11.3	5	80.4
□ healthy	31.7	57.1	59.6	65.8	75.4	7.5	23.3	71.7

Figure 9. Offers for disabled persons' participation in physical culture: 1 – promoted by local media, 2 – with provided volunteers' assistance, 3 – with organized transport, 4 – with individual transport, 5 – available all year, 6 – organized occasionally, 7 – partly paid, 8 – free of charge (χ^2 = **37,034**)

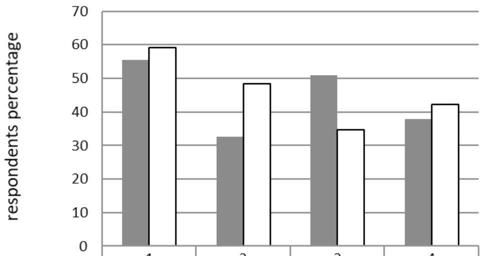
The vast majority of healthy and disabled respondents stated that participation in various sport, tourism and recreation events can be satisfactory for people with motor dysfunctions (73 and 61%). One in three respondents from both groups believe that watching sport and recreation events in mass media can be also satisfactory for disabled people (32 and 33%) (Figure 10). However, their observation that personal participation in the events can be even more satisfactory for those persons may instill optimism.



	1	2	3	4
■ physically disabled	72.9	16.7	32.5	3.8
□ healthy	61.3	30	33.3	0

Figure 10. Satisfactory forms of disabled persons' participation in physical culture: 1 – direct participation, 2 – cheering at sport events, 3 – media transmissions, 4 – different forms of participation (χ^2 = **20,588**)

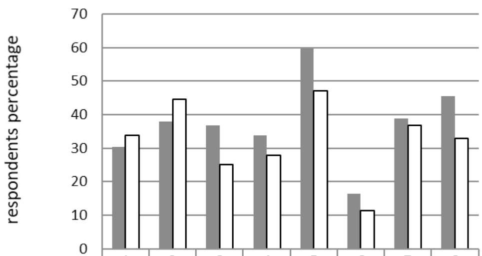
Most respondents rightly point out that the promotion of physical culture among disabled people should be ensured by official institutions, local authorities, mass media, and health services (Figure 11).



	1	2	3	4
physically disabled	55.4	32.5	50.8	37.9
healthy	59.2	48.3	34.6	42.1

Figure 11. Entities promoting disabled people's participation in physical culture: 1 – sport and tourism department, 2 – health department, 3 – local authorities, 4 – mass media (χ^2 = **15,311**)

Most respondents considered associations of disabled people as, above all, responsible for supporting people with motor dysfunctions (60 and 47%), part of them pointed also sport organizations (45 and 33%) and national institutions (38 and 45%). Healthy interviewees' answers were similar (Figure 12).



	1	2	3	4	5	6	7	8
physically disabled	30.4	37.9	36.7	33.8	59.6	16.3	38.8	45.4
healthy	33.8	44.6	25	27.9	47.1	11.3	36.7	32.9

Figure 12. Institutions and organizations which should support disabled persons' efforts to participate in physical activity: 1 – health centres, 2 – public administration, 3 – mass media, 4 – social organizations, 5 – associations of disabled people, 6 – church, 7 – local authorities, 8 – sport associations (χ^2 = 12,275)

Conclusions

1. The research showed that the respondents' knowledge of disabled persons' needs and their possibilities for participation in physical activity are insufficient. It may indicate insufficient education and promotion of this important social problem.

2. It is shocking that most healthy and disabled interviewees are not aware of health benefits of sport, tourism and physical recreation.

3. The respondents are aware of the fact that by limiting the chances for participation in physical activity life quality of disabled persons may be negatively affected.

4. People with motor disabilities associate their participation in physical culture mostly with strengthening their psychophysical condition, limiting insecurity, better self-confidence, attractive relationships, breaking life monotony and enhancing self-reliability.

5. Disabled people expect free of charge participation in physical activity, regardless of the year season, with the possibility of using public or individual transport and volunteers' assistance.

6. The problem of disabled people's participation in physical culture attracts social interest, proved by the positive attitude of the interviewees towards the interviewers, reliably filled out questionnaires and eager participation in the survey.

7. To promote disabled persons' participation in physical culture it is necessary to overcome barriers connected with education and information, organization, finance, and mentality. Modern program of participation in physical culture for disabled persons should be constructed in order to reduce their social marginalization..

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THE EFFECT OF 12-WEEK-LONG NORDIC WALKING EXERCISE ON BODY COMPOSITION, CHANGES IN LIPID AND CARBOHYDRATE METABOLISM INDICES, CONCENTRATION OF SELECTED ADIPOKINES AND CALCIDIOL IN HEALTHY MIDDLE-AGED WOMEN

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Abstract Research objective. This study aimed at analysing the changes in the level of somatic indicators, the secretion profile of selected adipokines, carbohydrate and lipid metabolism indices and calcidiol concentration after a 12-week-long nordic walking (NW) exercise in middle-aged women.

Research material and methods. The study included 13 women aged 45.5 ±4.2 years who participated in a 12-week-long NW exercise, 3 times a week, 90 minutes each. Each of the women had individually determined workout intensity zones which were monitored based on the heart rate. Prior to the exercise programme and after it, somatic traits were assessed and blood was sampled in order to make biochemical analyses.

Results. In the examined women, a decrease in mean body weight by 2.5 kg and a reduction in fat mass (FM), on average by 3.8 kg (i.e. 4.6%), coupled with an increase in lean body mass (LBM) by 1.3 kg, were observed after 36 workout units. A significant decrease in TC, LDL-C and TG concentrations and no changes in HDL-C concentration occurred after the exercise, which contributed to lowered atherogenic index of plasma (AIP) and atherosclerosis risk index (ARI).

Conclusions. Individualised and regular physical activity in the form of NW had a protective effect on the body, resulting in improved body composition, adiponectin secretion profile, lipid and carbohydrate metabolism, and calcidiol concentration in middle-aged women.

Key words health-related training, nordic walking, middle-aged women, exercise biochemistry

Introduction

Health-related training being conducted in various forms which allows maintaining the proper health at any age is an element of life still often underestimated by many people used in the prevention and treatment of metabolic civilisation diseases (Singh, Purohit, 2012). Scientists clearly indicate the physical activity as one of the main factors that reduce the risk of obesity, type 2 diabetes, ischaemic heart disease, and arterial hypertension (Katzmarzyk, 2010). Research data suggest that increased physical activity in middle-aged people may contribute to a reduction in mortality (Kokkinos, Myers, 2010) at a level comparable to smoking cessation (Byberg, Melhus, Gedeborg, Sundstrom, Ahlbom, 2009).

In addition, sedentary lifestyle, being the result of progress in development of civilisation, promotes the increased deposition of visceral adipose tissue which is a source of hormones and adipokines. The increase of adipocyte volume affects the changes in adipokine secretion (decreased adiponectin production and increased leptin secretion). A consequence of these changes is development of insulin resistance, type 2 diabetes, and cardiovascular diseases (Chudek, Adamczyk, Nieszporek, Więcek, 2006). On the other hand, adipocytes produce adiponectin which plays a key role in the stimulation of glucose consumption and the oxidation of fatty acids (Combs, Berg, Obici, Scherer, Rossetti, 2001). Numerous studies have shown that also ghrelin–which stimulates food ingestion–is responsible for normal body mass level (Mackelvie, Meneilly, Elahi, Wong, Barr, 2007; Wren, Small, Ward, Murphy, Dakin, 2000).

Many studies have emphasised that an appropriate vitamin D level in the body is necessary to maintain the structural integrity and function of muscles (Polly, Tan, 2014). Vitamin D, binding the intracellular and membrane receptors (VDR) of muscle cells, stimulates the synthesis of about 200 different proteins. Genes, being stimulated by vitamin D with its receptor, produce growth factor proteins that regulate the proliferation of satellite muscle cells and stimulate their maturation and differentiation to mature, fast-twitch (type 2) muscle fibres, being responsible for muscle strength, contraction speed and mass (Pojednic, Ceglia, 2014).

Nordic walking is a safe form of physical recreation for people of any age, being of endurance exercise nature, extensively involving – compared to traditional walking – the muscle groups of upper extremities. While maintaining the correct technique of walking during the NW exercise, 90% of muscles is being involved, while in the case of normal walking the number of involved muscles decreases to about 70% (Morgulec-Adamowicz, Marszałek, Jagustyn, 2011). Physical exercise programmes involving pole walking are used to counteract obesity, contributing this way to negative energy balance.

For middle-aged women, there are still no specific guidelines to create the training programmes involving the NW exercise, the regular and thorough performance of which would contribute to improved fat and carbohydrate metabolism and changes in adiopkine secretion profile, including calcidiol concentration.

In the literature, there is a number of reports that confirm the positive effect of NW exercise on human health (Tschentscher, Niederseer, Niebauer, 2013). However, the mechanism of the beneficial effect of physical exercise, its intensity and duration on fat and carbohydrate metabolism and changes in adipokine concentration is still the subject of many studies (Hagner, Hagner-Derengowska, Wiacek, Zubrzycki, 2009; Song, Yoo, Choi, Kim, 2013, Lubkowska, Dudzińska, Bryczkowska, Dołęgowska, 2015a). The selection of physical activity intensity, frequency and type, which would optimally affect the above changes, is also discussed.

This study aimed at analysing the changes in the level of somatic indicators, the secretion profile of selected adipokines, carbohydrate and lipid metabolism indices after a 12-week-long NW exercise in middle-aged women from a rural environment. Taking into account the fact that the workouts were performed in an open area in spring (March-May), also the changes in calcidiol concentration were analysed.

Material and methods

Research plan

The research project was approved by the Bioethics Committee of the Regional Medical Chamber in Cracow (137/KBL/OIL/2013). Joining the research programme, each of the women had to meet the following inclusion criteria: medical certificate stating the absence of medical contraindications to perform physical exercises, not using pharmacological hypotensive, hypolipemiant and hormonal therapy and using dietary supplements in a period of at least 4 weeks preceding the study, and not drinking alcohol in a period of at least 2 weeks preceding the study and during it. The female subjects were also asked to maintain their normal nutritional habits. The level of physical activity was determined using an IPAQ-SF (International Physical Activity Questionnaire–Short Form) survey questionnaire (Biernat, Stupnicki, Gajewski, 2007) that concerns the previous and current physical activity. The women with declared earlier physical activity at the level of 534 ±38 MET (Metabolic Equivalent) minutes/week were included in the study.

A 12-week-long health-related training lasting from March to May involved the women who participated three times a week in the activities with the NW exercise, 90 minutes each. During the whole training programme, each of the women took part in 36 workouts. Prior to the exercise programme and after it, somatic traits of the female subjects were assessed and blood was sampled in order to make biochemical analyses.

Characteristics of the subjects

The study included 13 women from Małopolskie Province who agreed in writing to take part in the research programme. During the project, the women did not participate in any other organised and regular physical activity. The characteristics of their somatic indicators is presented in detail in Table 1.

Measurement of anthropometric parameters

The measurement of somatic traits in the subjects was made one day before and one day after the training period. The subjects did not suffer from any diseases that would affect the water and electrolyte balance; 2–3 hours prior to the measurement of body structure, they did not perform any physical exercise. The following parameters were measured: body height (BH), body mass (BM), fat mass (FM), body fat percentage (F%), and lean body mass (LBM).

The body structure was determined by electrical bio-impedance technique using a Jawon Medical IOI 353 body composition analyser (Korea), body height was measured with a Martin-type anthropometer (USA) accurate to 0.1 cm.

Characteristics of the nordic walking exercise

Workouts took place in the morning hours in an open area with three instructors. Prior to the activity, the women took part in 3 instructive sessions on mastering the proper technique of pole walking. The length of NW poles was individually matched to the body height of the subjects (Morgulec-Adamowicz, 2011).

Each workout session was composed of three parts: a warm-up (15.0 ±2.0 minutes), the main workout (60.0 ±4.2 minutes), and a final part (15.0 ±1.2 minutes). The warm-up consisted of a set of stretching exercises and elements that build the proper technique of pole walking. In the main workout, aerobic exercises prevailed, being performed as continuous and interval walking in a varied terrain. In the final part, there were cooling down exercises.

During the physical activity, all women used heart rate monitors Polar RS400, (Finland). In the main part of the workout, the female subjects were supposed to keep the individually determined HR value (±4 beats · min^{-1}) so that the intensity of exercises in the study group was diversified. The intensity of the main part was also controlled by three instructors.

The 12-week-long training was divided into 3 4-week-long mesocycles of different intensity. During the first mesocycle, the intensity of walking in the main part corresponded to 50 ±1.2% HRmax, whereas during the second mesocycle to 60 ±2.3% HRmax, while being 65 ±3.1% HRmax in the third one. Maximum heart rate (HRmax) was estimated according to the following formula: HRmax = 211 – 0.64 · age (in years) (Nes, Janszky, Wisløff, Støylen, Karlsen, 2013) which corresponded to 181.9 ±2.7 beats · min^{-1} for the study group.

Biochemical analyses

One day before the training programme and one day after it, blood was drawn from a vein in the cubital fossa of all fasting subjects by a laboratory diagnostician in accordance with applicable standards. Blood was collected in Vacutainer™ blood collection tubes with EDTA. The following parameters were determined in blood plasma: total cholesterol – TC, HDL cholesterol – HDL-C, and triglycerides – TG, glucose, insulin, leptin, ghrelin, adiponectin and 25-hydroxyvitamin D (25(OH)D).

Determination of lipid metabolism indices

TC, HDL-C, TG levels were determined by the enzymatic method from Abbott Laboratories on an Architect ci8200 integrated serum/plasma analyser system, Abbott Laboratories, Abbott Park, IL (USA).

Low-density lipoprotein (LDL-C) level was calculated from the Friedwald formula (Friedewald, Levy, Fredrickson, 1972): LDL-C [$mmol \cdot l^{-1}$] = TC [$mmol \cdot l^{-1}$] – TG [$mmol \cdot l^{-1}$]/2.2 – HDL [$mmol \cdot l^{-1}$]. The LDL-C level was calculated assuming that the concentration of TG is below 4.6 $mmol \cdot l^{-1}$

Triglyceride (TG) level was determined by the triglyceride test from Abbott Laboratories on an Architect ci8200 integrated serum/plasma analyser system, Abbott Laboratories, Abbott Park, IL (USA).

Determination of atherosclerosis risk index

Atherosclerosis risk index (ARI) was calculated from the following formula: ARI = TG/HDL-C, where: TG – triglycerides (ml/dl), HDL-C – high-density lipoprotein expressed in ml/dl (Luc, Bard, Ferrieres, Evans, Amouyel, 2002).

Determination of the level of carbohydrate metabolism indices

The determination of insulin concentration was made by the electrochemiluminescent method (ECLIA) using a Cobas analyser, Roche Diagnostics (USA).

The glucose concentration in venous blood serum was determined by the hexokinase method using a Cobas analyser, Roche Diagnostics (USA).

The insulin resistance index $HOMA_{IR}$ (Homeostasis Model Assessment of Insulin Resistance) was calculated from the following formula (Matthews et al., 1985): $HOMA_{IR} = C_{INS}$ (μU/ml) · C_{GLUC} (mmol/l) · 22.5, where: C_{INS} – insulin, C_{GLUC} – glucose.

The atherogenic index of plasma (AIP) was calculated based on the following formula (Dobisova, 2004): AIP = log(TG/HDL-C), where: TG – triglycerides (mmol/l), HDL-C – high-density lipoprotein expressed in mmol/l.

Determination of the level of selected adipokines

The determination of ghrelin, leptin and adiponectin concentrations was made by the immunoenzymatic method from Phoenix Pharmaceuticals (USA), leptin ELISA assay from DRG International Inc. (USA), and adiponectin ELISA assay from Mediagnost GmbH, respectively (Germany).

Determination of the level of 25-hydroxyvitamin D (25(OH)D)

The concentration of 25(OH)D was determined in blood plasma by the immunoenzymatic method using a vitamin D test from from DRG International Inc (USA).

Methods of statistical analysis and ways of presenting research findings

Research findings are presented as arithmetic means and standard deviations. The goodness of fit of the distribution of indicators being evaluated with the normal distribution was verified with the Shapiro-Wilk test. Changes in the concentration of biochemical indices being evaluated as affected by the training (normal distribution) was verified with the t-Student test for dependent variables. The analysis of relationships between the variables being examined was made using the Pearson's linear correlation. The statistical analysis of the research findings was performed with Statistica 10.0 software package for Windows from Statsoft.

The significance level of differences for all analysed indicators was considered statistically significant at $\alpha \leq 0.05$.

Results

When starting the workouts with NW, the female subjects were characterised by normal body composition. After the training, a significant decrease in BM, FM and F% and a significant increase in LBM were observed (Table 1).

Table 1. Characteristic of somatic indicators in the examined women

Measurements	Baseline	Post 12 weeks	p
Age (years)	46.0 ±4,2		–
BH (cm)	164.9 ±5.4		–
BM (kg)	63.8 ±7,2	61.3 ±5.8*	0.0001
LBM (kg)	43.7 ±3,2	45.0 ±3.1*	0.04
FM (kg)	20,1 ±3,1	16.3 ±2.9*	0.03
F (%)	30.9 ±4.0	26.3 ±2.9*	0.02

BH – body height; BM – body mass, LBM – lean body mass, FM – fat mass, F% – fat percentage, *p < 0.05.

Before the training programme, mean TC, HDL-C, LDL-C and TG concentrations in all female subjects were within normal ranges. After the training, a significant decrease in TC, LDL-C and TG concentrations and no changes in the concentration of HDL-C were observed. These alterations contributed to a reduction in AIP and ARI (Table 2).

The mean glucose concentration in the female subjects prior to the training programme exceeded the accepted limit of 5.5 mmol/L, (glucose levels being within the upper limits of reference values were recorded in 60% of the subjects, while in other women the glucose concentration was above the normal range). The insulin concentration was within the normal range in all subjects. After a 12-week-long training, a decrease in the glucose concentration to standard values was observed in the women with its increased level, as well as a decrease in its concentration in other female subjects. A significant decrease in the insulin concentration contributed to a reduction in $HOMA_{IR}$ index (Table 2).

Table 2. Characteristics of blood biochemical indices in the examined women

Measurements	Baseline	Post 12 weeks	p
TC (mmol/l)	5.0 ±0.4	4.7 ±0.5*	0.04
HDL-C (mmol/l)	1.6 ±0.3	1.6 ±0.3	0.11
LDL-C (mmol/l)	2.9 ±0,7	2.5 ±0,6*	0.002
TG (mmol/l)	1.3 ±0,5	1.0 ±0,4*	0.002
AIP	–0.11 ±0.18	–0.24 ±0.17*	0.0007
ARI	0.85 ±0.4	0.62 ±0.24*	0.004
Glucose (mmol/l)	5.8 ±0,5	4.6 ±0.6	1.29
Insulin (µU/ml)	10,4 ±1,6	8.8 ±1.6*	0.01
$HOMA_{IR}$	2,7 ±0,5	1.8 ±0.3*	0.0007
Adiponectin (ng/ml)	33.9 ±12,8	41.8 ±12.5*	0.003
Ghrelin (ng/ml)	58,2 ±10.0	22,1 ±9,5*	0.03
Leptin (ng/ml)	14.6 ±3,7	10,6 ±2.4*	0.0001
Calcidiol (ng/ ml)	23.8 ±5,7	27.2 ±4.9*	0.008

AIP – atherogenic index of plasma, ARI – atherosclerosis risk index, $HOMA_{IR}$ – insulin resistance index.

After the training programme, a significant increase in the concentration of adiponectin and ghrelin, as well as a significant decrease in the leptin concentration, was observed in the female subjects (Table 2).

The baseline concentration of calcidiol in the female subjects was not within reference normal range (>30 ng/ml). The training performed in an open area contributed to its significant increase but the mean value of its concentration was still below the recommended limits (Table 2).

Discussion

The unique character of this study results from the analysis of changes in many indicators being responsible for carbohydrate and lipid metabolism and body composition as affected by individually determined training loads. The workouts were carried out in spring (March-May), which could contribute to more intensive synthesis of calcidiol in the skin and lead to an increase in its blood concentration (which was taken into account in the research methods).

Physical exercise, depending on its character, induces a number of phenotypic and physiological changes which include mitochondrial biogenesis, transformation of muscle fibres, improvement of insulin sensitivity and cytoprotection (Steinbacher, Eckl, 2015), as well as intensification of fatty acid oxidation in muscles, and modulation of the activity of many enzymes and development of the network of blood vessels (Macaluso, De Vito, 2004). With ageing and sedentary lifestyle, many adverse somatic alterations are being observed, the manifestation of which is, among others, reduced LBM and increased body fat level (Drygas, Jegier, 2003). Various studies have confirmed the effectiveness of regular physical activity in the fight against overweight and obesity in older people. However, the effectiveness of physical workouts being carried out depends largely on the exercise structure, duration and its intensity (Song et al., 2013, Lubkowska et al., 2015a), as well as – as shown by the most recent studies – on an adequate body level of vitamin D (Polly, Tan, 2014).

The results of the studies conducted so far have confirmed that the physical activity in the form of NW exercise being regularly applied may contribute to positive changes in the body build of the perimenopausal women who lead a sedentary lifestyle (Song et al., 2013; Mikalacki, Rajdo, Cokorilo, Korovliev, Smajic, 2012). When preparing the training loads for the participants of physical activities with the NW exercise, a particular importance was attributed to its intensity and individualisation. In the present study, the intensity of the main part of the workout was directed towards the dominance of fat metabolism in physical exercise energetics.

A consequence of the training programme being carried out in such a way was a decrease in BM by nearly 2.5 kg, as well as a reduction in body fat mass by 4.6% with a simultaneous increase in LBM by nearly 1.3 kg. Similar reduced BM and F% values have been obtained by Mikalacki et al. (2012) who applied a similar training programme in the women aged 58.5 ±6.9 years. The 12-week-long training plan being applied by them and carried out 3 times a week in the form of physical activities with the NW exercise with increasing intensity, from 60% to 80% HRmax, in obese women resulted in the reduction of BM by 3.72 kg and the decrease of %F by 4.28%.

An important factor influencing the changes in lipid metabolism at rest and during physical exercise is an age-related increase in body mass, a decrease in aerobic capacity and a reduction in fatty acid metabolism rate (DeNino, Tchernof, Dionne, Toth, Adres 2001; Horowitz, Klein, 2000). In the present study, a significant decrease in the TG concentration was observed as affected by a 12-week-long NW exercise. Many studies have shown that the TG concentration >1.7 mmol/l, obesity, arterial hypertension and type 2 diabetes are the most common factors accompanying the ageing process (Reznik, Morello, Pousse, Mahoudeau, Fradin, 2002). For many authors, the increased TG level is a more important risk factor for atherosclerosis than the increased concentration of LDL-C (Nilsson, Ohrvik, Lonnberg, Hedberg, 2009). In the study by Hagner et al. (2009), after a 12-week-long NW exercise in pre-, peri- and postmenopausal women, significant positive effects being related to changes in body composition, decreased TC. LDL-C and TG concentrations, and increased HDL-C concentration have been observed. In the present study, no changes in the HDL-C concentration were observed Such a difference in the changes is likely due to the selection of a form of physical activity, amount and intensity of undertaken physical workout, and baseline concentration values of respective lipid profile components in the female subjects.

Lipid profile disorders are one of the factors that increase the risk fo developing atherosclerosis (Kozak--Szkopek, Baraniak, Mieczkowska, 2006). Studies have shown the presence of a strong relationship between increased plasma TG level and increased atherosclerosis development. Due to these relationships and to determine the risk for developing atherosclerosis in the examined group of women, atherosclerosis risk index – TG/HDL-C (Luc et al., 2002) – and atherogenic index of plasma (Dobisova, 2004) were introduced into the study. In the present study, a significant change in the ARI and AIP values were obtained as affected by the NW exercise, just as in the study by Haskell, Lee, Russell, Powell, Blair (2007). Additionally, AIP was negative, both during the first and the second measurement, which indicates a low level of risk for developing atherosclerosis in the examined group of women.

A significant worsening of carbohydrate metabolism is observed with age, resulting in lowered glucose tolerance due to increased insulin resistance, as well as to increased insulin secretion (Scheen, 2005). Many authors have emphasised a positive effect of regular physical workout on improving the glucose tolerance and preventing the development of type 2 diabetes in the subjects at any age (Perk, De Backer, Gohlke, Graham, Reiner, 2012). In the present study, normal insulin concentration values were observed during the first and the second measurement in the female subjects. The statistical analysis being applied showed a significant decrease in the insulin level and insulin resistance index ($HOMA_{IR}$) after the NW exercise. The results obtained in the present study with respect to changes in glucose and insulin concentrations and $HOMA_{IR}$ index as affected by the NW exercise and negative correlations between these indicators and the changes in body fat mass as affected by the workouts have been confirmed by the studies of other authors (Hu, Pekkarinen, Hanninen, Tian, Guo, 2001). In the study by Matthews et al. (1985), normal insulin resistance has been found in healthy subjects for the $HOMA_{IR}$ index being in the range of 1.25–1.41. Other authors have recorded higher $HOMA_{IR}$ values amounting to 2.1 (Chevenne, Trivin, Porquet, 1999) and 2.7 (Yani-Komshian, Carantoni, Abbasi, Reaven, 2000). In the present study, a significant decrease was observed in the $HOMA_{IR}$ index as affected by 36 workout units, from 2.7 during the first measurement to 1.8 in the second one.

Glucose metabolism disorders progressing with age are often associated with lipid accumulation in myocytes (Lowell, Shulman, 2005) and an age-related decrease in adiponection level (Haluzik, 2005). Studies have shown that the level of adiponectin, as one of the adipose tissue cytokines, decreases in the blood plasma of people with the obesity of internal organs (Kopff, Jegier, 2006). In the present study, an increase in the adiponectin concentration was observed after 36 workout units. Other studies, have yielded similar results, showing an increase in its concentration and a decrease in body mass in the women after regular physical activity (Bouassida, Chamari, Zaouali, Feki, Zbidi, Tabka, 2010; Kondo, Kobayashi, Murakami, 2006).

Leptin, among others, is responsible for the homeostasis of energy expenditure and the control and regulation of the amount of body fat (Güçlü, 2014). Studies have shown that the leptin concentration decreased during body mass reduction, while it increases with the increase of adipocyte volume. In women, as compared with men, a 2–3 times higher plasma level of this hormone, with similar BMI values, has been observed (Olszanecka-Glinianowicz, Zahorska-Markiewicz, 2008). However, it is still unclear whether a decrease in the leptin concentration is the result of body mass reduction or the result of physical activity (Jürimäe, Jürimäe, 2004; Rubin, Hackney, 2010, Lubkowska, Radecka, Bryczkowska, Rotter, Laszczyńska, Dudzińska, 2015b). In the study by Hickey et al. (1997), a decrease in the leptin concentration has been observed, with no changes in body fat mass, in women after a 12-week-long regular aerobic training. Some authors have suggested that a decrease in the leptin concentration after endurance training may be associated with a decrease in the insulin level (Jürimäe, Jürimäe, 2004). The increase of serum leptin level is directly related to the content of body fat (Güçlü, 2014). In the present study, a significant decrease in the leptin concentration was observed which significantly correlated with decreased body fat content and insulin concentration.

The concentration of ghrelin increases during fasting and decreases after ingestion of meal; it is a hormone which plays an important role in the control of hunger and satiety through energy homeostasis regulation (Cummings, Frayo, Marmonier, Aubert, Chapelot, 2004; Cederberg, Koivisto, Jokelainen, Surcel, Keinänen-Kiukaanniemi, Rajala, 2012). In the treatment of civilisation diseases, such as obesity, the key issue is to fully understand the hormonal control of appetite in order to apply effective therapeutic methods (Mackelvie et al., 2007; Cederberg et al., 2012). Therefore, one of the research problems being undertaken in this study was to assess the effect of increased physical activity in women on changes in the ghrelin concentration. In the present study, a significant decrease in the ghrelin concentration was observed after the training. Many studies being conducted have clearly indicated the presence of a relationship between the intensity of physical activity and the post-training level of ghrelin (King, Miyashita, Wasse, Stensel, 2010; King, Wasse, Broom, Stensel, 2010). The present study confirmed that moderate-intensity exercise, which significantly decreases blood ghrelin concentration, is effective in body mass reduction for middle-aged women.

In recent years, vitamin D_3 deficiency has been shown to be significantly involved in the development of overweight and obesity in the populations of both children and adolescents and adults (Alemzadeh, Kichler, Babar, Calhoun, 2008; Foss, 2009; Niemann et al., 2011). Its deficiency may impair the effect of insulin, adversely affect glucose metabolism and other metabolic processes both in adipose tissue and in other tissues. Furthermore, recent findings disclosed a strong correlation between changes in lipid profile and level of 25(OH)D (Dziedzic, Przychodzeń, Dąbrowski, 2016; Pittas, Lau, Hu, Dawson-Hughes, 2007). Excess body fat causes the retention of fat-soluble vitamin D_3 and a decrease in its serum concentration, which reduces its bio-availability (Alemzadeh et al., 2008; Foss, 2009). McGill, Stewart, Lithander, Strik, Poppitt, (2008) have shown a decrease in vitamin D_3 concentration by 0.74 nmol/l per unit (1 kg/m^2) increase in BMI value and a decrease in vitamin D_3 concentration by 0.29 nmol/l per 1 cm of increased waist circumference. Moreover, recent studies prove that a physical activity could increase the use of calcidiol which emphasizes the need of its supplementation (Pilch et al., 2016). In the present study, a significant increase in the concentration of blood-circulating calcidiol was observed in the female subjects. This was probably due to an increase in its synthesis in the skin because the workouts took place in spring. According to the data of the Institute of Meteorology and Water Management in Warsaw, the total insolation in the study year for the Małopolska Province amounted to 110–120 hours in March and 140–160 hours in April and was higher by about 10–30 hours than the multi-annual average of 1971–2000. May, with a total of 200–220 hours, also had higher sunshine duration, by 10–30 hours, than the multi-annual average for this month. In the present study, an increase in the calcidiol level was observed after a 12-week-long observation period although, despite its increase, its concentration was still below the standard values. A positive correlation between final calcidiol concentration and decreased leptin concentration is evidence of its positive effect on maintaining the normal energy balance of the body.

Implications for Practice and/or Policy

The findings being obtained could be, according to the authors, the result of properly matched exercise intensity and form in suitable season. Moreover, the results of our research indicate the necessity of vitamin D supplementation despite the performance of outdoor physical activity during March-May period. The results of this study are very important for physicians and coaches, as well as for instructors who deal with physical activation and activity of middle-aged people.

Conclusions

1. The physical activity in the form of NW exercise with individually matched training intensity regulates body composition towards increased lean body mass and decreased body fat mass.

2. Individualised and regular physical activity has a protective effect on the body, preventing adverse alterations associated with the process of ageing, the result of which is improvement in adipokine secretion profile, lipid profile and carbohydrate metabolism.

3. Sun exposure of the female subjects during a 12-week-long physical training in an open area in spring contributed to the synthesis of calcidiol but did not result in the increase of its level to the reference values, and therefore vitamin D supplementation should be additionally recommended in people with low calcidiol level and performing physical exercise.

4. Significant and positive changes in the biochemical indices in the female subjects that took place after a 12-week-long training programme can be an effective inhibitor in the struggle with civilisation diseases.

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OCCURRENCE AND INTENSITY OF SPINAL PAIN IN MOTORCYCLISTS DEPENDING ON MOTORCYCLE TYPE

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Abstract Introduction: Motorcycles in Poland become more and more popular also as convenient means of transport, especially in large cities. Factors influencing on driver during riding the motorcycle are assumed to cause spinal pain in motorcyclist. These factors may vary in motorcycles of different construction or purpose. Few information is available about spinal pain connected with riding a motorcycle. The aim of this study was the assessment of occurrence and intensity of spinal pain in motorcyclists depending on motorcycle type.

Material and methods: The study group consisted of 2,124 motorcyclists aged 19–79 yrs., using motorcycle with an engine size bigger than 50 ccm and participating in minimum 1 riding season. An original, on-line available questionnaire composed of questions regarding riding a motorcycle and ailments of all parts of the spine was used. The results underwent statistical analysis using the Statistica 10.0.

Results: The results showed that 58.4% respondents experienced pain of at least one part of spine during riding the motorcycle. The biggest percentage (51.1%) of persons with spinal pain in general was found out in cross/enduro type users. Neck pain was significantly connected with riding the sport motorcycle ($p = 0.001$).

Conclusions: Spinal pain in motorcyclists depends on the motorcycle type.

Key words back pain, motorcyclists, motorcycle type, drivers

Introduction

Spine pain is one of the most frequent disorders occurring in general population. Epidemiological studies show that lifetime prevalence of low back pain (LBP) concerns even 84% of population (Balagué, Mannion, Pellisé, Cedraschi, 2012). Neck pain occurs in about 23.1% of general population, which places it on the second place after LBP while women are more susceptible than men (Hoy, Protani, Buchbinder, 2010). The factors determining occurrence of spinal pain are, among others, long time maintained static position, whole body vibrations (WBV) and awkward sitting positions. These factors may also appear during riding the motorcycle (Goode, Carey, Jordan, 2013;

Sasin, Cieślak, 2014; Bovenzi 2010). Simultaneously, motorcycles become more and more popular mean of transport in Poland and number of issued driving licenses systematically increases. The license of A category was acquired by 13,240 in the year of 2013 and 12,557 in the year of 2014. Generally in Poland this category of driving license is possessed by 4.8 million people whereas the number of registered motorcycles also increased by 18% in relation to previous year and the number of motorcycles with engine size up to 125 ccm increased by 40% due to the possibility of driving with "B" license only (GUS, 2014).

Depending on construction features and operational characteristics the following types of motorcycles can be distinguished: sport, tourist, cruiser/chopper, enduro/cross. About the selection of motorcycle most often decides its purpose without regarding the matching up to the individual physiological and anatomical limitations of the driver. Different construction determines significantly different positions taken on particular types of motorcycles. Sports motorcycles have many features adapting them to riding on sport tracks e.g. plastic fairings improving aerodynamics, smaller wheelbase and weight, lower and hard adjusted suspension and relatively higher engine power. Enduro/cross type motorcycles designed for riding in difficult terrains are usually lighter with solid, strengthened construction of frame and suspension, without fairings but with center of gravity located higher than in other types. Due to recreational or sport purpose this type is commonly one-seated. Tourist motorcycles designed to covering long distances are longer and heavier than sport or cross/enduro machines, with more ergonomic position and additional

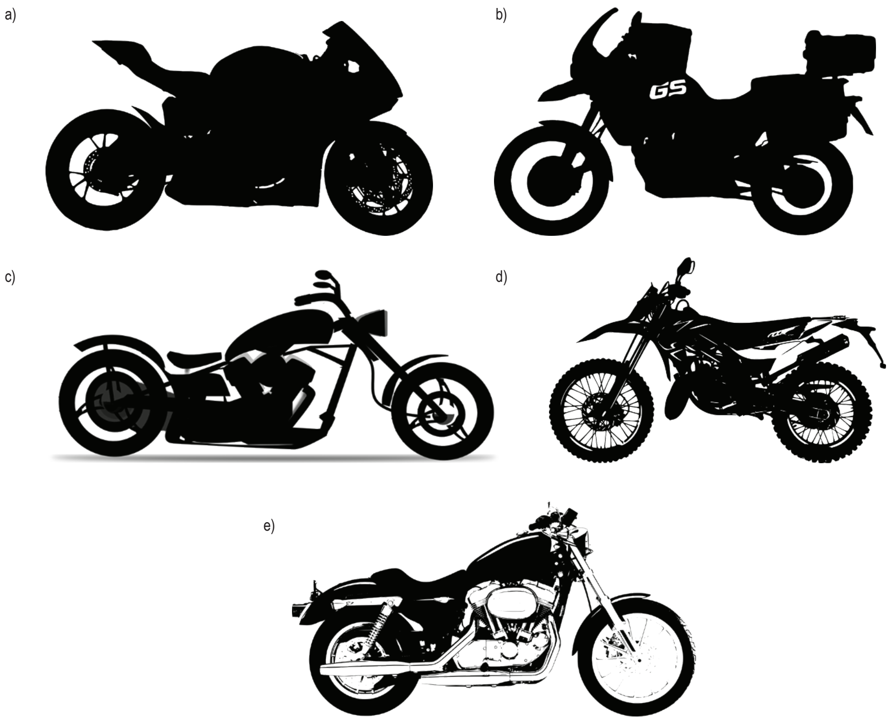

Figure 1. Examples of particular motorcycle type outlines: a) sport, b) tourist, c) chopper, d) enduro/cross, e) cruiser
Source: www.pixabay.com (8.02.2017).

frames for luggage or cases. Cruiser and chopper are both low seated types with extended handle bars while chopper type is differentiated by strongly forwarded fork and raised, T-shaped handle bars (Figure 1a–e) (Teoh, Campbell, 2010).

Various types of motorcycles due to lack of possibility of adjustment determine constant specific riding position. Body positions on individual motorcycle type with angle values between particular body parts are shown on figures 2–5 (source: own based on cycle-ergo.com – accessed: 6.01.2017).

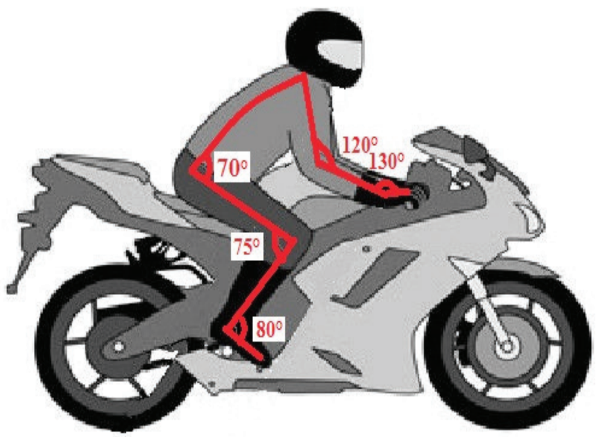

Figure 2. Position on sport motorcycle

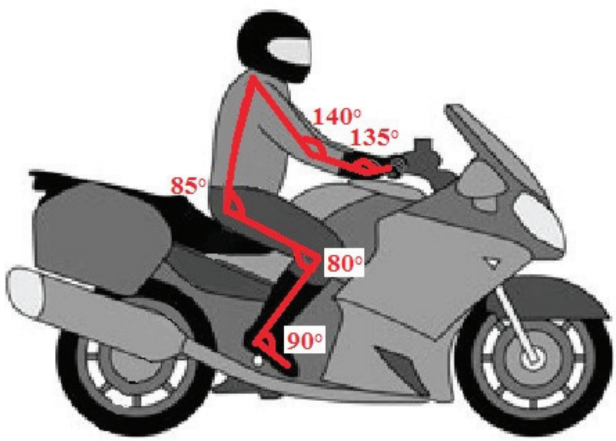

Figure 3. Position on tourist motorcycle

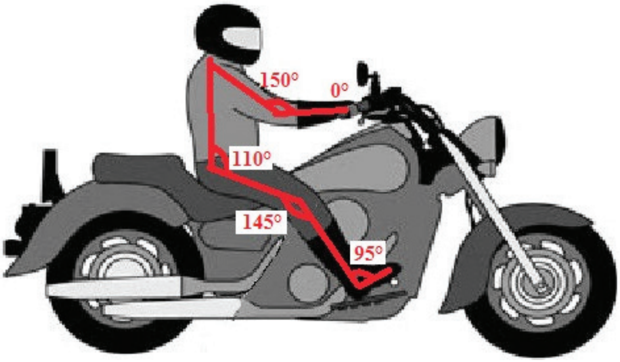

Figure 4. Position on cruiser/chopper motorcycle

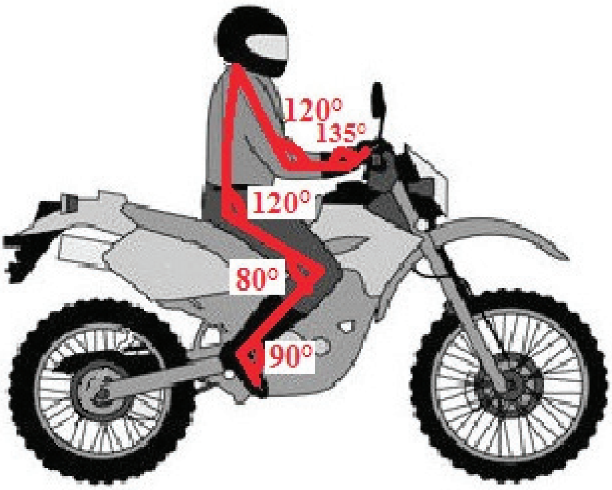

Figure 5. Position on cross/enduro motorcycle

Static position maintained for long time and vibrations transmitted onto the driver are main factors that may cause spinal pain during or after riding the motorcycle. Sitting longer than 20 minutes leads to decrease of muscle tension which causes passive structures (ligaments, joint capsules) to seize the role of stabilizers. Long-lasting tension of ligaments may cause its structural disorders thus decreasing elasticity and efficiency. In such situation human body gives pain impulse which is assumed to effect in position change. When it is impossible the ailments can become stronger and pathological changes can occur. Such situation can also take place during riding the motorcycle (Goode et al., 2013). Repetitive long-lasting disorders of muscles and ligaments may cause morphological changes that can be irreversible (Sheeran, Sparkes, Caterson,Busse-Morris, van Deursen, 2012).

Motorcyclists during riding are also exposed on whole body vibrations that can be generated by the engine and ground bumps and could be transmitted onto the driver because of rigid construction of chassis. They can be divided to local – transmitted from handle bars to hand – and general – transmitted through the seat into the trunk (Bovenzi, 2010; Slatkovska, Alibhai, Beyene, Cheung, 2010).

The goal of this study was the assessment of the occurrence, frequency and intensity of pain in all parts of the spine in motorcyclists in relationship to the type of the motorcycle used.

Material and methods

Study group characteristics

We collected 2881 records of persons who meet inclusion criteria. The inclusion criteria were: riding the motorcycle with engine size over 50 cm^3, having relevant category of driving license and participation in at least one riding season which was defined as time period from March until October inclusively. Persons, who declared having of formally diagnosed disorders that can proceed with spinal pain were not involved in the study group. The final study group consisted of 2,124 motorcyclists meanly aged 29.7 yrs., in that 1,754 (82.6%) men and 370 (17.4%) women residing in Poland. Mean of height was 178.4 cm, mean weight was 80.38 kg and mean BMI was 25.14 kg/m^2 (Table 1).

Table 1. General somatic characteristics of examined persons

Parameter	n	$\bar{x}$	SD	Minimum	Maximum
Age (yrs)	2,124	29.70	9.05	19	79
Weight (kg)	2,124	80.38	7.89	40	140
Height (cm)	2,124	178.40	8.03	150	205
BMI (kg/m^2)	2,124	25.14	4.02	16.2	42

Considering the type of motorcycle 737 (43.7%) persons have sport motorcycle, 711 (33.47%) tourist motorcycle, cruiser/chopper have 535 (25.19%) respondents and cross/enduro 141 (6.64%) of them (Figure 6).

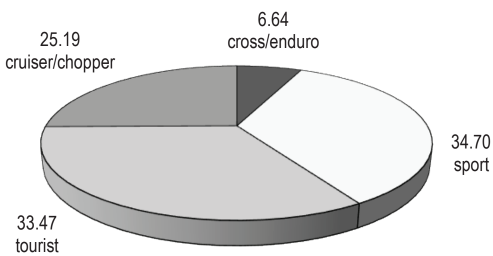

Figure 6. Percentage of particular motorcycle type in the study group

Motorcycle was mainly used for tourism by 1,162 (67.75%) of respondents. The least respondents have used it for sport 277 (13.04%). 697 (32.82%) of respondents have used the motorcycle 4-times per week while 458 (21.56%) 2–1 per week and only 18 persons (0.85%) less often than 1 per month. Average number of riding years was 8.77 while average number of seasons comes to 6.36. The respondents rode meanly 2.72 hours a day with monthly mileage on average 1,030.78 km (Table 2). The majority of the respondents (2,022 persons – 95.2%) used specialized protective clothing during riding.

Table 2. Characteristics of selected parameters related to motorcycle riding in the study group

Parameter	n	$\bar{x}$	SD	Minimum	Maximum
Riding years	2,124	8.77	8.52	1	53
Number of seasons	2,124	6.36	5.75	1	53
Riding hours per day	2,124	2.72	1.56	0.5	9
Monthly mileage (km)	2,124	1,030.78	978.59	20	11,000

Examination

The research was conducted between January and April 2015 through authors questionnaire available on-line at university platform *ankiety.cm-uj.krakow.pl* designed with *LimeSurvey Manual (*ver. 2.05+ Build 150211). Link to this questionnaire was broadcasted via social media (e.g. Facebook) and various forums focused on motorcycling uniting motorcyclists in Poland (e.g. http://www.smgp.info/forum; http://forum.motocyklistow.pl). Due to its elaborated character, the questionnaire could be saved partly filled and respondent could complete it later on. The questions were of a single- and multi-answer type. First group of questions asked about age, sex, weight and height of the respondent as well as about motorcycle characteristics such like model, type, daily and weekly riding time, mileage covered monthly, number of seasons and use of protective clothing. Following questions asked about pain in every part of the spine, its frequency and intensity during and after motorcycle riding. Pain intensity was assessed using modified VAS (*visual analog scale*) in which the examined subject had to indicate pain intensity between 1 and 10 when 1 is the smallest pain and 10 is the worst imaginable pain (Williams, Morlock, Feltner, 2010). Performed modification based on three-grade categorization of pain: slight (VAS 1–3), medium (VAS 4–6), strong (VAS 7–10).

Frequency of pain occurrence during motorcycle riding was quantified in Likert Scale including 5 questions starting from complete acceptance to complete negation. In this study 1 meant very frequent and 5 very rare (Li, 2013).

Statistical analysis

Statistical analysis was performed using *Statistica 10* (StatSoft Inc.). The Shapiro-Wilk test was used to check the accordance to normal distribution while Chi Square Pearson test was used to evaluate the relationships between qualitative variables. Results were considered statistically significant with $p < 0.05$.

Results

In the study group 1,240 persons (58.4%) experienced pain in any part of spine during riding the motorcycle. Pain was more often reported by men – 770 (43.9%) – than women – 114 (30.8%). 569 (26.8%) persons declared neck pain, 187 persons (8.8%) – thoracic pain and 826 persons (38.9%) – lumbo-sacral pain. Pain intensity in VAS averaged in neck 3.96 ±0.6, 4.19 ±1.75 in thoracic spine, and 4.02 ±1.7 in lumbo-sacral.

Statically significant difference (p = 0.033) was stated between pain intensity in spine without division to particular sections and motorcycle type. The highest percentage (51.1%) of persons with spinal pain was found out in cross/enduro type users. Also statistically significant (p = 0.001) difference concerned relationship between neck pain and the use of sport type motorcycle – neck pain occurred in 31.5% of drivers of this type (Table 3).

Table 3. Occurrence of pain in particular parts of spine depending on motorcycle type

Spine segment	Sport		Tourist		Cross/enduro		Chopper/cruiser		p
	n	%	n	%	n	%	n	%	
General	283	38.4	301	42.3	72	51.1	228	42.6	0.033
Cervical	232	31.5	186	26.2	30	21.3	121	22.6	0.001
Thoracic	76	10.3	59	8.3	8	5.7	44	8.2	0.234
Lumbo-sacral	289	41.5	273	40.6	47	35.6	217	43.2	0.442

No statistically significant difference was stated between motorcycle type and frequency of pain occurrence in any particular spine section (Table 4).

Table 4. Frequency of pain occurrence in particular spine sections depending on motorcycle type

Motorcycle type	Very often (every day)		Often (several times per week)		Sometimes (several times per month)		Rarely (several times per year)		Very rarely (once per couple of years)	
	n	%	n	%	n	%	n	%	n	%
Cervical spine										
Sport	14	6.03	32	13.79	83	35.78	91	39.22	12	5.17
Tourist	5	2.69	16	8.60	75	40.32	79	42.47	11	5.91
Chooper/cruiser	5	4.13	20	16.53	46	38.02	44	36.36	6	4.96
Cross/enduro	3	10.00	2	6.67	10	33.33	13	43.33	2	6.67
p = 0.52										
Thoracic spine										
Sport	7	9.21	17	22.37	26	34.21	25	32.89	1	1.32
Tourist	2	3.39	8	13.56	30	50.85	15	25.42	4	6.78
Chooper/cruiser	0	0.00	8	18.18	18	40.91	14	31.82	4	9.09
Cross/enduro	2	25.00	0	0.00	4	50.00	2	25.00	0	0.00
p = 0.065										
Lumbo-sacral spine										
Sport	24	8.30	42	14.53	111	38.41	96	33.22	16	5.54
Tourist	13	4.78	28	10.29	106	38.97	107	39.34	18	6.62
Chooper/cruiser	12	5.56	27	12.50	79	36.57	89	41.20	9	4.17
Cross/enduro	3	6.38	6	12.77	16	34.04	15	31.91	7	14.89
p = 0.19										

Also no statistically significant difference was stated between motorcycle type and pain intensity in any spine section (Table 5).

Table 5. Pain intensity in particular spine sections depending on motorcycle type

Pain intensity	Slight pain		Medium pain		Strong pain	
	n	%	n	%	n	%
Cervical spine						
Sport	106	45.69	119	51.29	7	3.02
Tourist	87	46.77	98	52.69	1	0.54
Chopper/cruiser	50	41.32	67	55.37	4	3.31
Cross/enduro	12	40.00	18	60.00	0	0
p = 0.45						
Thoracic spine						
Sport	29	52.73	25	45.45	1	1.82
Tourist	21	63.64	12	36.36	0	0
Chopper/cruiser	23	69.70	10	30.30	0	0
Cross/enduro	4	66.67	2	33.33	0	0
p = 0.71						
Lumbo-sacral pain						
Sport	124	63.27	65	33.16	7	3.57
Tourist	114	65.14	57	32.57	4	2.29
Chopper/cruiser	94	69.12	37	27.21	5	3.68
Cross/enduro	23	71.88	9	28.13	0	0
p = 0.751						

Discussion

The goal of described study was the assessment of pain occurrence in motorcyclists in relationship to motorcycle type. The pain of any spine section occurred generally in 58.4% persons of the study group. The most frequent location was lumbo-sacral spine which occurred in 38.9% of respondents whereas in the cervical and thoracic spine these numbers came to 26.8% and 8.8% respectively. These results are in a large extent consistent with those published by other authors. Akinbo, Odebiyi, Osasan (2008) who examined spine pain occurrence in Nigerian motorcyclists stated the percentage of general occurrence as 60% while the lumbar spine pain – also the most frequent – occurred in 43% of examined persons. Pain in the cervical and thoracic spine together was stated in 13.7% persons. Pretty similar results were obtained by Mohd Hafzi, Rohayu, Noor Faradila, Wong (2009) who assessed the occurrence of musculoskeletal disorders in two groups – recreational and professional – of Malesian motorcyclists. They stated 62.8% of low back pain in the recreational group during last 12 months, however in this study the respondents reported two times bigger percentage of neck pain (50.7%). Makhsous et al. (2009) say that main factors determining such a high percentage of spinal symptoms are long time kept sitting position and reduction of lumbar lordosis while Lis, Black, Korn, Nordlin (2007) stated that the risk of low back pain occurrence is markedly increased by the combination of whole body vibrations and forced improper sitting position. All these factors are combined together during riding the motorcycle which may explain such relatively high percentage of low back pain among motorcyclists.

The authors have not found any published data related to the influence of motorcycle type on the occurrence of musculoskeletal system symptoms in motorcyclists. Our assumption of such relationship was based on the differences between positions taken on different motorcycle types which can effect in various loading level in particular spine parts. Velegapudi, Balasubramanian, Babu, Mangaraju (2010) conducted analysis of two different positions – straightened and leaning forward – on motorcycle on the fatigue level of muscles responsible for posture maintaining and driving the motorcycle. The experiment was performed in two different road conditions: providing large number of road shocks and in heavy traffic requiring intensive maneuvering. Muscle fatigue was measured by superficial electromyography (sEMG). The results elicited that leaning forward position causes smaller fatigue when driver is exposed to large number of road shocks while fatigue caused by motorcycle control is similar for both positions. The sEMG measurements were also confirmed by subjective ratings of the driver. On the basis of these results it can be assumed that leaning forward position provides better absorption of shocks and vibrations. It could entail smaller rate of spinal pain occurrence and/or its intensity in case of motorcycles with leaning forward position and higher occurrence rate and/or pain intensity in case of motorcycles with straightened positions. In our study we do not stated significant differences in frequency and intensity of pain symptoms in particular spine sections however in case of sport type motorcycles which have more leaned position the pain occurrence rate in general was in fact the smallest (38.4%) – however this difference was insignificant. These rates were higher on chopper/cruiser and cross/enduro type motorcycles 42.6% and 51.1% respectively) which have much more straightened positions, however statistical significance was stated for cross/enduro type only. It can be probably linked, besides the position, to riding specificity mainly involving covering tracks in difficult terrain with high number of road shocks and vibrations, frequent changes of driving direction and also higher activity of muscles responsible for maintaining the balance and controlling the motorcycle. This theory seems to be supported by the analysis performed by Wągrowska-Koski (2007) who also links causes of spinal symptoms in drivers with long time maintained position and dynamic changes of spinal loading caused by acceleration and/or braking albeit she emphasizes that general vibrations markedly increase the risk of symptoms linked with sitting position. Similar findings about long lasting sitting position were stated by Balasubramanian, Jagannath (2014) who assessed local muscle fatigue during motorcycle riding using sEMG and seat pressure distribution by pressure mapping system. The study group consisted of 20 men who drove the motorcycle for one hour through the heavy road traffic. Muscle activity was measured bilaterally in following muscles: extensor carpi radialis, biceps brahii, trapezius, sternocleidomastoideus, lattissimus dorsi and erector spinae. Essential fatigue and decrease of postural muscle activity as well as uneven seat pressure distribution were stated. The authors supposed that local fatigue could be caused by long lasting static position and necessity of maintaining the balance on motorcycle.

In our study statistically significant ($p = 0.001$) neck pain occurred in respondents driving the sport type motorcycle. Due to the lack of comparative studies we can only presume that it is the effect of more leaned position that forces cervical spine extension which causes intensive isometric work of neck extensors thus inducing their overloading and pain as a final result. This assumption could be confirmed by conclusions of Hill, Lewis, Papageorgiu, Dziedzic, Croft (2004) who identified riding a bicycle as one of risk factors for neck pain considering the position on bicycle and overloading of neck extensors as the main reasons of pain symptoms. Villavicencio, Hernández, Burneikiene, Thramann (2007) present similar opinion assessing neck pain occurrence in the group of triathlonists. They also state the positive relationship between number of hours spent on bicycle and neck symptoms in examined athletes. Taking into consideration the similarity of neck positions on bicycle and on the motorcycle the assumption about use of the sport type motorcycle as a risk factor for neck pain seems to be quite reasonable.

Conclusions

1. The motorcycle type significantly influences on spinal pain occurrence in general which was the highest in enduro/cross type drivers.

2. The motorcycle type significantly influences on occurrence of neck pain to which the most susceptible are sport type motorcycles drivers.

3. The use of particular motorcycle types do not determine neither the frequency nor the intensity of pain in any spine region.

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CHANGES IN MOTOR SKILLS OF CHILDREN WHO TRAIN SPORTS SWIMMING AT THE INITIAL STAGE OF SCHOOL EDUCATION (IN AN ANNUAL TRAINING CYCLE)

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Abstract This paper presents an empirical approach to the changes in motor skills of children who train sports swimming at the initial stage of school education in an annual training cycle. Swimming belongs to the disciplines in which training starts at the age of 6–7. The proper selection of candidates to train certain disciplines is a complex process as they should be chosen from a large population of children, both girls and boys, having specific somatic and motor characteristics which, developed in the long-term, will enable them to achieve sports mastery. The aim of the research was to define which changes in motor skills occur in girls who train sports Aim: swimming in an annual training cycle. The Subject group consisted of 85 girls aged 7 who attended four elementary schools in Szczecin, Poland. 36 of them belonged to the Swimmers group and they were all members of the Municipal Swimming Club (MKP) in Szczecin. The Control group consisted of 49 girls who attended the same elementary schools. All subjects took part in two examinations (carried out in the school year 2009/2010. Physical ability tests were conducted in gyms. Motor skills were assessed with EUROFIT Test Battery which is the most reliable and accurate tool according to scientific research. The research revealed changes in both groups (Sw, C) in terms of all eight tests. Examination II proved statistically significant improvement of results in both groups (Sw, C) in comparison to Examination I. Changes between Examination I and Examination II results were most visible in the Swimmers groups in terms of balance, agility, static strength, functional strength and agility run. Changes between Examination I and Examination II were similar in both groups (Sw, C) in terms of speed of limb movement, explosive strength and torso strength. Progressive changes in motor skill of subjects are a positive phenomenon in the physical development of a child. Swimming training resulted significantly in positive changes in terms of motor skills of subject who were at the initial stage of swimming trainings, compared to their non-training peers. Participation in organized, regular sports classes results in the development of motor (physical) skills of children.

Key words selection, motor skills, swimming, girls, analysis

Introduction

Current world-class athletes' bodies display specific characteristics which result from the sports discipline they train. They are of certain age and have certain parameters: somatic, motor and functional. Their size and quality result in a so-called 'champion model' (Kosmol, 1997; Karpiński, Opyrchał, 2008; Socha, 2008; Kolbowicz, 2012) Continuous observation over the years and analysis of characteristics of the best athletes, Olympic Games medalists, help trainers make changes in their training programs in order to achieve the model champion qualities in their trainees (Karpiński, Opyrchał, 2008).

Knowledge of model parameters (qualities) of world's best athletes is used by trainers during selection of prospective athletes for a given sports discipline, and subsequently at various stages of sports selection. It is advisable to seek future champions based on their specific qualities (including motor skills), which – developed over the years of trainings – may lead to championship in sports (Chomiak, Migasiewicz, 1998; Cięszczyk, 2005, 2008; Opyrchał, Karpiński, Sachnowski, 2005). Effects of trainers' work depend largely on a correct selection process for sports swimming, and on professional, multi-step selection at a later stage (Eider, 2014).

The aim of this study was to determine what changes in motor skills occurred in girls who trained sports swimming during a 1-year training cycle.

Material and research methods

Subject group consisted of 85 girls aged 7 (1st grade of elementary school) who attended four elementary schools in Szczecin, Polamd. 36 of them belonged to the Swimmers group. All girls were members of the Municipal Swimming Club (MKP) in Szczecin. Before selecting the girls for swimming classes, they did not participate in any systematic swimming training. The Control group consisted of 49 girls who attended the same elementary schools. The Control group members were selected based on the age of the Swimmers group members, with 3 months' precision; all subjects attended the same grade (1st grade of elementary school). Children from the Control group did not participate in any sports/recreation classes. All subjects took part in two examinations (Table 1), carried out in the 2009/2010 academic year among 1st graders of Elementary School no. 51, 55, 56 and 62 in Szczecin (five swimming groups and four control groups) Examination I was conducted in September 2009, immediately after

Table 1. Number of girls in Swimmers and Control groups during examinations

School	Group	Class number	Study	
			I	II
El. Sch. 51	Sw	1a	9	9
	Sw	1b	8	8
	C	1c	12	12
	C	1d	11	11
El. Sch. 51	Sw	1a	10	10
El. Sch.56	Sw	1a	5	5
	C	1b	11	11
El. Sch. 62	Sw	1a	4	4
El. Sch. 56	C	1c	15	15
Total			85	85

El. Sch. – Elementary School, Sw – Swimmers, C – Control.

selection of Swimmers and Control groups (1st graders), while Examination II took place in June 2010, i.e. at the end of the 1st grade. The analysis included only those children who participated in both examinations.

Physical ability tests were conducted in gyms and were preceded by standard warm-up for all children (7–8 minutes). The tests were as simple as possible and required minimal equipment. The most reliable and accurate indirect tests were used (Szopa, Chwała, Rychlewicz,1998). Motor skills were assessed with eight tests of the EUROFIT Test Battery (Grabowski, Szopa, 1991):

1. Flamingo Balance Test – general balance – keeping balance while standing on one leg on a beam of certain dimensions.
2. Plate Tapping Test – speed of upper limb movements – touching quickly two purposefully placed plates with the preferred (stronger) hand.
3. Sit-and-Reach Test – flexibility – sitting and reaching forward as far as possible.
4. Standing Broad Jump Test – explosive leg power – broad jump from a standing position.
5. Handgrip Strength Test – static strength – gripping forcefully a dynamometer.
6. Sit-Up Test – torso strength – lying on the back and doing max. number of sit-up within 30 seconds
7. Bent Arm Hang Test – functional strength – total time of maintaining the hang position with bent arms on a bar.
8. 10 × 5 m Shuttle Run Test – agility run – running with max. speed and changes of direction.

Research results

Flamingo Balance Test – general balance

In the analyzed groups of girls (Sw, C), average results of the Flamingo Balance Test during Examination I were identical. Examination II, however, revealed statistically better results of girls from the Swimmers group. Examination II proved statistically significant improvement of results in both groups (Sw, C) in comparison to Examination I (Table 2). In the Swimmers group, it was on average 3.4 attempts, while in the control group: 1.9 ($p < 0.0001$) (Figure 1).

Table 2. Descriptive characteristics of Flamingo Balance Test (general balance) in the Swimmers and Control groups

	Distribution type	Examination I		Examination II		Examination I vs. Examination II	
		Sw	C	Sw	C	Sw	C
Girls	n	36	49	36	49		
	min–max	5.0–10.0	6.0–9.0	2.0–7.0	3.0–9.0		
	mean	8.0	8.0	4.0	6.0		
	$\overline{X}$ (SD)	7.7 (1.1)	7.7 (1.1)	4.3 (1.2)	5.8 (1.2)		
	ss	0.960		<0.0001		<0.0001	<0.0001

Sw – Swimmers, C – Control, min – minimum value, max – maximum value, $\overline{X}$ – arithmetic mean, SD – standard deviation, ss – statistical significance.

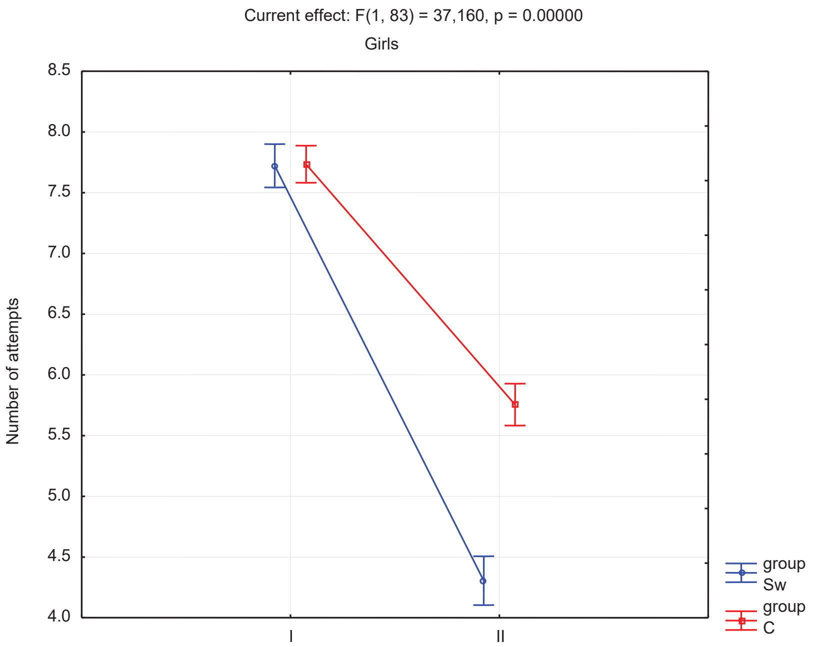

Figure 1. Changes in results of Flamingo Balance Test (general balance) in Swimmers (Sw) and Control (C) groups

Plate Tapping Test – speed of upper limb movements

Swimmers group displayed statistically insignificantly better results in Examinations I and II in terms of speed of upper limbs than the Control group. Examination II proved statistically significant improvement of results in both groups (Sw, C) in comparison to Examination I (Table 3). In the Swimmers group, it was on average 1.3 s, while in the Control group it was 1.9 s (p < 918) (Figure 2).

Table 3. Descriptive characteristics of Plate Tapping Test (speed of upper limb movements) results in the Swimmers Group (Sw) and Control group (C).

	Distribution type	Examination I		Examination II		Examination I vs. Examination II	
		Sw	C	Sw	C	Sw	C
Girls	n	36	49	36	49		
	min–max	15.0–31.1	21.6–34.3	14.8–29.5	20.3–32.6		
	mean	27.6	26.9	25.8	25.7		
	$\bar{X}$ (SD)	26.6 (3.7)	27.1 (3.1)	25.3 (3.4)	25.7 (3.0)		
	ss	0.527		0.514		<0.0001	<0.0001

Sw – Swimmers, C – Control, min – minimum value, max – maximum value, $\bar{X}$ – arithmetic mean, SD – standard deviation, ss – statistical significance.

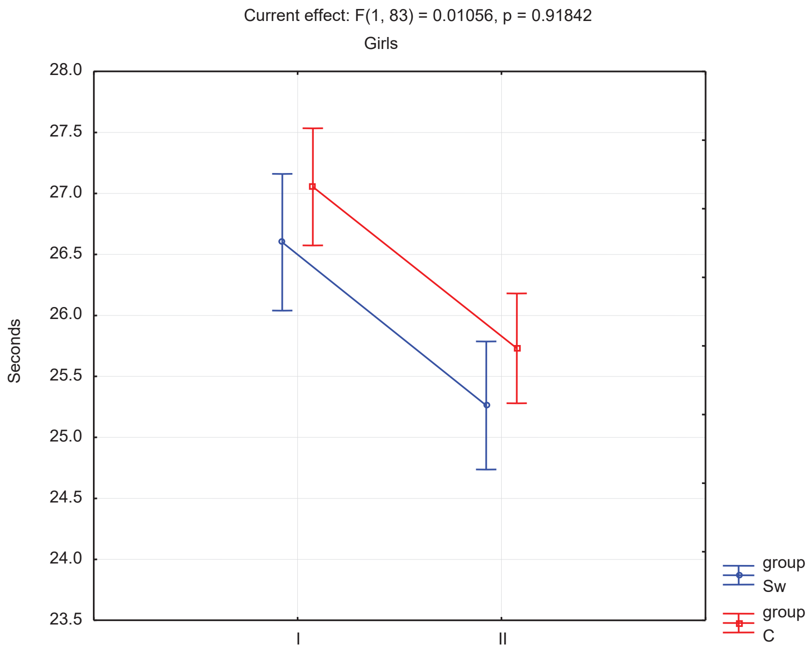

Figure 2. Changes in the results of Plate Tapping Test (speed of upper limb movements) in the Swimmers group (Sw) and Control group (C)

Sit-and-Reach Test – flexibility

Swimmers group displayed statistically significantly better results in Examination I and II in terms of torso flexibility. Examination II proved statistically significant improvement of results in both groups (Sw, C) in comparison to Examination I (Table 4). In the Swimming Group, it was on average 4.8 cm, while in the Control group it was 3.9 cm ($p = 0.007$) (Figure 3).

Table 4. Descriptive characteristics of Sit-and-Reach Test (flexibility) results in Swimmers (Sw) group and Control (C) group

	Distribution type	Examination I		Examination II		Examination I vs. Examination II	
		Sw	C	Sw	C	Sw	C
Girls	n	36	49	36	49		
	min–max	–6.0–14.0	–12.0–13.0	–1.0–17.0	–6.0–16.0		
	mean	3.0	1.0	8.0	4.0		
	$\overline{X}$ (SD)	3.9 (4.7)	–0.5 (5.6)	8.7 (4.0)	3.4 (5.4)		
	ss	0.0002		<0.0001		<0.0001	<0.0001

Sw – Swimmers, C – Control, min – minimum value, max – maximum value, $\overline{X}$ – arithmetic mean, SD – standard deviation, ss – statistical significance.

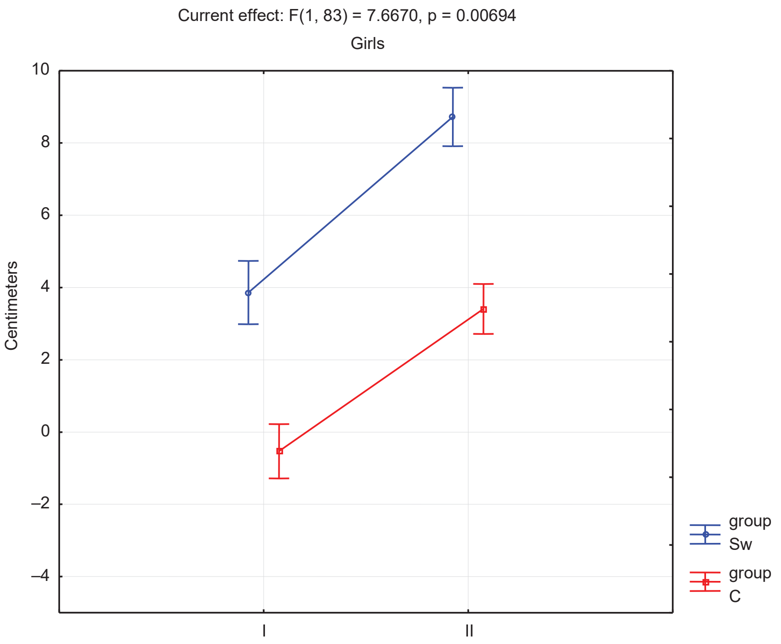

Figure 3. Changes in results of the Sit-and-Reach Test (flexibility) in Swimmers (Sw) group and Control (C) group

Standing Broad Jump Test – explosive leg power

Swimmers group displayed statistically significantly better results in Examination I and II in terms of standing broad jumps. Examination II proved statistically significant improvement of results in both groups (Sw, C) in comparison to Examination I (Table 5). In the Swimmers group, it was on average 12.4 cm, while in the control group it was 15 cm (p = 0.123) (Figure 4).

Table 5. Descriptive characteristics of Standing Broad Jump Test (explosive leg power) results in the Swimmers (Sw) group and Control (C) group

	Distribution type	Examination I		Examination II		Examination I vs. Examination II	
		Sw	C	Sw	C	Sw	C
Girls	n	36	49	36			
	min–max	55.0–132.0	52.0–129.5	64.5–146.0	65.5–141.0		
	mean	105.8	94.0	117.5	108.0		
	$\bar{X}$ (SD)	105.4 (14.8)	91.4 (16.9)	117.8 (15.7)	106.4 (16.5)		
	ss	0.0002		0.002		<0.0001	<0.0001

Sw – Swimmers, C – Control, min – minimum value, max – maximum value, $\bar{X}$ – arithmetic mean, SD – standard deviation, ss – statistical significance.

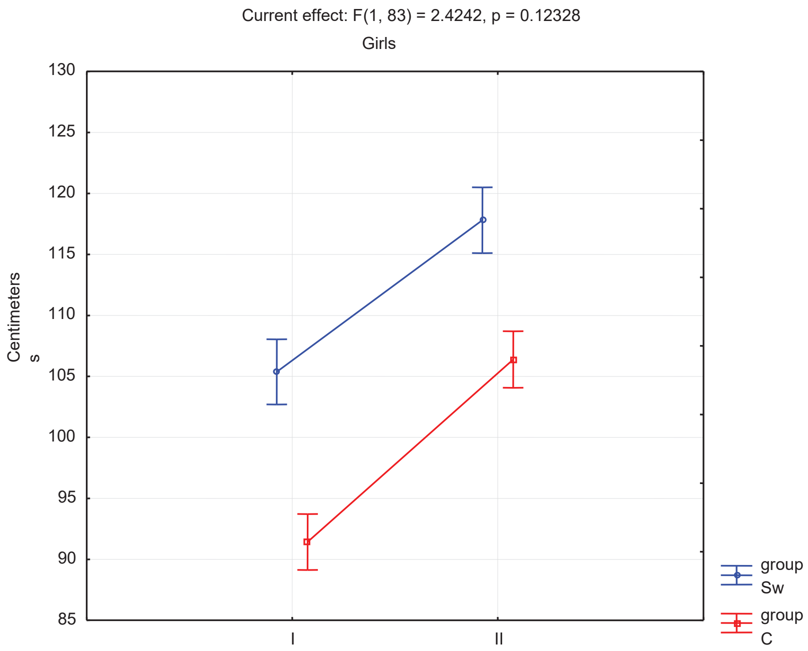

Figure 4. Changes in the results of Standing Broad Jump Test (explosive leg power) in the Swimmers (Sw) group and Control (C) group

Handgrip Strength Test – static strength

Swimmers (Sw) group displayed statistically insignificantly worse results in Examination I in terms of handgrip strength, in comparison to the Control (C) group. In Examination II, Swimmers group obtained statistically insignificantly better results than their peers from the Control group. Examination II proved statistically significant improvement of results in both groups (Sw, C) in comparison to Examination I (Table 6). In the Swimmers group it was 1.2 (psi)*, and in the Control group it was 0.7 (psi) ($p < 0.0001$) (Figure 5).

Table 6. Descriptive characteristics of Handgrip Strength Test (static strength) results in the Swimmers (Sw) and Control (C) groups

	Distribution type	Examination I		Examination II		Examination I vs. Examination II	
		Sw	C	Sw	C	Sw	C
Girls	n	36	49	36	49		
	min–max	1.0–4.0	0.5–5.0	2.5–5.0	1.0–5.5		
	mean	2.0	2.5	3.5	3.0		
	$\overline{X}$ (SD)	2.3 (0.9)	2.5 (0.9)	3.5 (0.8)	3.2 (1.0)		
	ss	0.309		0.220		<0.0001	<0.0001

Sw – Swimmers, C – Control, min – minimum value, max – maximum value, $\overline{X}$ – arithmetic mean, SD – standard deviation, ss – statistical significance.

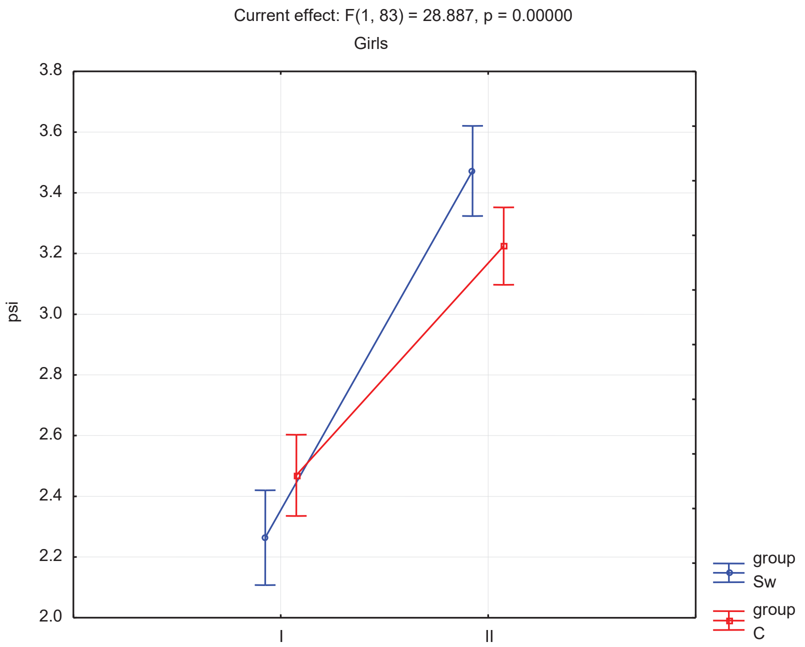

Figure 5. Changes in Handgrip Strength Test (static strength) results in the Swimmers (Sw) and Control (C) groups

Sit-Up Test – torso strength

Swimmers (Sw) group displayed statistically insignificantly higher results in Examination I in terms of sit-ups, in comparison to the Control (C) group. Examination II revealed statistically better results of girls from the Swimmers group. Examination II proved statistically significant improvement of results in both groups (Sw, C) in comparison to Examination I (Table 7). In the Swimmers group, it was on average 6.5 (n), while in the Control group it was 5.6 (n) (p = 0.083) (Figure 6).

Table 7. Descriptive characteristics of Sit-Up Test (torso strength) results in the Swimmers (Sw) and Control (C) groups

	Distribution type	Examination I		Examination II		Examination I vs. Examination II	
		Sw	C	Sw	C	Sw	C
Girls	n	36	49	36	49		
	min–max	6.0–19.0	1.0–21.0	12.0–28.0	7.0–26.0		
	mean	12.5	11.0	18.5	17.0		
	$\bar{X}$ (SD)	12.3 (3.6)	10.7 (4.6)	18.8 (3.7)	16.3 (4.2)		
	ss	0.078		0.006		<0.0001	<0.0001

Sw – Swimmers, C – Control, min – minimum value, max – maximum value, $\bar{X}$ – arithmetic mean, SD – standard deviation, ss – statistical significance.

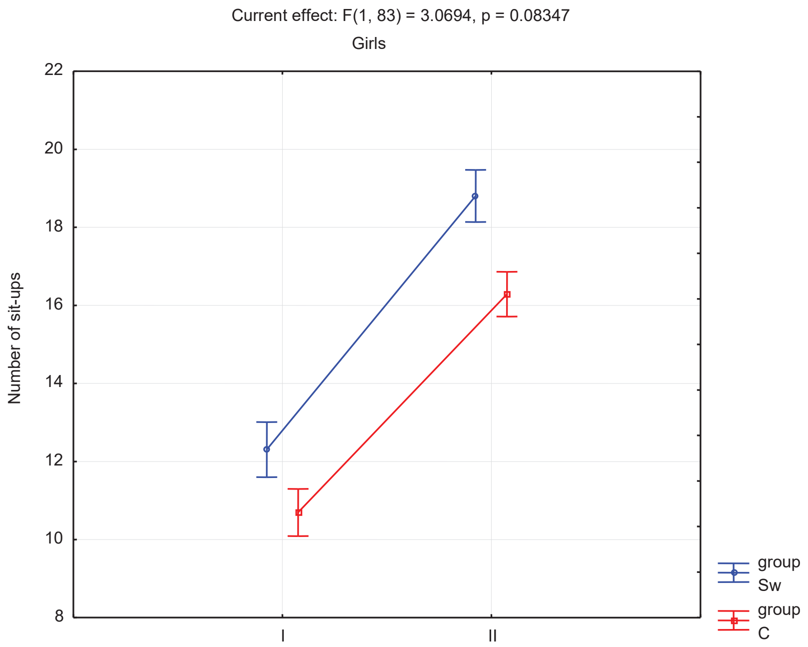

Figure 6. Changes in Sit-Up Test (torso strength) results in the Swimmers (Sw) and Control (C) groups

Bent Arm Hang Test – functional strength

Swimmers group displayed statistically significantly better results in Examination I and II in terms of bent arm hang. Examination II proved statistically significant improvement of results in both groups (Sw, C) in comparison to Examination I (Table 8). In the Swimming Group, it was on average 3.6 s, while in the control group: 1.9s (p = 0.0001) (Figure 7).

Table 8. Descriptive characteristics of Bent Arm Hang Test (functional strength) results in the Swimmers (Sw) group and Control (C) group

	Distribution type	Examination I		Examination II		Examination I vs. Examination II	
		Sw (seconds)	C (seconds)	Sw (seconds)	C (seconds)	Sw	C
Girls	n	36	49	36	49		
	min–max	1.4–21.1	0.9–20.0	4.9–23.1	3.6–22.2		
	mean	9.2	6.4	13.4	7.7		
	$\overline{X}$ (SD)	9.2 (4.2)	6.6 (4.1)	12.8 (3.8)	8.5 (3.7)		
	ss	0.004		<0.0001		<0.0001	<0.0001

Sw – Swimmers, C – Control, min – minimum value, max – maximum value, $\overline{X}$ – arithmetic mean, SD – standard deviation, ss – statistical significance.

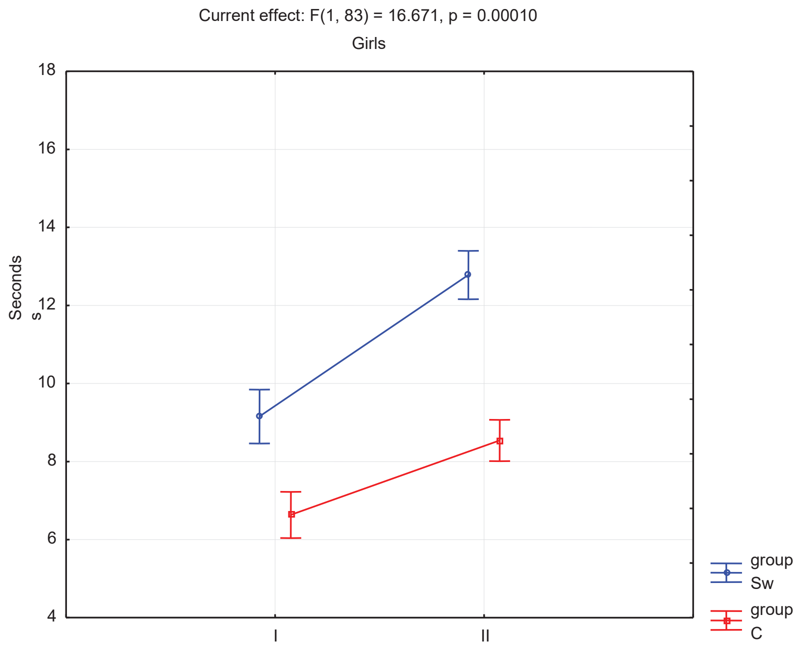

Figure 7. Changes is Bent Arm Hang Test (functional strength) results in the Swimmers (Sw) group and Control (C) group

10 × 5 m Shuttle Run Test – agility run

In Examination I, average results of the Shuttle Run were statistically insignificantly better in the Swimmers group, while in Examination II the statistical difference was significant. Examination II proved statistically significant improvement of results in both groups (Sw, C) in comparison to Examination I (Table 9). In the Swimmers group, it was on average 2.7 s, while in the Control group it was 2.0 s (p = 0.036) (Figure 8).

Table 9. Descriptive characteristics of 10 × 5 m Shuttle Run Test (agility run) results in the Swimmers (Sw) group and Control (C) group

	Distribution type	Examination I		Examination II		Examination I vs. Examination II	
		Sw (seconds)	C (seconds)	Sw (seconds)	C (seconds)	Sw	C
Girls	n	36	49	36	49		
	min–max	20.7–37.4	23.0–34.6	19.2–35.9	21.2–32.5		
	mean	26.1	27.2	23.5	25.1		
	$\overline{X}$ (SD)	26.7 (3.4)	27.8 (3.0)	24.0 (3.0)	25.8 (2.7)		
	ss	0.097		0.006		<0.0001	<0.0001

Sw – Swimmers, C – Control, min – minimum value, max – maximum value, $\overline{X}$ – arithmetic mean, SD – standard deviation, ss – statistical significance.

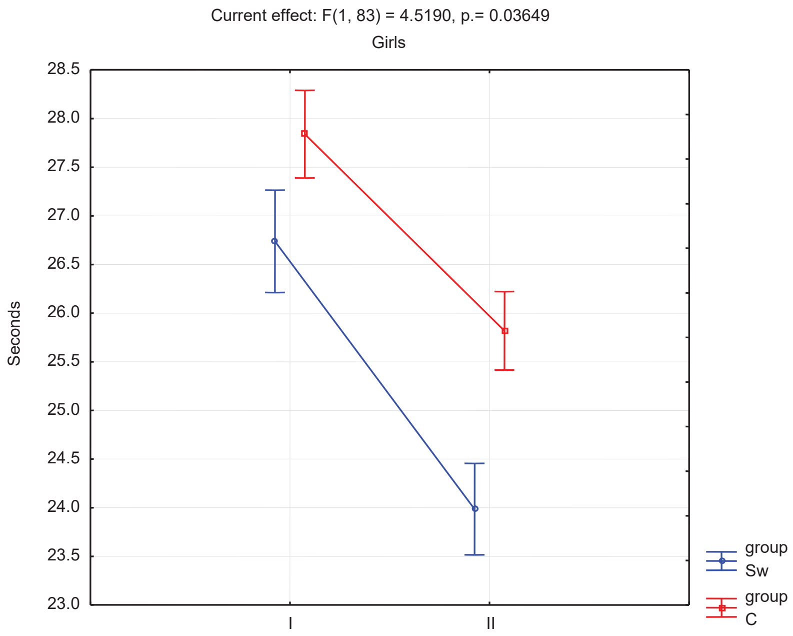

Figure 8. Changes in 10 x 5m Shuttle Run Test (agility run) results in the Swimmers (Sw) group and Control (C) group

Discussion

The research revealed changes in both groups (Sw, C) in terms of all eight tests. Examination II proved statistically significant improvement of results in both groups (Sw, C) in comparison to Examination I. Changes between Examination I and Examination II results were most visible in the Swimmers groups in terms of balance, agility, static strength, functional strength and agility run. Changes between Examination I and Examination II were similar in both groups (Sw, C) in terms of speed of limb movement, explosive strength and torso strength.

The analysis of statistical data from the EUROFIT Test Battery conducted by the author of this paper proved that the increased number of training hours resulted in enhanced motor skills in girls who started their swimming trainings. Other authors' research (Pietrusik, 1981; Dziedziczak, Witkowski, 1998) also indicated positive correlation between increased number of sports hours/trainings and motor skills of children who trained swimming.

Pietrusik's research (1981) confirmed that girls in swimming groups displayed significant improvements in final results of all physical ability tests (ICSPFT). There were no significant improvements in the examined motor skills (motor qualities) of subjects in control groups. It must be noted that the initial stage of school education is the period of significant development of all motor skills (Osiński, 2011), which was confirmed by Denisiuk, Milcerowa's (1969) research, conducted in the 1960s.

As for this study, the Swimmers group did not attain better dynamics of changes in all tests than the peer Control group (i.e. speed of upper limb movement, agility, explosive strength, torso strength, agility run). It may be explained by the specificity of swimming trainings: it was conducted at the swimming pool, not at the gym, which would increase strength of young swimmers more notably.

Progressive changes in motor skill of subjects are a positive phenomenon in the physical development of a child. During both Examinations (I and II) subjects attended elementary school 1st grade, i.e. the first grade of the early school age (Osiński, 2011). School authorities, Physical Education teachers and Integrated Education teachers at Elementary Schools no. 51, 55, 56 and 62 in Szczecin (attended by the subjects from both groups: Sw and C) facilitated the development of motor skills by their didactic, sports and recreational activities. Diversified motor and recreational activities provided during PE classes might have significantly influenced the EUROFIT Test results.

During both Examinations (I and II) subjects were 1st-graders, therefore their physical development was at an early school age, which lasts until puberty (at the age of 10–12) (Osiński, 2011). During this period, especially when children begin their school education, they must conform to certain requirements, school duties and new environment (Osiński, 2011). According to Przewęda (1981, p. 164) children display a great 'need to blow off steam by physical activity, to satisfy their great «hunger for activity».' Schools (their sports and recreational infrastructure), Physical Education teachers, Integrated (early age) education teachers influence the quality of motor skills development. Therefore, a Physical Education teacher plays a significant role in the process of physical development of the new generation. Participation in organized, regular sports classes results in the development of motor (physical) skills of children (Torrance, McGuire, Lewanczuk, McGavock, 2007; Chalcarz, Merkiel, Pach, Lasek, 2008; Wilk, Eider, 2014).

Conclusions

1. Examination II proved statistically significant improvement of results in both groups (Swimmers, Control) in comparison to Examination I.

2. Comparative analysis of motor skill of both groups confirmed that the dynamics of changes between Examinati0on I and II was greater among swimming subjects in five tests (general balance, agility, static strength, functional strength, agility run) (Figures 1, 3, 5, 7, 8).

3. In the remaining motor skill tests (speed of upper limb movement, explosive strength, torso strength) differences in results between Examination I and Examination II were similar in both groups (Swimmers and Control group) (Figures 2, 4, 6).

4. Progressive changes in motor skill of subjects are a positive phenomenon in the physical development of a child.

5. Swimming training resulted significantly in positive changes in terms of motor skills of subject who were at the initial stage of swimming trainings, compared to their non-training peers.

6. Participation in organized, regular sports classes results in the development of motor (physical) skills of children.

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THE EFFECTS OF A SIX-WEEK PLYOMETRIC TRAINING PROGRAM ON THE STIFFNESS OF ANTERIOR AND POSTERIOR MUSCLES OF THE LOWER LEG IN MALE VOLLEYBALL PLAYERS

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Abstract The study assesses the effects of a six-week plyometric training program (PT) on muscle stiffness in the dominant and non-dominant leg in male collegiate volleyball players. The study group comprised 16 volleyball players who had played collegiate volleyball for at least four years. For six consecutive weeks, twice a week, the players undertook a plyometric program of 60-min training sessions, each preceded with a specialist warm-up. The analysis of the anterior muscles of the right and the left lower leg revealed a significant increase in stiffness in the muscles of the right leg and the left leg. No significant differences were found between the anterior muscles of the left lower leg and the right lower leg in particular weeks of the training program. The analysis of the posterior lower leg muscles revealed no significant differences, either in the consecutive weekly training microcycles or between the left leg and the right leg. The measurement of muscle tone and biomechanical properties of muscles can be used as a fast and direct assessment of plyometric training-related muscle fatigue. A similar level of muscle stiffness in both lower legs (symmetry) is a reflection of the appropriate selection of plyometric training loads.

Key words plyometric training, muscle stiffness, volleyball

Introduction

Modern training of elite volleyball players must prepare them to face huge match demands for high-level competitions that comprise two or more matches a week, or more than ten matches during the European

Championship, World Cup, or Olympic Games. Incremental fatigue during competition make the players successfully cope with those demands, only if their training and competitive loads as well as active regeneration and supplementation are properly adjusted.

Our novel research into muscle stiffness is aimed at determining predictors of athletes' fatigue due to overtraining. An early identification of such predictors can prevent muscle microinjuries, which then can lead to serious injuries. Masi (Masi, Nair, Evans, Ghandour, 2010) confirmed that objective measurements of the muscle tone, tension level, and such biomechanical properties as muscle elasticity and stiffness can be effectively used for detection of overloads and for injury prevention.

From the biomechanical standpoint muscle stiffness is a response to an emitted stimulus, which results from muscle resistance to mechanical lengthening (Rack, Westbury, 1969). According to Wilson, Wood, Elliott (1991) optimal muscle stiffness is significantly correlated with augmentation of muscle training loads.

Laboratory measurements of muscle tone and biomechanical properties are performed with the use of different measurement devices and methods (Chen, Wu, Huang, Lee, Wang, 2005; Gavronski, Veraksits, Vasar, Maaroos, 2007; Gennisson, Cornu, Catheline, Fink, Portero, 2005; Leonard, Brown, Price, Queen, Mikhailenok, 2004; Tous-Fajardo et al., 2010; Viir, Laiho, Kramarenko, Mikkelsson, 2006), which stimulate muscles mechanically or electrically and analyze muscle response. The MyotonPRO measurement tool (Estonia) implements a state-of-the-art technology used in vivo for muscle stiffness, tension and elasticity assessment both in patients in clinical conditions and in healthy athletes during sport competition. MyotonPRO measurements can be conveniently and reliably carried out in extra-laboratory conditions, e.g. to determine the post-exercise status parameters in healthy athletes. MyotonPRO induces – in a non-invasive way – the oscillation of muscle tissue and then computes the parameters of muscle tone (oscillation frequency), elasticity, and dynamic stiffness.

Material and Methods

Subjects

The study involved 16 male collegiate volleyball players from AZ'S Opole University of Technology Sports Club (age, 21.12 ±1.67 years; body mass, 86.30 ±6.66 kg; height, 191.60 ±5.74 cm; Vuma, 52.88 ±4.408) with experience (minimum, 4–5 years) performing regular volleyball training participated in this experiment (Table 1). None of the players had any physical or physiological limitations (injuries) that could have affected the training. All layers were healthy and there was an official certified medical advisor for those competing in the Division II league.

Initially, the plyometric intervention program was started by the whole team (n = 16); however, only 8 players completed the entire six weeks. The experimental team was composed of 11 hitters (3 middle blockers, 5 service receivers, 3 opposite attacker), 3 setters, and 2 liberos. All players were healthy and were counseled by an official medical advisor for competing in league matches, in accordance with the university sports law. The protocol of research on human subjects was approved by the university ethical committee. Before the commencement of the plyometric intervention program (PIP) the players were informed about the research aim and methods. A written informed consent to participate was obtained from the participants before any plyometric training and testing.

It was assumed that the homogeneity of the tested group was evident from the standard deviation of the BMI measure (Ward, Johnson, Stager, 1984), which did not exceed 10% of the arithmetic mean for all subjects – 23.47 BMI (±1.68).

Table 1. Mean ± SD for body height, body mass, and body mass index

Group	Age (years)	Body height (m)	Body mass (kg)	BMI (%)
All players (n = 16)	21.12 ±1.67	191.6 ±5.74	86.3 ±6.66	23.47 ±1.68
Attacker (n = 3)	21.00 ±0	193.33 ±2.52	88.33 ±7.64	23.65 ±2.29
Service receiver (n = 5	21.20 ±2.68	190.20 ±3.49	82.60 ±5.55	22.83 ±1.33
Middle blocker (n = 3)	20.67 ±0.58	199.33 ±1.16	91.0 ±1.00	22.90 ±0.14
Setter (n = 3)	20.67 ±1.15	190.00 ±4.00	87.67 ±10.97	24.23 ±2.04
Libero (n = 2)	22.50 ±2.12	183.50 ±7.78	83.00 ±2.83	24.76 ±2.93

Procedures

The study was carried out five weeks before the commencement of the Polish volleyball league season: at the start of the direct pre-competitive preparation period (Week 0), mid preparation period (Week 3), and two weeks at the start of competitive preparation period (Week 6). The team under study practiced 5–6 times a week, in 80–90 min training sessions which included sparring matches and league matches at the beginning of the season. In Week 0 the measurements of stiffness of anterior and posterior muscles of the lower leg in the lying position were carried out in all 16 players before the training units.

For six consecutive weeks, twice a week – on Mondays and Wednesdays - the players undertook a plyometric training program of 60-min sessions (Table 1), each preceded with a specialist warm-up. The training sessions consisted of multiple types of vertical and horizontal jumps and hops performed at different intensities, paces, and directions (Table 2). On the remaining week days the players undertook a specialist volleyball training program prepared by the team's coaches, and played a few sparring matches. In the competitive period the players played regular league matches (Thursday, Saturday). All studied volleyball players also performed regular activities of daily living; however, due to their low and sporadic intensity they did not affect the training process. A single plyometric training unit lasted from 70 to 90 min and consisted of a 10-min specialist warm-up, 60-min main part, and 10-min recovery.

Table 2. Summary of strength exercises and plyometric training program

Weeks	Workout 1 Exercise	Sets	Reps	Load % of 1 RM	Workout 2 Exercise
1	2	3	4	5	6
1/2	Bench press	2	10	70	Incline bench press
	Squat	2	10	70	Leg presses
	Power clean	3	6	60	Power snatch
1/4	Double leg squat jump	2	8	–	Double legs vertical back kicks
	Combination: standing long jump and "spiking" jump	2	5	–	Combination: standing long jump and "spiking" jump
	Double leg hops over hurdles	2	8	–	Double leg horizontal speed hops
	Horizontal scissors jumps in place	2	20	–	Alternate leg vertical box step-ups
	Alternate vertical high knee jumps	2	6	–	Double leg vertical knee-tuck jumps
	Total number of foot contacts			116	
3/4	Bench press	2	10	75	Incline bench press
	Squat	2	10	75	Leg presses
	Power clean	3	6	60	Power snatch

1	2	3	4	5	6
2	Double leg squat jump	3	8	–	Double legs vertical back kicks
	Combination: standing long jump and “spiking” jump	3	5	–	Combination: standing long jump and “spiking” jump
	Double leg hops over hurdles	3	8	–	Double leg horizontal speed hops
	Horizontal scissors jumps in place	3	20	–	Alternate leg vertical box step-ups
	Alternate vertical high knee jumps	3	6	–	Double leg vertical knee-tuck jumps
	Total number of foot contacts			174	
5	Bench press	2	10	80	Incline bench press
	Squat	2	10	80	Leg presses
	Power clean	3	6	70	Power snatch
3/5	Double leg squat jump	4	6	–	Double legs vertical back kicks
	Combination: standing long jump and “spiking” jump	4	5	–	Combination: standing long jump and “spiking” jump
	Double leg hops over hurdles	4	8	–	Double leg horizontal speed hops
	Horizontal scissors jumps in place	4	20	–	Alternate leg vertical box step-ups
	Alternate vertical high knee jumps	4	6	–	Double leg vertical knee-tuck jumps
	Total number of foot contacts			224	
6	Bench press	2	–	85	Incline bench press
	Squat	2	10	85	Leg presses
	Power clean	3	10	75	Power snatch
6	Double leg squat jump	5	6	–	Double legs vertical back kicks
	Combination: standing long jump and “spiking” jump	4	5	–	Combination: standing long jump and “spiking” jump
	Double leg hops over hurdles	5	8	–	Double leg horizontal speed hops
	Horizontal scissors jumps in place	4	20	–	Alternate leg vertical box step –ups
	Alternate vertical high knee jumps	5	5	–	Double leg vertical knee-tuck jumps
	Total number of foot contacts			240	

Measurement procedure using MyotonPRO

The measurements were performed with the MyotonPRO Digital Palpation Device (MyotonPRO, Myoton Ltd, Estonia). The procedure consisted of inducing and recording damped natural oscillation of muscle in the form of an acceleration signal and the subsequent simultaneous computation of the parameters of state of tension (frequency in Hz), elasticity, and dynamic stiffness (N/m). The measurement was performed under constant pre-load (0.18N) through compression of the skin surface by a mechanical impulse (15 ms) of low force of 0.4 N followed by quick release (http://www.myoton.com/en/technology).

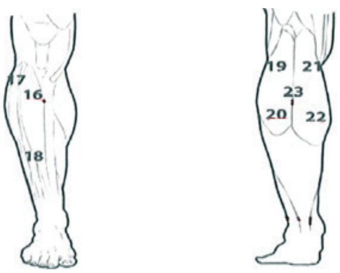

Figure 1. Positioning of the MyotonPRO device on selected muscles during muscles stiffness measurement

Each week, before the start of the procedure measurement spots were marked on the skin surface of particular muscle bellies and attachments (Figure 1) of anterior muscles of the lower leg (tibialis anterior muscle – spot 16, peroneous longus muscle – spot 17, peroneous brevis muscle – spot 18) and posterior muscles of the lower leg (lateral head of the gastrocnemius muscle mm – spots 19 and 20, medial head of the gastrocnemius muscle – spots 21 and 22, mid-part of the gastrocnemius muscle – spot 23). Following the manufacturer's instructions the probe of the MyotonPRO device was placed on the spots marked on the skin, in numerical order in Figure 1. Muscle stiffness was measured before exercise (before warm-up) for all marked muscles.

Statistical analysis

Descriptive statistics (means and ±SD) were calculated. The Shapiro-Wilk test indicated a normal distribution for all variables. Comparisons between the jumping exercises were examined with unpaired Student's *t* tests, and the effect size was calculated using Cohen's *d* (Thalheimer, Cook, 2002). Effect sizes were interpreted as negligible ($d \geq 0.2$), small ($0.2 \leq d \leq 0.5$), medium ($0.5 \leq d \leq 0.8$), or large ($0.8 \leq d$). Spearman's correlation coefficients were used to examine the relationships between the load (volume - number of foot contacts, and intensity – HR) of PT and jumping performance. The level of significance was set at $p \leq 0.05$ or $p \leq 0.01$. Data were statistically analysed with the use of SPSS for Windows 15.0 (Chicago, IL, USA).

Results

The analysis of stiffness of the anterior muscles of the right and the left lower leg did not reveal any significant changes in stiffness between the measurement before the start of the plyometric training program (right leg 545.92 ±75.97; left leg 548.50 ±74.39) and the measurement in the third week of the program (right leg 525.15 ±67.81; left leg 524.29 ±69.50). In the sixth week of the program significant increases in the muscle stiffness of the right leg (for 61.41) and the left leg (for 76.77) ($p < 0.001$) were noted.

No significant differences were found between the anterior muscles of the right and the left lower legs in particular weeks of the plyometric training program (Figure 2).

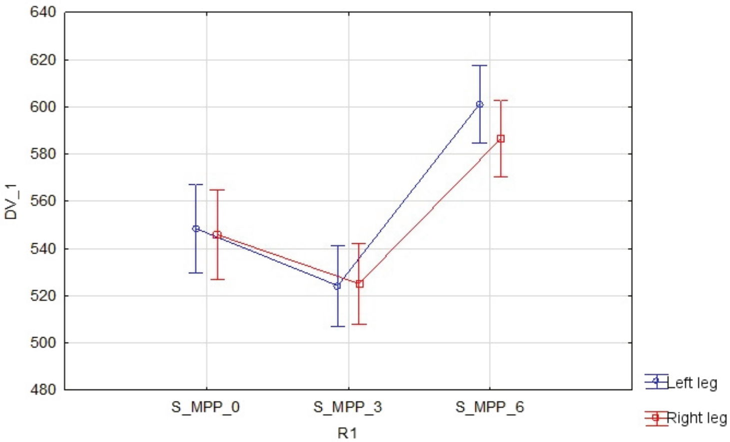

Figure 2. Changes in stiffness of lower leg muscles within a six-week plyometric training program

The analysis of stiffness of posterior muscles of the lower leg revealed no differences between particular weekly training microcycles or between muscles of the right and the left lower leg (Figure 3).

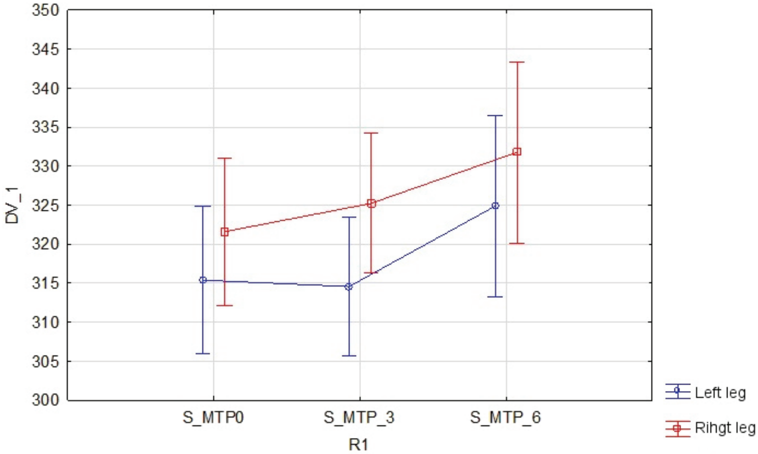

Figure 3. Changes in stiffness of lower leg muscles within a six-week plyometric training program

Discussion

The examination of stiffness of anterior and posterior muscles of the lower leg revealed initially a greater tone of the anterior than the posterior muscles. The analysis also showed that with the increased tone the level of stiffness of anterior muscles of the lower leg was significantly higher after six weeks of plyometric training than at rest (Week 0). On the one hand, the increased muscle tone can be explained by the activity of the central nervous system in regulating muscles stiffness and elasticity through muscle spindles within the body of muscles (Aura, Komi, 1986). While performing jumping exercises, it appears to be particularly significant in the sudden shock absorption phase during landing and the rapid take off after a brief floor contact.

The goal of used plyometric exercises is to increase the power of subsequent movements by using the natural and elastic components of the muscle, tendon, and stretch reflex. Plyometric training causes muscular and neural changes that facilitate and enhance the development of rapid and powerful movements (Fatahi, Sadeghi, 2014). Muscles are prestretched prior to jumping, and the stretch shortening cycle is involved. Prestretching causes the muscles to store potential elastic energy (Ishikawa, Komi, Grey, Lepola, Bruggemann, 2005; Potach, Chu, 2000) and then recoil during take-off, thus allowing more power while jumping (Ishikawa et al., 2005). Plyometric exercises train and activate the fast muscle fibers and nerves and activate the reflexes (Harmandeep, Satinder, Amita, Anupriya, 2015). Therefore, plyometric training is one primary tool that enhances both explosive power and speed, especially in volleyball. The plyometric method is ranked among the most frequently used methods for conditioning in volleyball (Lehnert, Lamrova, Elfmark, 2009).

The analysis of posterior lower leg muscles showed than while the level of initial muscles stiffness was significantly lower, its increase after the 3rd and the 6th week of plyometric training was statistically non-significant, but also respectively lower than in the anterior muscles. In this case a great role in regulation of muscles stiffness is played by Golgi tendon organs in the Achilles tendon at the origins of skeletal muscle fibers (Cameron-Tucker, 1983). This tendon-muscle complex is particularly protected by the central nervous system during dynamic eccentric-concentric muscle performance.

The significant increase in the stiffness of anterior muscles of the thigh can also be impacted by plyometric training, especially while performing jumps different from jumps exercised by volleyball players to which they were adapted during the sport-specific training. The applied training program comprised dynamic exercises with higher loads (because of the preparatory training period of the volleyball players) which significantly shorten the ground contact time of the foot and improve jumping quality. During swinging movements, as Maćkała (Mackala, Stodolka, Siemienski, Coh, 2013) claim, the most active are the rectus femoris muscle and the tibialis anterior muscle.

The applied plyometric training was a new and non-specific stimulus to the volleyball players and thus their system of locomotion could respond to the program with increased activity and greater fatigue manifested by muscle stiffness. During training particular attention was paid to the jumping technique that emphasized brief ground contact time and prolonged time of the flight stage. In consequence, the volleyball players performed the new jumping exercises differently than the jumps during matches and, therefore, loaded the locomotor system in a different way. Plyometric exercises (jumping, hopping, modified bounding, and some type of skipping) executed bilaterally and unilaterally can strongly increase muscle stiffness (Behrens, Mau-Moeller, Bruhn, 2014; Behrens et al., 2016), thereby enhancing the dynamic muscular performance (Impellizzeri et al., 2008) of activities related to the vertical jumping ability (King, Cipriani, 2010; Kotzamanidis, 2006; Mackala, Fostiak, 2015; Sozbir, 2016) which are very demanding and required in volleyball.

The analysis did not show any significant differences in stiffness between anterior and posterior muscles of both lower legs. This can be explained by similar training loads (number of jumps) for both legs. The plyometric training program was performed during the preparatory training period, during which general exercises, including jumping exercises, dominate over volleyball-specific loads. However, a full explanation of the observed changes would be possible with a future comprehensive analysis of kinematic chains of anterior and posterior muscles of the lower leg. In the present study, for example, data on the ankle joint activity was not collected and analysed.

Conclusion

The measurement of muscle tone and biomechanical properties of muscles can be used as a method of quick and direct assessment of plyometric training-related muscle fatigue. The volleyball player represented an intermediate level of sport performance and had a minimum of five years of training /match experience. This allowed to performed a 6 weeks of plyometric training without injury. The use of plyometric training in younger athletes representing lower level of sport experience needs a lot of care and methodical attention.

A similar level of muscle stiffness of different muscle groups in both lower legs (symmetry) is a reflection of the appropriate selection of plyometric training loads. Different levels of muscle stiffness for both legs indicate the necessity of adjustment of training loads to ensure the balanced development of muscles and to prevent and reduce the risk of injuries.

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