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Editorial Office

Secretary: Dominika Niedźwiedź

51-684 Wrocław, ul. Mickiewicza 98, Poland, tel. 071 347 30 51

hum_mov@awf.wroc.pl

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EDITORIAL

The present volume of *Human Movement* deals with very interesting and multidisciplinary papers from all significant fields of physical culture including sport, rehabilitation, sport psychology and physical recreation.

In the first article, the authors are concerned with the relationship between skinfold thickness and race time in cyclists in ultra-endurance cycling race. It is followed by a paper in which the authors aim to assess expiratory flow limitation and to determine how tidal volume is regulated within forced vital capacity during exercise.

The paper entitled “Bone mineral density and body composition of senior female students of the University of the Third Age in view of their diverse physical activity” investigate the direction and dynamics of changes in various functions and processes of the human body affected by physical activity and assess the biological effects of regular exercise in older adults.

In their study “Social and somatic determinants of physical fitness in men aged 20–70 years from Cracow” authors evaluate the contribution of social and somatic factors to the age-related regression of physical fitness and endurance in men.

The effects of strength training carried out on four disabled subjects from the Foundation of Active Rehabilitation are described in the next article. Authors revealed a correlation between the body’s physical endurance and strength capacities of subjects with cervical spine injuries.

Another publication, which discusses the results of wind tunnel tests for different angular configurations of a V-style (Graf–Boklev style) ski jumper model, is the first such comprehensive ski wind tunnel research in professional literature.

The next study results point to the impact of exercise on the repeatability of applied force. Further research can indicate ways of control of adaptation changes in the central nervous system and the locomotor system on a general level, since the studies so far have described either local changes, e.g. EMG, or provided specific data related to typical patterns of activity in a given sport.

The results of the study “Force-velocity parameters of knee flexors and extensors in 10–12-year-old children

with spinal and knee diseases” indicate that a corrective exercise programs for children with scoliosis of the first degree and knock-knees should involve strength and endurance training of muscles of the lower limbs.

The present volume also contains three works concerned with biomechanics. The first one discusses the changes of maximal power output and power–velocity relationship in male volleyball players. The other paper on the efficiency of power training involving single joint and multiple joint exercises is a comparative study of training exercises involving different groups of muscles. The third one presents evaluation of the torque of muscles responsible for internal and external rotation of the shank.

The aim of the next article was to determine changes in mood and chosen personality traits in women taking part in a three-month exercise program, and find correlations between dimensions of mood and personality traits and personality predictors of mood changes.

Another article presents study on professional burn-out in PE teachers. The obtained results point to the necessity of development of teachers’ sense of self-efficacy, which enhances effective stress management and coping with professional duties; it also facilitates changes in the working environment and prevention of the burnout causes.

The next article focuses on the influence of culture on sports achievements. The Individualism–Collectivism dimension (IC) research has become one of the most interesting fields of modern intercultural psychology. The article presents merely some issues of IC research as a measure explaining cross-cultural differences.

The last article in the volume touches on the social significance of the problem of low level of physical activity of Polish women. The authors determine relations between ways of spending free time and professional, household and family duties of women, who had participated in physical recreation for many years.

We would like to express our deepest gratitude to all Reviewers for their most effective contribution to the improvement of quality of *Human Movement* in 2009:

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NO ASSOCIATION BETWEEN SKINFOLD THICKNESSES AND RACE PERFORMANCE IN MALE ULTRA-ENDURANCE CYCLISTS IN A 600 KM ULTRA-CYCLING MARATHON

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Beat Knechtle^{1, 2*}, Patrizia Knechtle¹, Thomas Rosemann²

¹ Gesundheitszentrum St. Gallen, St. Gallen, Switzerland

² Institute of General Practice and Health Services Research, University of Zurich, Zurich, Switzerland

ABSTRACT

Purpose. In long-distance runners, an association between skinfold thicknesses and running performance has been demonstrated. **Basic procedures.** We investigated the relationship between skinfold thicknesses and race time in cyclists in an ultra-endurance cycling race. In 28 ultra-endurance cyclists at the 'Swiss Cycling Marathon' over 600 km, skinfold thickness at 8 sites was measured pre race. Single skinfold thicknesses, the sum of 8 skinfolds and percent body fat were correlated with total race time. **Main findings.** The cyclists finished within 1.596 (296) min riding at an average speed of 26.8 (5.7) km/h. There was no correlation between single skinfold thicknesses, the sum of 8 skinfold thicknesses and percent body fat with total race time. **Conclusions.** In male ultra-cyclists in a 600 km ultra-marathon, no correlation between skinfold thicknesses and race performance has been detected as demonstrated in long-distance runners.

Key words: anthropometry, ultra-endurance, body fat

Introduction

Ultra-endurance races are becoming more and more attractive and an increasing number of cyclists intend to start in ultra-cycling races such as the 'Race Across America' (RAAM) in the USA or 'Paris–Brest–Paris' in Europe. There is very limited data concerning anthropometry in ultra-endurance cyclists and a question is whether a slim and light body, respectively low body fat is of importance in finishing such an ultra-cycling race.

In these ultra-cycling races, a considerable decrease in body mass has been described [1, 2], as already stated in shorter ultra-cycling races [3, 4]. In two case reports [1, 2] and two field studies [3, 4], anthropometric data including age, body mass, body height and body mass index of the cyclist and the loss of body mass were provided. In the two case studies, the athletes were riding for several days and lost substantially more body mass in the form of body fat [1, 2] than the cyclists in the two ultra-cycling races of less than one and a half day [3, 4].

Regarding body fat, the relationship between skinfold thicknesses and endurance performance has been

intensely investigated in long-distance runners. Hagan et al. [5] demonstrated a correlation between the sum of 7 skinfold thicknesses and marathon performance time. Total skin-fold, the type and frequency of training and the number of years running were the best predictors of running performance and success at the 10 km distance according to Bale et al. [6]. In recent studies, a relationship between the thicknesses of selected skinfolds and running performance has been demonstrated in top class runners [7, 8]. In these studies, elite runners of distances from 100 m to 10,000 m and the marathon distance have been investigated [7, 8]. Arrese and Os-táriz [7] showed high correlations between the front thigh ($r = 0.59$, $p = 0.014$) and medial calf ($r = 0.57$, $p = 0.017$) skinfold and 10,000 m running time. It is supposed that the thicknesses of the lower limb skinfolds are the result of intense training in running [8].

The relationship between skinfold thicknesses and race performance was investigated in all running distances from 100 m to 10,000 m in male top level athletes; but not in ultra-endurance cyclists. We therefore investigated the existence of an association between skinfold thicknesses and race performance in male ultra-endurance cyclists. Considering the fact that ultra-endurance cyclists have to climb partly step ascents,

* Corresponding author.

low body fat respectively low skinfold thicknesses would probably enhance performance and the training in the preparation for the race should lead to an association between skinfold thickness and training volume, respectively intensity in training.

We therefore hypothesized to find a correlation between skinfold thicknesses, respectively the sum of skinfold thicknesses and race performance. Furthermore, training volume and thickness of skinfolds should show an association.

Material and methods

Subjects

The organiser of the 'Swiss Cycling Marathon' contacted all participants of the race in 2007 by a separate newsletter, three months before the race, in which they were informed about the study. Athletes were asked about their average weekly training volume in hours and kilometres in cycling over the last 3 months in the preparation for the race. During these 3 months prior to the race, each athlete maintained a comprehensive training diary consisting of daily workouts with distance and duration in order to determine speed in cycling during training. Additionally, they reported their training volume in cycling kilometres over the past 12 months before the race. A total of 123 male non-professional cyclists started in order to qualify for the ultra-cycling marathon 'Paris-Brest-Paris'. Thirty-six male athletes were interested in our investigation. Subjects were informed of the experimental risks and gave informed consent prior to the investigation. The investigation was approved by the Institutional Review Board for use of Human subjects. Twenty-eight cyclists with mean (SD) 42.3 (7.3) years, 78.3 (7.5) kg body mass, 1.81 (0.07) m body height and a BMI of 24.2 (1.9) kg/m² out of our study group finished the race successfully.

The race

The 'Swiss Cycling Marathon' took place from the 29th to 30th June 2007 as a non-stop ultra-cycling race from the outskirts of Bern (Switzerland) over the border to Germany, then along Lake Constance into the Alps of Eastern Switzerland and back to Bern. During this 600 km race, the athletes had to climb a total altitude of 4,630 m. The weather in Bern was fine and sunny, with 22 °C during the day and 11 °C in the night. Athletes

were allowed to have a support crew with a car. About every 60 km, a checkpoint was set where every cyclist had to stop and register. Besides, food and drinks were served at these aid stations. A time limit was set at 40 hours.

Measurements and calculations

Before the start of the race, every participant underwent anthropometric measurements in order to determine body mass, body height and skinfold thicknesses at 8 sites in order to calculate the sum of 8 skinfold thicknesses and percent body fat. Body mass was measured using a commercial scale (Beurer BF 15, Beurer, Ulm Germany) to the nearest 0.1 kg. Body height was measured using a stadiometer to the nearest 1.0 cm. Skinfold thicknesses of pectoralis, midaxillary (vertical), triceps, subscapular, abdominal (vertical), suprailiac (at anterior axillary), thigh and calf were measured using a skinfold calliper (GPM-Hautfaltenmessgerät, Siber & Hegner, Zurich, Switzerland) to the nearest 0.2 mm at the right side of the body. Percent body fat was calculated using the following anthropometric formula for men: Percent body fat = $0.465 + 0.180(\Sigma 7SF) - 0.0002406(\Sigma 7SF)^2 + 0.0661(\text{age})$, where $\Sigma 7SF$ = sum of skinfold thickness of pectoralis, midaxillary, triceps, subscapular, abdomen, suprailiac and thigh mean, according to Ball et al. [9]. This formula was evaluated in 160 men aged 18–62 years and cross-validated using DXA (dual energy X-ray absorptiometry). The mean differences between DXA percent body fat and calculated percent body fat ranged from 3.0% to 3.2%. Significant ($p < 0.01$) and high ($r > 0.90$) correlations existed between the anthropometric prediction equations and DXA. One trained investigator took all skinfold measurements as inter-tester variability is a major source of error in skinfold measurements. Intra-tester reliability check was conducted on 27 male runners prior to testing. No significant difference between the 2 trials for the sum of 8 skinfolds was observed ($p > 0.05$). The intra-class correlation was high at $r = 0.95$. The same investigator was also compared to another trained investigator to determine objectivity. No significant difference existed between testers ($p > 0.05$). The skinfold measurements were taken once through entire 8 skinfolds and then repeated 3 times by the same investigator; the mean of the 3 times was then used for the analyses. The timing of the taking of the skinfold measurements was standardised to ensure reliability. According

Table 1. The correlation of the anthropometric variables with speed in training, average weekly training volume, race time and speed in the race

Variable	Pre race	Speed in training (km/h)	Training volume (km/week)	Race time (min)	Speed in the race (km/h)
SF pectoral (mm)	8.4 (3.2)	-0.19	-0.24	0.29	-0.36
SF axillar (mm)	9.4 (3.5)	-0.16	-0.12	0.23	-0.29
SF triceps (mm)	9.1 (3.2)	-0.16	-0.16	0.30	-0.34
SF subscapular (mm)	12.1 (4.9)	-0.28	-0.16	0.17	-0.22
SF abdominal (mm)	20.2 (8.2)	-0.25	-0.24	0.28	-0.36
SF suprailiacal (mm)	16.4 (5.6)	-0.21	-0.26	0.20	-0.23
SF thigh (mm)	14.0 (5.5)	-0.20	0.24	0.15	-0.20
SF calf (mm)	7.1 (3.1)	-0.23	0.02	0.28	-0.35
Sum of 8 skinfolds (mm)	96.7 (28.7)	-0.28	-0.16	0.30	-0.38
Percent body fat (%)	17.3 (3.7)	-0.28	-0.17	0.35	-0.42

Results are presented as mean (SD); R-values are presented for all variables; no significant association has been found

to Becque et al. [10], readings were performed 4 s after applying the calliper.

Statistical analysis

Data are presented as mean (SD). Speed in training and speed during race were compared with Wilcoxon signed rank test. The coefficient of variation ($CV\% = 100 \times SD/\text{mean}$) of performance for total race time was calculated. The Pearson's correlation coefficient was used to test for univariate associations between speed in training and speed in the race with the anthropometric variables. Bonferroni correction was used to compensate for multiple testing effects. Significant p -values after Bonferroni correction were assumed at a level of $p < 0.005$ ($n = 10$ tests for the relationship between race time with the anthropometric variables, 8 single skinfolds, sum of 8 skinfolds and percent body fat).

Results

In the preparation of this race, the athletes were cycling 13.1 (4.7) h per week and were completing 340 (117) km. During training, the cyclists were riding at an average speed of 26.8 (5.7) km/h, significantly faster compared to speed in the race with 23.2 (3.7) km/h. The athletes reported a yearly training volume of 11,100 (4,700) cycling kilometres. The cyclists finished the race in a mean time of 1,596 (296) min ($CV = 17.9\%$). The relationship between the skinfold thicknesses and training volume, speed in training, race time as well as speed in the race is shown in Tab. 1. No association could be shown between the thickness of the single

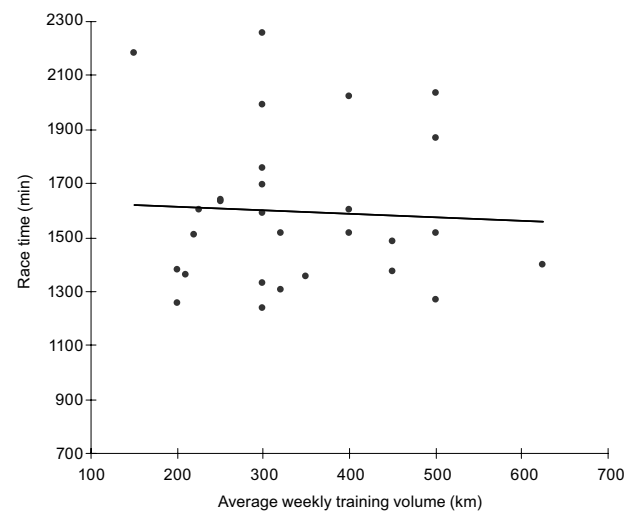


Figure 1. The average weekly training volume showed no association with race performance ($r = -0.05$, $p > 0.05$)

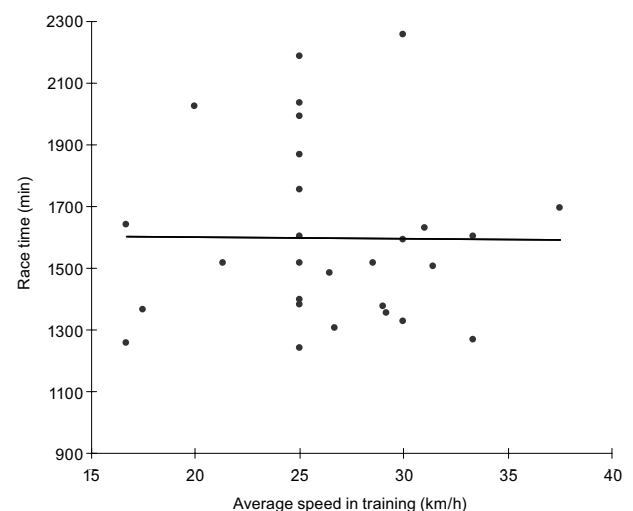


Figure 2. The intensity during training showed no association with race performance ($r = -0.01$, $p > 0.05$)

skinfolts, the sum of 8 skinfold thicknesses and percent body fat neither for speed in training and racing nor for training volume in cycling kilometres and total race time. Neither average weekly training volume (Fig. 1) nor average speed in training (Fig. 2) were related to race performance.

Discussion

In contrast to male long-distance runners [7] where a correlation between skinfold thicknesses at the lower limb and running performance has been shown, we could not detect an association between thickness of selected skinfold sites and race performance in these male ultra-endurance cyclists. A possible explanation for these different findings might be the kind of exercise since Arrese and Ostáriz [7] and also Legaz and Eston [8] investigated runners while we investigated cyclists. Running might lead to an increased decline in body fat since fat oxidation is increased during running compared to cycling [11, 12]. This might explain why Legaz and Eston [8] found an association between training volume and decrease in the sum of 6 skinfold thicknesses.

Arrese and Ostáriz [7] showed high correlations between the front thigh ($r = 0.59$, $p = 0.014$) and medial calf ($r = 0.57$, $p = 0.017$) skinfold thickness and 10,000 m running time in male high-level runners; however, no association between the sum of 6 skinfold thicknesses and both 10,000 m ($r = 0.42$, $p > 0.05$) and marathon ($r = 0.13$, $p > 0.05$) performance time. Running training leads to a decrease in skinfolts of the lower body. Legaz and Eston [8] could demonstrate a significant decrease in abdominal skinfold thickness ($p = 0.032$), front thigh skinfold thickness ($p = 0.008$), medial calf skinfold thickness ($p = 0.028$) and the sum of 6 skinfold thicknesses ($p = 0.037$) due to running training. Both in running and cycling muscles of the lower limb are used; a relationship between training and skinfold thickness at the lower limb has been found in long-distance runners, however, not in these ultra-endurance cyclists. Obviously cycling is not so intense and muscular work of these specific muscle groups seems to have no effect on the adipose subcutaneous tissue.

Legaz and Eston [8] suggested that intensity in training is related to thinner skinfolts. Training resulted in a significant decrease in the sum of 6 skinfold thicknesses and the thickness of abdominal, front thigh and medial calf skinfold in their investigation over a 3 year period. They concluded that the loss in body fat was

specific to muscular groups used during training. We would therefore expect that ultra-endurance cyclists using their legs would show an association between the skinfold thickness of the lower limb such as thigh respectively calf and training volume or intensity during training. However, we could not find a relationship between average weekly training volume and training intensity with skinfold thickness (Tab. 1).

Arrese & Ostáriz [7] and also Legaz and Eston [8] did not report intensity or volume in training during running in their athletes. Training volume in our ultra-endurance cyclists was presumably too low to have an effect on body fat. On average, our ultra-cyclists trained for 340 km per week in the specific preparation for this particular race. This would amount to a calculated average yearly volume of 17,680 km. However, the athletes reported a yearly training volume of 11,100 (4,700) cycling kilometres in the preparation for the race. This value corresponds to the average yearly volume of a recreational ultra-endurance cyclist in an ultra-cycling marathon [13], whereas an elite professional road cyclist trains for about 24,000 kilometres during one season [14]. Since ultra-endurance events are not attractive for professional road cyclists, only recreational athletes race in these events. The fact of finding no association between both training volume (Fig. 1) and intensity during training (Fig. 2) with race performance might be explained.

A limitation of this investigation might be a rather small sample size of athletes. Unfortunately, the number of participants in ultra-endurance races is rather low compared to contests of shorter distances. Therefore the available data is small and statistical power is less than in other studies, such as the one performed by Arrese and Ostáriz [7] with 130 male runners. In contrast to the latter study, the volunteers in this study were part of the participants of the competition and the number of subjects was definitely limited to that number. Therefore, the power of the current study could not be increased by the number of participants. Arrese and Ostáriz [7] investigated a total of 130 athletes; however, in their subgroups, smaller sample sizes of 16 to 24 athletes were analysed. Likewise, Legaz and Eston [8] investigated a small group of 24 male runners. Coefficients of variance (CV) of performance in the male runners in Arrese and Ostáriz [7] varied between 2.13% and 3.36% whereas we had a CV of 17.9%. Presumably a larger cohort of ultra-endurance cyclists could show associations. A longitudinal study with a larger sample of ultra-endurance

cyclists could probably assess the influence of skin-fold thickness on performance.

Conclusions

In summary, this study showed no association between skinfold thicknesses and race performance in recreational male ultra-endurance cyclists in contrast to high-level long-distance runners. A longitudinal study to assess the influence of skinfold thickness on performance in a larger sample of ultra-endurance cyclists including elite cyclists is recommended. Since neither training volume nor intensity in training revealed an association with race performance, potentially other factors such as equipment, nutrition, previous experience and motivation might be of importance to endure such a competition.

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Address for correspondence

PD Dr. med. Beat Knechtle
 Facharzt FMH für Allgemeinmedizin
 Gesundheitszentrum St. Gallen
 Vadianstrasse 26
 9001 St. Gallen, Switzerland
 e-mail: beat.knechtle@hispeed.ch



THE STUDY OF LUNG FLOW LIMITATIONS IN AEROBICALLY TRAINED CHILDREN

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Mohsen Ghanbarzadeh^{1*}, Abdolhamid Habibi¹, Masoud Nikbakhat¹, Gholamhosain Ebadi², Hossein Poursoltani³

¹ Faculty of Physical Education and Sports Science, Shahid Chamran University, Ahwaz, Iran

² Education Organization of Khuzestan Province, Ahwaz, Iran

³ Sport Science Research Center of Ministry Science Research and Technology, Ahwaz, Iran

RETRACTION NOTICE

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

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

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



BONE MINERAL DENSITY AND BODY COMPOSITION OF SENIOR FEMALE STUDENTS OF THE UNIVERSITY OF THE THIRD AGE IN VIEW OF THEIR DIVERSE PHYSICAL ACTIVITY

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Zofia Ignasiak¹, Anna Skrzek^{2*}, Grażyna Dąbrowska³

¹ Faculty of Physical Education, University School of Physical Education, Wrocław, Poland

² Faculty of Physiotherapy, University School of Physical Education, Wrocław, Poland

³ University of the Third Age at the University of Wrocław, Poland

ABSTRACT

Purpose. Human physical activity is an important component of health and it gains a special significance with age, influencing the quality of life of elderly people. The present study discusses the question of whether the level of physical activity is a sufficient stimulus to evoke positive changes in body composition and bone mineral density in women from the University of the Third Age. **Basic procedures.** The research was conducted on 90 women aged between 65 and 74, students of the U3A. The subjects were divided into two groups on the basis of the amount of their level of physical activity declared by them in questionnaires (1–2 times a week – low physical activity group; 3 and more times a week – high physical activity group). The following measurements were taken: body weight and body height (on the basis of which the BMI was calculated for each subject), body composition including percent fat and water content as well as the amount of body fat and water, with the aid of Futurex-5000 (NIR technique). Dual-energy X-ray absorptiometry (DXA) was used to measure the bone mineral density (BMD) of the proximal segment of the femoral bone (g/cm²) with the Lunar DPX-plus densitometer. **Main findings.** Mean, standard deviation and coefficient of variation were applied in the statistical analysis. The differences between the variables were analyzed with Student's t-test. **Conclusions.** The research results imply the necessity of conducting a systematic and thorough analysis of the lifestyle and quality of life of elderly people.

Key words: physical activity, women, bone mineral density, body composition

Introduction

Physical activity and physical fitness are two main factors determining human development and health throughout the entire ontogenesis. In childhood and adolescence physical activity activates processes of biological development. During these two periods patterns of motor behavior are most easily developed, affecting adult life. In adulthood and professional life physical activity reduces the risk of some diseases, enhances physical and mental health, minimizes the consequences of daily stress and positively affects social and family relations. Also in people of advanced age regular physical activity contributes to the improvement of quality of life, allows maintaining an independent lifestyle, inhibits involutional processes and improves one's frame of mind [1–4]. Physical activity and physical fitness are important and independent health factors, and are the basic non-pharmaceutical

measures in therapy and prevention of many diseases. In elderly people regular physical activity has a particularly positive impact on the passive and active locomotion system, improves muscle strength and range of articular movements, enhances coordination of movement and body balance. It also positively affects a number of functions and processes in the human body, primarily in the respiratory, cardiovascular or nervous systems [3, 5]. Thus the study of cause and effect relations between one's level of physical activity and biological condition becomes particularly important. Many authors indicate that such research must involve regional, cultural and environmental factors as well as factors such as age, sex, health or biological condition [4, 6–8]. Simultaneously, the complexity of reactions of the body to physical exercise makes it difficult to produce reliable data about the optimal intensity and duration of health training. Both excessive and insufficient physical activity can be harmful. The main problem is to set the proper limits. Another interesting issue is the study of the direction and dynamics

* Corresponding author.

of changes in various functions and processes of the human body affected by physical activity.

There have been very few research studies assessing the biological effects of regular exercise in older adults. Parameters which are clearly sensitive to the level of physical activity are bone mineral density and adiposity. Improper dietary habits and significant limitation of physical activity in the elderly people contribute primarily to the incidence of overweight and obesity. Researchers observe that excessive obesity leads to a number of various diseases [9–11]. In a similar way, involutional processes and limited physical activity affects the bone tissue, whose structure and endurance gradually deteriorate [8, 12]. Changes in the nervous and muscular systems can also be observed with age. Slower reaction time, limited function of the sensory organs and decreased muscle strength are conducive to postural balance disorders and increase the risk of falls [5].

The aim of the present study was to evaluate differences in bone mineral density and body composition in women – students of the University of the Third Age involved in physical activity on different levels.

Material and methods

The University of the Third Age (U3A) in the University of Wrocław is an institution educating retired members of the community. Intellectual and psychophysical activation of U3A students is an important component of gerontological prevention and improvement of the quality of life in elderly people. Physical education is one of the most crucial aspects of gerontological education. The U3A students actively, systematically and willingly participate in theory classes (lectures and seminars) and PE classes. They take part in individual and collective recreational programs (hiking trips, tourism, cycling, skiing, outdoor games) [13].

The study sample consisted of 90 female students of the U3A in the University of Wrocław, aged 65–74 years. On the basis of their declared levels of regular physical activity the subjects were divided into two groups: Group I was composed of highly physically active women ($n = 36$), exercising regularly at least three times a week, who chose to participate in organized forms of physical recreation (e.g. health training as part of osteoporosis prevention, backache prevention, Tai Chi, social dances, swimming) or individual exercises (gymnastics, walking, tourism, individual sports and recreation). Group II included women with a low level

of physical activity ($n = 54$), i.e. exercising once or twice a week. The mean age was 66.8 years in Group I, and 67.6 years in Group II. The study was carried out in the Center for Biokinetic Research of the University School of Physical Education in Wrocław in 2005 and 2006. The basic somatic parameters were measured: body height with an anthropometer (to 0.1 cm), body weight with an electronic scales (to 0.1 kg). On the basis of body height and weight measurement results the Body Mass Index (BMI) was calculated for each subject. Body composition was assessed with the Futuress-5000 computer-printer using Near Infrared Interactance technique (NIR). The body fat, body water and lean body mass (LBM) were given in percent and kilograms. The measurements were taken on the biceps brachii.

The measurements of bone mineral density were taken at the femoral neck (Neck), Ward's triangle (Ward) and greater trochanter (Troch) of the femur. Bone Mineral Density (BMD) was measured with Dual-Energy X-ray Absorptiometry (DXA) using the Lunar DPX-plus densitometer (USA). The measurements were taken in the Densitometrics Center of the Chair and Teaching Hospital of Endocrinology and Diabetology at the Wrocław Medical University. The results were presented as absolute BMD values; percent of BMD peak values with t-score standard deviation; and percent of BMD age standard with z-score standard deviation. The statistical analysis parameters included mean, SD and coefficient of variance. The differences between the mean values were assessed with Student's t-test ($p < 0.05$). The correlations between body composition and bone mineral density were estimated with the Pearson's correlation coefficient in both groups under study.

Results

The body height values in both groups were similar, i.e. under 159 cm. The mean body weight was a few kilograms lower in the group of physically active women. There were also fewer differences in body weight within Group I than within Group II. In both groups the BMI slightly exceeded the upper limit set by the WHO at 25. In Group I, however, the BMI was lower than in Group II. There were also fewer BMI differences within Group I than within Group II (Tab. 1).

The BMD measurement results in the proximal segment of the femur were far better among the highly active women (Group I). Statistically significant differences

Table 1. Characteristics of selected somatic parameters of women under study

Parameter	Group I (high physical activity) (<i>n</i> = 36)			Group II (low physical activity) (<i>n</i> = 54)			Student's t-test	
	\bar{x}	SD	ν	\bar{x}	SD	ν	<i>t</i>	<i>p</i>
Age (years)	67.56	2.93	4.34	66.80	3.03	4.54	-1.18	0.2414
Body weight (kg)	64.45	7.48	11.61	67.46	10.93	16.20	1.44	0.1531
Body height (cm)	157.14	5.07	3.23	158.24	5.67	3.58	0.94	0.3507
BMI (kg/m ²)	26.09	2.62	10.04	26.93	4.10	15.20	1.10	0.2755
Body fat (%)	34.46	4.88	14.17	38.46	3.19	8.28	4.72	0.0000
Body fat (kg)	22.32	4.66	20.88	26.18	6.08	23.21	3.22	0.0018
Lean body mass (kg)	42.13	4.76	11.30	41.28	5.32	12.88	-0.77	0.4438
Body water (%)	50.70	3.34	6.58	47.91	2.20	4.60	-4.78	0.0000
Body water (kg)	32.59	3.54	10.87	32.15	4.17	12.96	-0.51	0.6083

Statistically significant differences set in bold ($p < 0.05$)

Table 2. Statistical analysis of bone mineral density in women under study

Parameter	Marked bone area	Group I (high physical activity) (<i>n</i> = 36)			Group II (low physical activity) (<i>n</i> = 54)			Student's t-test	
		\bar{x}	SD	ν	\bar{x}	SD	ν	<i>t</i>	<i>p</i>
BMD (g/cm ²)	Neck	0.857	0.119	13.750	0.823	0.091	11.000	-1.67	0.0994
	Ward	0.713	0.144	20.410	0.682	0.114	15.800	-1.01	0.3147
	Troch	0.769	0.137	17.970	0.729	0.113	15.420	-1.65	0.1025
BMD as % of the peak value	Neck	87.47	11.86	13.55	84.13	9.27	11.02	-1.50	0.1379
	Ward	77.86	15.92	20.44	74.93	11.85	15.82	-1.00	0.3192
	Troch	97.44	17.74	18.21	92.02	14.18	15.41	-1.61	0.1116
t-score	Neck	-1.02	0.97	-95.65	-1.30	0.76	-58.05	-1.56	0.1229
	Ward	-1.55	1.11	-71.75	-1.76	0.83	-47.09	-1.01	0.3131
	Troch	-0.18	1.26	-705.87	-0.58	1.02	-176.84	-1.65	0.1023
BMD as % of the age standard value	Neck	109.36	13.22	12.09	103.35	10.17	9.84	-2.43	0.0170
	Ward	109.67	20.19	18.41	103.74	15.18	14.64	-1.59	0.1160
	Troch	112.08	17.67	15.77	104.67	15.14	14.46	-2.13	0.0361
z-score	Neck	0.62	0.87	138.66	0.23	0.68	295.45	-2.43	0.0173
	Ward	0.50	1.01	201.22	0.19	0.77	403.16	-1.64	0.1037
	Troch	0.78	1.12	143.22	0.30	0.95	319.25	-2.20	0.0306

Statistically significant differences set in bold ($p < 0.05$)

were noted in the percent of BMD age standard and z-score for measurements at the femoral neck (Neck) and greater trochanter (Troch). The bone density measurement results at Ward's triangle (Ward) were better for women from Group I. These differences, however, were statistically non-significant (Tab. 2).

The BMD absolute values and percentage of peak values from the femoral measurements (Neck, Ward, Troch) varied depending on the bone area. However, the BMD values presented as percent of age standard showed no such differences.

Much better measurement results were obtained by the active women from Group I: their BMD values as

percent of age standard amounted to 90% for the femoral neck and 97% for the greater trochanter (Tab. 2). It should be noted that in both study groups the BMD as percent of age standard exceeded 100%.

The body fat content (in % and kg) was significantly lower in women exercising regularly than in women from Group II (Tab. 1). As far as the water body content was concerned, the subjects from Group I achieved much better results than their counterparts from Group II (Tab. 1). The better values of body fat and body water content also produced a better lean body mass record in Group I as compared with Group II. This difference, however, was not statistically significant (Tab. 1).

Table 3. Correlations between bone mineral density, somatic parameters and body composition in the group of more physically active women ($n = 36$)

Parameter		Body height (cm)	Body weight (kg)	BMI (kg/m ²)	Body fat (%)	Body fat (kg)	LBM (kg)	Body water (%)	Body water (kg)
BMD (g/cm ²)	Neck	0.01	0.55	0.62	0.44	0.58	0.29	-0.47	0.32
	Ward	0.01	0.51	0.57	0.45	0.57	0.25	-0.48	0.27
	Troch	0.08	0.60	0.62	0.32	0.54	0.42	-0.37	0.43
BMD as % of the peak value	Neck	0.02	0.54	0.60	0.46	0.59	0.27	-0.48	0.30
	Ward	0.01	0.52	0.57	0.45	0.57	0.25	-0.48	0.28
	Troch	0.07	0.59	0.63	0.32	0.53	0.41	-0.36	0.43
t-score	Neck	0.02	0.54	0.60	0.46	0.59	0.28	-0.48	0.31
	Ward	0.01	0.51	0.57	0.45	0.57	0.24	-0.48	0.27
	Troch	0.08	0.60	0.62	0.32	0.54	0.42	-0.36	0.43
BMD as % of the age standard value	Neck	-0.08	0.39	0.50	0.47	0.51	0.12	-0.49	0.15
	Ward	-0.08	0.39	0.48	0.47	0.51	0.11	-0.49	0.14
	Troch	0.00	0.49	0.55	0.33	0.47	0.31	-0.37	0.32
z-score	Neck	-0.07	0.41	0.51	0.47	0.52	0.14	-0.48	0.17
	Ward	-0.06	0.41	0.49	0.46	0.51	0.14	-0.48	0.16
	Troch	0.02	0.50	0.56	0.32	0.48	0.33	-0.36	0.34

Statistically significant differences set in bold ($p < 0.05$)Table 4. Correlations between bone mineral density, somatic parameters and body composition in the group of less physically active women ($n = 54$)

Parameter		Body height (cm)	Body weight (kg)	BMI (kg/m ²)	Body fat (%)	Body fat (kg)	LBM (kg)	Body water (%)	Body water (kg)
BMD (g/cm ²)	Neck	0.45	0.39	0.19	0.15	0.33	0.43	-0.19	0.42
	Ward	0.36	0.34	0.18	0.18	0.30	0.36	-0.23	0.35
	Troch	0.18	0.41	0.35	0.31	0.40	0.39	-0.35	0.39
BMD as % of the peak value	Neck	0.45	0.40	0.20	0.14	0.33	0.44	-0.19	0.42
	Ward	0.35	0.35	0.19	0.19	0.30	0.37	-0.23	0.36
	Troch	0.18	0.41	0.35	0.30	0.40	0.40	-0.35	0.39
t-score	Neck	0.45	0.39	0.19	0.15	0.33	0.43	-0.19	0.42
	Ward	0.36	0.34	0.18	0.18	0.30	0.36	-0.23	0.35
	Troch	0.18	0.41	0.35	0.30	0.40	0.40	-0.35	0.39
BMD as % of the age standard value	Neck	0.29	0.11	-0.04	-0.00	0.07	0.14	-0.03	0.13
	Ward	0.21	0.09	-0.01	0.06	0.07	0.11	-0.09	0.10
	Troch	0.06	0.17	0.14	0.15	0.16	0.16	-0.19	0.15
z-score	Neck	0.29	0.11	-0.04	-0.01	0.07	0.15	-0.02	0.13
	Ward	0.22	0.09	-0.02	0.05	0.06	0.11	-0.08	0.10
	Troch	0.07	0.18	0.14	0.15	0.17	0.17	-0.19	0.16

Statistically significant differences set in bold ($p < 0.05$)

A number of statistically significant correlations can be found between the examined somatic parameters, body fat and water content and the BMD of the femur (Tab. 3, 4). These correlations were stronger and more often statistically significant in Group I (Tab. 3), especially correlations between the BMD of the femur and body weight, and the BMI and fat content in kg and water content in %. The strongest correlations were observed between the BMD at the femoral neck and the greater trochanter and the BMI (0.62). In Group II the strength of correlation between the studied parameters was significantly lower (Tab. 4). Negative correlations between BMD and the percent of body water content are due to the fact that the bone tissue contains almost no water at all. On the other hand, body water content in kg was positively correlated with BMD, as it is a component of the total body mass constituting the natural and mechanical load of the skeleton.

Discussion

The Universities of the Third Age play a crucial role in gerontological prevention as they activate senior citizens psychophysically, intellectually and socially. The first University of the Third Age was founded at the University of Toulouse in the academic year of 1973–1974. Poland was the third country in the world (after France and Belgium) which offered university education for senior citizens. In 1975 the U3A was founded in Warsaw and a year later in Wrocław. According to Szwarc [4], “The primary objective of U3A is improvement of quality of life of the elderly, ensuring good conditions of the aging process by broadening knowledge of the world, creative teamwork and physical culture.”

Significant changes in the bone tissue are part of the aging process in living organisms. There are no precise measures of general bone endurance. Bone mineral density, which is a supplementary measure, accounts for about 70% of bone endurance. A densitometric measurement permits a quantitative assessment of bone calcification and thus, indirectly, bone mass. BMD measurements have been shown to be highly correlated with mechanical endurance of the femoral neck, spine and the risk of bone fracture. Maintaining the proper state of the skeletal system should be a lifetime process to avoid osteoporosis which leads to reduced bone endurance and an increased risk of fracture [14–17].

The obtained results show that bone mineral density of the proximal segment of the femur is higher in physi-

cally active women. A number of experiments and clinical examinations reveal that physical exercises, which are properly carried out and adjusted to individual predispositions, can prevent the decrease in bone mass in older people. Regular physical activity of the elderly should be organized in controlled and limited forms, with relatively low loads of the skeleton to minimize the risk of falls and shocks.

The positive influence of physical activity in postmenopausal women has been discussed in a number of studies [18–20]. The results of densitometric measurements in the present study indicate the possibility of osteopenia or osteoporosis in some of the subjects examined. All the U3A female students participated in a comprehensive educational program on osteoporosis prevention. The research results allowed us to select individuals with a high risk of the disease, who began to take part in preventive programs or treatment and were referred to specialist centers.

The above results point to statistically significant correlations between bone mineral density and somatic parameters and bone composition in older women. In the group of women who were highly physically active, as opposed to their physically passive counterparts, these correlations were stronger and more often statistically significant.

The positive correlation between the BMI and bone mineral density has been confirmed in a few studies [18, 21–23]. Heavier women were characterized by a higher BMD at the lumbar spine (L2–L4), proximal segment of the femur and the radius, as compared with women with normal body weight. Beiseigel [18] in a study of 800 women showed that the BMD of the L2–L4 region of the spine and the femur was positively correlated with BMI. The mechanical factor (mass and volume) of all tissues, including the fatty tissue, plays a crucial role in the prevention of bone fractures. A larger amount of the muscular and adipose tissue is tantamount to a greater load of the skeleton. A greater load of the skeleton in adolescence causes an increase in the peak bone mass, which in the postmenopausal period makes reaching the critical point of bone fracture a much slower process. Women with thicker bones must lose more bone mass (faster bone resorption, longer bone tissue duration than women with thinner bones) to reach the same critical threshold of fracture. Additionally, the fatty tissue not only overloads the skeleton but there also takes place an extraglandular synthesis of estrogens [23].

The observed BMD differences in particular areas of the femur (femoral neck has the highest BMD, and Ward's triangle the lowest) are confirmed in the bone structure. The density of the femoral neck is most important in assessment of the risk of fracture, as changes in this area reflect the structure of a cortical bone (with 75% of cortex and 25% of cancellous bone). Ward's triangle is not strictly an anatomical area but an area of the femoral bone with the lowest BMD automatically marked by the densitometer. It is assumed that it reflects the structure of a cancellous bone. However, as the area of the earliest decline of bone mass in the femur in postmenopausal women, Ward's triangle is the best standard of changes in trabecular bone. In the area of greater trochanter the distribution of cortical and cancellous bone is more or less even [24, 25]. This differentiation is characteristic of bone tissue undergoing involutional changes.

It should be noted that the U3A female students under study are not representative of the general population of the elderly. Dąbrowska et al. [26] reveals that U3A students usually have a secondary or higher education and regularly attend courses related to issues of health education, physical recreation and rehabilitation. The educational program of the U3A is aimed at broadening health knowledge, and is conducive to development of pro-health behavior patterns and to raising the level of quality of life. It can be assumed that such a curriculum offered to senior citizens promotes not only a physically active lifestyle, but also good dietary habits.

Although women who are highly physically active feature better parameters of body composition and bone density, their less active counterparts only slightly exceed the accepted norms of their parameters, in particular, BMI and percent of body fat (commonly accepted at no more than 33% of the total body mass [11]). The more physically active women exceed this limit by about 1%, while the less active ones by about 5%. The bone mineral density (BMD) as percent of the ideal value in both groups of women exceeds 100%. It is highly positive, as at an advanced age the sense of balance deteriorates, which leads to a higher risk of falls [2, 3, 5]. A higher BMD can prevent bone fracture during falls.

Conclusions

The study results show that the bone mineral density is higher and measurement results of body composition are better in physically active women. The strength and

number of correlations between BMD and somatic parameters are higher in women who are more physically active. The positive correlation between BMD, body weight and the BMI, and adiposity indicate that the higher somatic parameters are related to more positive BMD values. At the same time the parameters in the experimental group (Group I) were lower than in the control group (Group II). This could be an indication of the fact that loading the skeleton with body mass and its components is optimally desirable.

The obtained results point to the need of further and more thorough research into the area since the relations between changes in older people's bodies and physical activity have been often subject to rather ambiguous reports and analyses.

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Address for correspondence

Dr hab. Anna Skrzek, prof. nadzw.

Wydział Fizjoterapii

Akademia Wychowania Fizycznego

Al. I. J. Paderewskiego 35

51-617 Wrocław, Poland

e-mail: anna.skrzek@awf.wroc.pl



SOCIAL AND SOMATIC DETERMINANTS OF PHYSICAL FITNESS IN MEN AGED 20–70 YEARS FROM CRACOW

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Stanisław Gołąb*, Jan Sobiecki, Janusz Brudecki

Department of Anthropology, University School of Physical Education, Cracow, Poland

ABSTRACT

Purpose. The aim of this study was to determine effects of social and somatic variables on changes of physical fitness in men aged 20–70 years. For this purpose a cross-sectional study of 1,420 industrial workers was carried out. **Basic procedures.** Correlations were examined between several variables: age, education, physical activity level, BMI, WHR, results of five Eurofit tests (flamingo balance test, plate tapping, sit and reach, standing broad jump, hand grip) and YMCA 3-minute Step Test. ANOVA and step-wise regression were used in the statistical analysis. **Main findings.** The obtained results point to: (1) a varied regression of motor and cardio-vascular fitness in male subjects between 20 and 70 years of age; (2) high correlation between the standing broad jump results and all the analysed variables; (3) the highest percentage of assignable variation in the results of standing broad jump, hand grip strength tests and % HR_{max} affected by age and BMI. **Conclusions.** The significance of the impact of social and somatic variables on motor fitness varies and depends on subjects' age. The regression of motor fitness in men after 50 years of age is a symptom of gradual loss of adaptability to social life concurring with andropause, which is discussed in detail in professional literature.

Key words: physical fitness, man, social determinants, somatic determinants

Introduction

With the universal acceptance of the concept of health-related fitness, which underlines the biological and social significance of development and maintenance of physical fitness [1–3], the level of physical fitness of individuals or groups of people has become one of the positive indices of health [4, 5]. Body composition, muscle strength, endurance, flexibility and cardiovascular efficiency are most often regarded as components of physical fitness conditioning reduction of the risk of diseases [6, 7].

The regression of physical fitness with age, related to involutional changes, is conditioned by biological, psychological and socio-economic factors. These factors in the progressive stage of ontogenesis are in fact determinants and modifiers of human development. Following the behavioral and cultural approach to physical fitness [8], the correct performance of a motor task requires specific motor and somatic capabilities, motor skills, knowledge, experience and motivation (awareness of goals and strength of will). These

conditions determine human motor function and directly affect results of fitness tests.

Variables affecting changes in human physical fitness and endurance with age include somatic parameters (body weight, lean body mass) and socio-economic factors, which also indirectly reflect the level of awareness and lifestyle, e.g. education or physical activity during leisure time [9]. Literature concerning the issue of physical activity in adult lifestyle includes a number of population studies showing no correlations between physical activity and the family's socio-economic status and size. Frömel et al. [10], for instance, claims that the main factor differentiating physical activity levels in the Czech Republic is the size of the place of residence: the most physically active are residents of small towns (population below 100,000 residents).

An analysis of physical fitness development in different age ranges: during the stabilization stage and later during involutional changes (dominance of catabolic changes over anabolic ones) is particularly difficult. Any interpretation of observed changes is impeded by genetic and environmental influences accumulating with age, mutual interactions along the growing significance of lifestyle, as well as effects of secular changes in the case of cross-sectional samples. In Poland studies

* Corresponding author.

Table 1. Number of subjects in particular age groups

Age (years)	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	> 64
<i>n</i>	48	159	197	180	251	268	212	61	22	22

on representative samples concerning somatic traits and motor characteristics of individuals in the productive and post-productive age are fewer than studies concerning the early stages of ontogenesis [11–18]. All these studies confirm the diverse regression of fitness test results with regard to the type of motor abilities and impact of socio-economic factors (education, occupation, physical activity in leisure time). The majority of research, however, fails to estimate the contribution of social or somatic factors to the variability of physical fitness and endurance. The confirmed impact of social variables of the level of regression is lifestyle-related (physical activity, dietary habits) and associated with somatic traits [19–22].

The political and economic transformations in Poland in the last decades have brought a number of changes in economic and living conditions of the country's social classes. In many Polish cities workers of big industrial companies founded in communist times still constitute a large social group. The present study focuses on this particular group for two reasons: its great representativeness in the urban community and availability of subjects.

The aim of the study was to determine the effects of social and somatic variables on changes of physical fitness in a group of men of different ages working in a large metallurgic plant. The application of uniform methodological procedures to the entire sample allowed assessment of the contribution of social and somatic factors to the age-related regression of physical fitness and endurance in men.

Material and methods

The material consisted of results of cross-sectional anthropometric tests, motor fitness tests, cardiovascular endurance tests and social variables (survey data) carried out on a sample of 1,420 industrial workers from the Tadeusz Sendzimir Steelworks in Kraków, aged 20–70 years (Tab. 1). The tests and surveys were carried out by a research team from the Chair of Anthropology and Anatomy of the University School of Physical Education in Kraków in the years 2001–2003 in cooperation with the Medical Center in Nowa Huta.

The dependent variables included results of the following motor fitness tests: hand grip test (relative static strength), standing broad jump (explosive strength) [23], sit and reach test (flexibility), plate tapping test (hand movement speed) [1, 24], balance test (modified, i.e. measuring the actual balancing time) and cardiovascular endurance test (YMCA 3-minute Step Test: 30.5 cm step, stepping rate of 24 steps per minute, measurement of post-exercise HR) [25]. Post-exercise heart rate was also calculated as the percentage of the maximum heart rate, following the Karvonen Formula ($HR_{\max} = 220 - \text{age}$) [26]. The relative static strength was determined in relation to body weight.

The independent variables included subjects' age, education, declared physical activity in leisure time, body mass index (BMI) and waist-hip ratio (WHR).

The statistical analysis involved description of the level and changes of qualitative and quantitative parameters in particular age groups, analysis of variance (ANOVA) and step-wise regression to determine the percentage of independent variables in the variability of fitness test results.

Results

The education profiles of the examined workers grouped in ten age categories were similar (Fig. 1). More than 50% of subjects had a vocational education, with the exception of men over 60 years of age (almost 40%), and 25–30% a secondary education. 12% of subjects under 30 years of age declared having a post-secondary education, with the exception of the oldest group (18%). The lowest percentage of subjects (5–12%) had a primary education.

The subjects grouped into physical activity categories display certain differences between particular age groups resulting from the gradual increase in the number of inactive men (declaring no physical activity in their leisure time) – from 30% in the youngest group to over 40% in the group over 50 years of age – and from a simultaneous decrease in the number of subjects declaring physical activity at present only (Fig. 2). In the other physical activity categories no significant changes were observed, i.e. the percentage of men active now

and in the past is similar in the other groups (about 30%), with the exception of the lower value in the group of 50-year-olds. The declared physical activity changes with the education level (Fig. 3). There is a visible decrease in the number of physically inactive men: from 70% in the primary education group to 10% in the post-secondary education group. Simultaneously, the number of the most active men increases nine times.

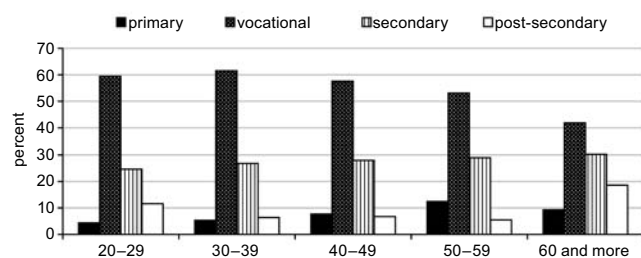


Figure 1. Education profile of age groups

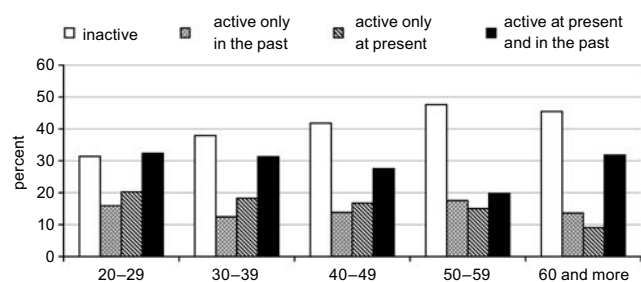


Figure 2. Physical activity in age groups

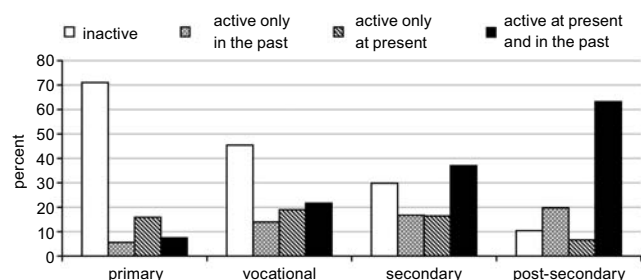


Figure 3. Physical activity in education groups

The basic somatic traits and parameters in five consecutive age groups are illustrated with medians (%) in relation to the youngest group (20–24 years of age – 100%) (Fig. 4)¹ [27]. The variable of body height decreases steadily until 60 years of age. The other traits increase with age: BMI until the 50 years of age and WHR until 60 years of age. The BMI also increases in the group of subjects between 50 and 54 years of age,

but decreases in the consecutive age groups. The somatic variables decrease rapidly between the two oldest age groups, with the exception of body height.

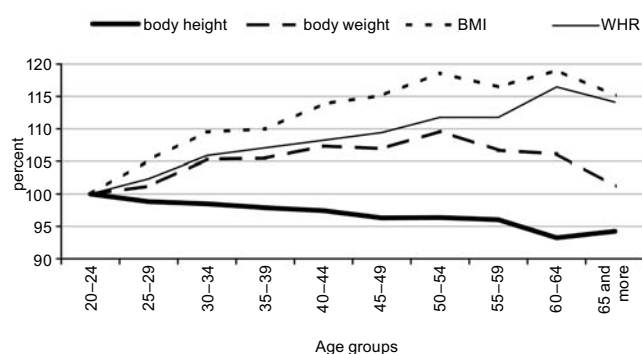


Figure 4. Medians of somatic parameters and indices in age groups (100% in age group 20–24)

The analysis of results of five fitness and cardiovascular endurance tests is presented in Fig. 5 [27]. In the fitness tests the highest regression between the youngest and the oldest groups was noted in the results of the balance, standing broad jump and sit-and-reach tests (over 40%); and the lowest in the hand grip and plate tapping tests (about 20%). The heart rate after a 30-minute exercise remained on a similar level in consecutive groups. However, the % HR_{max} indicates gradual worsening of cardiovascular endurance for more than 20% until 64 years of age, and even over 50% including the oldest group. The median curves of the subjects' functional characteristics reveal four characteristic periods: (1) between 20 and 34 years of age – small regression in motor fitness test results, and significant after 30 years of age in % HR_{max}; (2) between 35 and 49 years of age – increased regression of the results of all fitness

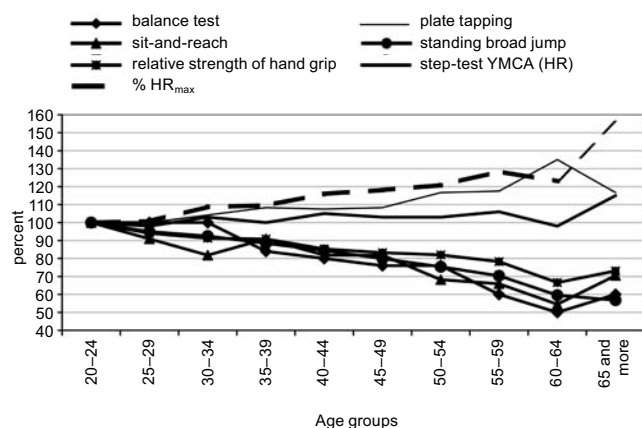


Figure 5. Medians of fitness test results in age groups (100% in age group 20–24)

¹ For general quantitative characteristics of somatic traits and fitness test results see [27].

Table 2. Pearson or Spearman's correlation coefficients and level of statistical significance between the variables under study

	Educa- tion	Physical activity	BMI	WHR	Balance test	Plate tapping	Sit and reach	Standing broad jump	Relative hand grip strength	YMCA Step Test (HR)	% HR _{max}
Age	−0.03 NS	−0.08 ***	0.25 ***	0.39 ***	−0.20 ***	0.20 ***	−0.18 ***	−0.51 ***	−0.29 ***	−0.06 *	0.36 ***
	Educa- tion	0.33 **	−0.02 NS	−0.13 ***	0.07 ***	−0.17 ***	0.08 ***	0.23 ***	0.03 NS	0.08 **	0.07 ***
		Physical activity	−0.01 NS	−0.07 ***	0.09 ***	−0.13 ***	0.09 ***	0.21 ***	0.00 NS	0.06 NS	0.03 NS
			BMI	0.61 ***	−0.13 ***	0.02 NS	−0.15 ***	−0.23 ***	−0.50 **	0.17 **	0.22 ***
				WHR	−0.05 *	0.05 *	−0.12 ***	−0.15 ***	−0.25 **	0.04 **	0.23 ***
					Balance test	−0.11 ***	0.12 ***	0.22 ***	0.16 **	−0.01 ***	−0.11 ***
						Plate tapping	−0.07 ***	−0.26 ***	−0.12 **	0.01 NS	0.04 NS
							Sit and reach	0.29 ***	0.22 **	0.04 ***	0.06 ***
								Standing broad jump	0.36 **	0.01 NS	−0.17 ***
									Relative hand grip strength	0.01 NS	−0.08 *
										YMCA Step Test (HR)	0.95 ***

* $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$, NS – not significant

 – coefficient calculated for motor fitness tests and YMCA Step Test (HR) expressed in z-score (normalisation for mean and standard deviation of the additional age group)

tests; (3) between 50 and 64 years of age – further regression of results; (4) 65 years of age and over – inhibition of regression or even improvement of test results, with the exception of the explosive force test and cardiovascular endurance test.

Table 2 presents correlations between the analyzed qualitative and quantitative variables and age using Spearman's or Pearson correlation coefficients. The high number of subjects in the studied groups affected the high level of statistical significance for most correlation coefficients. Thus the significance of correlations was assessed mainly on the basis of the quantity of the coefficients (correlation strength). The analysis of correlations with the subjects' age revealed:

- no significant correlations with the levels of education, physical activity and YMCA Step Test results (HR);

- a moderate correlation with the standing broad jump test results, WHR and % HR_{max}; and a weak one with the results of hand grip, balance, plate tapping and sit and reach tests.

The subjects' education revealed few correlations with physical activity and explosive strength, and low correlations with the plate tapping test results and WHR; while physical activity showed low correlations with explosive strength and plate tapping test results. Relatively, the most highly correlated were the BMI and WHR, which in turn are negatively correlated with relative static strength, explosive strength and flexibility. The significant correlations between the explosive strength test results and all studied variables should be noted as well as the lack of correlations between the 3-minute YMCA Step Test results (HR) with the variables, with the exception of BMI. The % HR_{max} values,

however, turned out to be highly correlated with the YMCA Step Test results, moderately correlated with the subjects' age and weakly correlated with the explosive strength and balance test results. The significant but weak correlations with the results of motor fitness tests were negative: a higher % HR_{max} corresponds to lower motor fitness test results. On the other hand, correlations between the HR, especially between age and % HR_{max} depend to a great extent on the way the maximum heart rate is estimated.

In the analysis of the effects of social variables and somatic traits on the results of motor fitness test results normalization of motor fitness tests and cardiovascular endurance test were applied on 0 and 1 of a given age group. The result was a fitness profile of men with a specific independent variable. With the use of analysis of variance and Duncan's test the statistical significance of differences at the level of fitness test results between independent variables was estimated. In terms of subjects' education (Fig. 6) the significant differences for explosive strength, balance, hand movement speed and flexibility displayed a decreasing gradient from post-secondary to primary education. In post-exercise HR and % HR_{max} the direction of significant differences was reverse, i.e. the lowest values were noted in subjects with a post-secondary education.

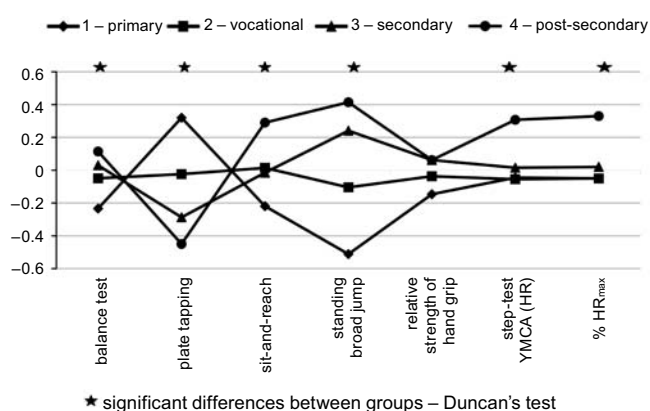


Figure 6. Fitness profiles in education groups (z-score)

The fitness profiles in activity groups are less diversified (Fig. 7). Significant and relatively consistent results were displayed by the results of the explosive strength and balance tests: the test results improve along increasing physical activity. In the plate tapping test significant differences were noted between the inactive group (the lowest values) and other activity groups. In the flexibility test there were significant differences

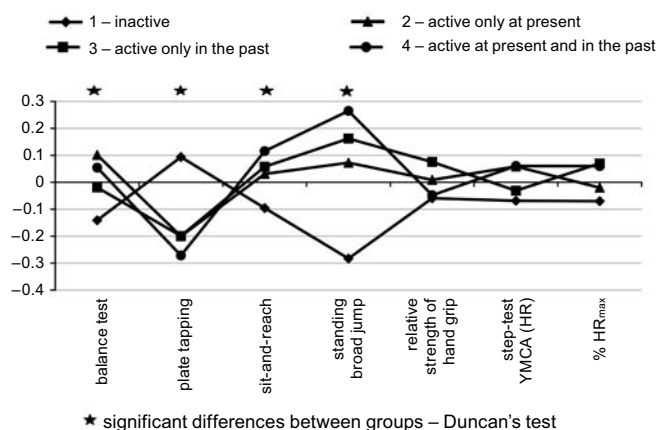


Figure 7. Fitness profiles in activity groups (z-score)

only between the inactive subjects and subjects active at present and in the past.

The division of subjects into three BMI categories (< 25, 25–29.9, ≥ 30) reveals a consistent differentiation of results of all fitness tests (without the plate tapping test) and cardiovascular endurance test (Fig. 8): better fitness results with low BMI. In the case of WHR categories (< 1 and ≥ 1) the results of plate tapping, flexibility, explosive strength and relative static strength were significantly different: better fitness results with WHR < 1.

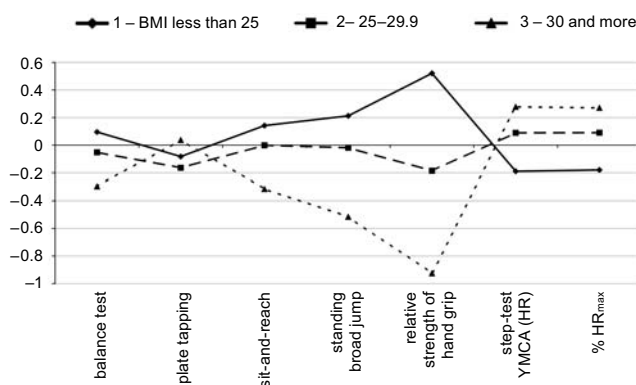


Figure 8. Fitness profiles in BMI groups (z-score)

The significance of social and somatic variables in differentiating the results of fitness tests and cardiovascular test varies depending on the subjects' age. The analysis of regression of somatic traits with age focused on two periods: < 50 – smaller regression and 50 ≥ – greater regression (Tab. 3).

At over 50 years of age the subjects' education affects differences in the results of fitness tests and cardiovascular endurance to a much smaller degree, with the exceptions of differences in the relative static strength test. In terms of physical activity, however, the test re-

Table 3. Significant differences in results of motor fitness tests, YMCA Step Test and % HR_{max} with regard to social and somatic variables (ANOVA and Duncan's test). Differences in two age groups: under 50 years and over 50 years

Motor fitness test	Education level		Physical activity level		BMI		WHR	
	1, 2, 3, 4		1, 2, 3, 4		1, 2, 3		1, 2	
	< 50	≥ 50	< 50	≥ 50	< 50	≥ 50	< 50	≥ 50
Balance test	3 – 1				1 – 2			
	4 – 1	–	3 – 1	–	1 – 3	–	–	–
	4 – 2		4 – 1		2 – 3			
	4 – 3							
Plate tapping	2 – 1							
	3 – 1	3 – 1	2 – 1	4 – 1	–	–	–	–
	4 – 1	4 – 1						
	4 – 2							
Sit-and-reach	2 – 1							
	3 – 1			3 – 1	1 – 3	1 – 2	1 – 2	–
	4 – 1	–	–	4 – 1	2 – 3	1 – 3		
	4 – 2							
	4 – 3							
Standing broad jump	2 – 1							
	3 – 1	3 – 1	2 – 1	2 – 1	1 – 2	1 – 3	1 – 2	1 – 2
	4 – 1	4 – 1	3 – 1	4 – 1	1 – 3	2 – 3		
	3 – 2		4 – 1	4 – 3	2 – 3			
	4 – 2							
Relative hand grip strength		3 – 1			1 – 2	1 – 2		
	–	4 – 1	–	–	1 – 3	1 – 3	1 – 2	1 – 2
		4 – 2			2 – 3	2 – 3		
YMCA Step Test (HR)	1 – 4				1 – 2			
	2 – 4	–	–	–	1 – 3	–	–	–
	3 – 4							
% HR _{max}	1 – 4				1 – 2			
	2 – 4	–	–	–	1 – 3	–	–	–
	3 – 4							
Total number of significant differences for all motor fitness tests	24	7	6	6	15	7	3	2
Education levels:	Physical activity levels:		BMI:		WHR:			
1 – primary	1 – inactive		1 – < 25		1 – < 1			
2 – vocational	2 – active only at present		2 – 25 do 29		2 – ≥ 1			
3 – secondary	3 – active only in the past		3 – ≥ 30					
4 – post-secondary	4 – active at present and in the past							

sults differ to a similar degree in both age categories: most significantly in the explosive strength and balance tests in subjects before 50 years, and in the flexibility test after 50 years of age.

The BMI is a significant differentiating factor in the majority of motor fitness tests and the cardiovascular endurance test especially in subjects under 50 years of age. There are no differences in subjects over 50 in the results of the balance, speed of hand movement and cardiovascular endurance tests. The WHR differentiates significantly the flexibility, explosive strength and relative static strength test results in subjects under 50

years, and in the older age group only the results of the explosive strength and relative strength results.

In the analysis of the effects of age, education, physical activity, BMI, WHR, YMCA Step Test and % HR_{max} on the variability of fitness test results step-wise regression was used. The highest percentage of assignable variation was noted in the explosive strength and static strength test results (over 36%). The factor of age explained mainly the regression of explosive strength, while the BMI the regression of static strength (Tab. 4). These factors were followed by the assignable variation of % HR_{max} (almost 16%) mostly affected by subjects'

Table 4. Coefficients of determinants (R^2) in a step-wise regression model for motor fitness tests and cardiovascular endurance test (% of assignable variation)

Motor fitness test	Variables important in step-wise regression model					
	R^2	Age	Education	Physical activity	BMI	WHR
Standing broad jump	36.80	27.69	3.47	1.36	4.09	0.19
Relative strength of hand grip	36.73	2.65	—	—	33.59	0.49
% HR _{max}	15.63	13.30	0.41	—	1.92	—
Sit-and-reach	6.62	1.17	—	0.53	0.38	4.54
Plate tapping	6.58	3.90	2.14	0.54	—	—
Balance test	5.82	4.01	—	0.60	1.21	—
YMCA Step Test (HR)	0.33	0.33	—	—	—	—

age. The remaining fitness tests featured a much lower percentage of explained variability – about 6%, with the hand speed movement and balance affected mostly by the factor of age, while flexibility by the WHR.

The impact of physical activity on explaining fitness variability is relatively the lowest one (even below 1%). With the low variability of the YMCA Step Test results (post-exercise HR) they are hardly assigned to independent variables. Among the results of all motor fitness tests

only the effects of the explosive strength test (standing broad jump) can be noted. Therefore the results of this particular test can be considered a good index of assessment of the impact of social factors, lifestyle and somatic traits on the physical fitness in adult men.

Figure 9 presents linear regression models of the standing broad jump test with reference to education and physical activity. The greatest downward trend of the test results with subjects' age (particularly visible in men over

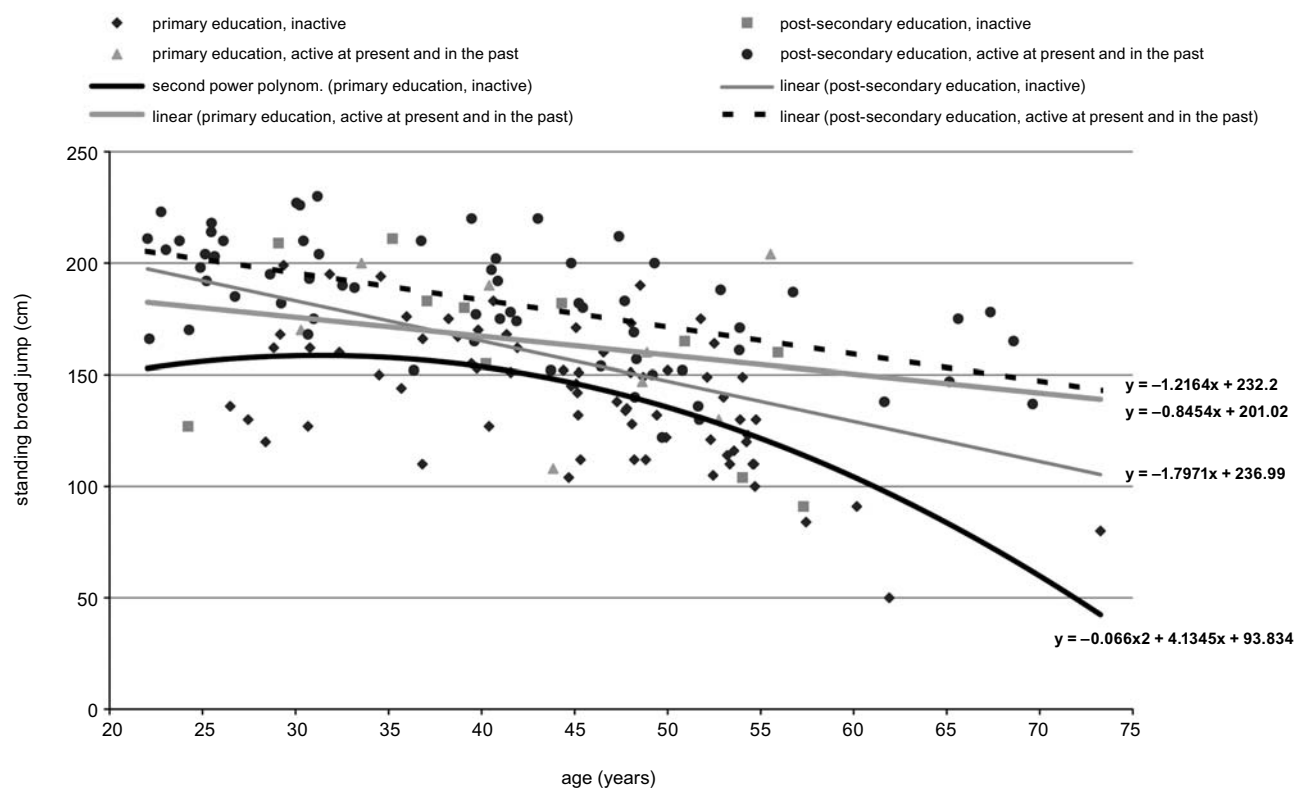


Figure 9. Standing broad jump regression models in education and activity groups

45 years of age) was observed among inactive men with a primary education, and in inactive men with a post-secondary education. A much smaller regression can be noted in men physically active at present and in the past with a primary education and post-secondary education.

Discussion

The obtained results of motor fitness tests indicate a decreasing level of physical fitness in men from Kraków, starting with the age group of 20–24-year-old men (flexibility, explosive strength and static strength) and the age group of 30 year-old men (balance, hand movement speed). The subjects' age and the order of regression of the results of fitness tests correspond to the results obtained by Jopkiewicz [14, 28] as well as Wolański's observations [29] concerning correlations between the rate of regression and the top stage of development of a given parameter. The highest rate of regression, visibly marked above 50 years of age, should be regarded as a consequence of the aging process and andropause [30, 31].

A cross-sectional study of men aged 40–90 years from the Wielkopolska region and central and north-western Poland carried out by Skrzypczak [32], revealed the following characteristics in men over 50 years of age:

- moderate physical and psychical symptoms (muscle pain, fatigue, exhaustion, irritability, depression, lack of concentration) in 60–63% of subjects;
- reduction in libido (decreased interest in sex, dissatisfaction with one's sex life) in 59% of subjects.

The symptoms mentioned should also include regression of physical fitness, which is a manifestation of the gradual loss of adaptability to social life. The observed slowdown of the regression of the results of five fitness tests in the age group under 64 years can be caused by the relatively small number of subjects in this group ($n = 22$) as well as professional activities taken up by retired men who are still physically fit.

The analysis of the impact of social and somatic variables on fitness variables point to some detailed conclusions. The assessment of significance of differences of mean arithmetic results between the factor of education and the BMI, for instance, indicate more frequent significant differences greatly affecting the fitness test results (education more than the BMI). These are not, however, spontaneous effects since the independent variables also include a part of common varia-

tion (education is also correlated with physical activity and WHR, and WHR with BMI and age).

The conclusion is altered following the step-wise regression allowing for a more spontaneous contribution of a given factor (in the model) to the total variation of a dependent variable. In this context the BMI is a significant factor explaining the percentage of variability of the results of fitness tests as compared with the level of education.

The relatively small differences between the fitness test results in reference to the level of declared physical activity in leisure time may result from the less marked (too general) categorization of this variable made on the basis of the questionnaire survey responses. Despite these reservations the consistent course of the regression curves, e.g. of explosive strength with social variables, should be affirmed, which points to the significance of undertaken physical activity in reducing the regression of physical fitness with age.

The results of studies by Bovens et al. [33] concerning the effects of regular endurance training on the declining rate of VO_{2max} with age in 40–60-year-old women, and by Rogers et al. [34] in 60–70-year-old physically active and inactive men, reveal a similar tendency in reducing the rate of declining physical fitness with age in training men at present and in the past as compared with inactive subjects.

Cardiovascular endurance measured only with the 3-minute YMCA Step Test fails to show hardly any significant changes with age or significant correlations with social, somatic and motor fitness variables. Apparently, the exercise load in the YMCA Step Test was too low to determine specifically the differences in the examined group of men. The cardiologists from the Nowa Huta Medical Center looking after the subjects did not give their consent to the use of greater exercise loads. Only did the estimation of % HR_{max} make a more accurate and comparative assessment of cardiovascular endurance with age possible. However, the noted statistically significant differences in the arithmetic means of HR and % HR_{max} between the education groups of men before 50 years of age (with lower results in the groups with a post-secondary education) should be treated as an indication of the lack of physical activity in leisure time in this group.

In studies on physical activity of adult populations an important issue is the place of professional activities in total physical activity on a weekly basis. The comprehensive research by Proper et al. [35] of Dutch steel in-

dustrial workers showed that the percentage of their physical activity at work amounted to 42% on the average and was one-third higher than in all other labor sectors. In the global assessment of physical activities (min/week) the steel industrial workers achieved the results 25% above the average physical activity of all labor sectors workers.

The unavailability of accurate and representative data for analysis of correlations with the results of fitness tests in adult men made it impossible to carry out a comparative analysis of regressive changes in motor function using other studies in this area of research.

Conclusions

1. The observed regression of results of motor fitness tests and cardiovascular endurance test in men between 20 and 70 years of age (cross-sectional data) amounts to:

- about 40% in the explosive strength, flexibility and balance tests;
- over 20% in the % HR_{max} , relative static strength and hand movement speed tests;
- about 6% in the YMCA Step Test (HR).

2. The noted decline of explosive strength is mostly assigned to the subjects' age (28%), of relative static strength to the BMI (34%), and of % HR_{max} to the subjects' age (13%). For all other tests the percentage of assignable variation is low (about 6%), and for HR in the YMCA Step Test it amounts to merely 1%.

3. The results of the explosive strength, balance and hand movement speed tests reveal a marked decreasing social gradient: from subjects with a post-secondary education (or secondary) to subjects with a primary education. In the case of cardiovascular endurance test results a reverse gradient can be observed. The education level remains a decisive factor differentiating the level of physical fitness.

4. The significance of the impact of social and somatic variables on physical fitness varies depending on subjects' age, e.g. there are smaller differences between the fitness test results between education categories and the BMI in men under 50 years of age.

5. Physical activity undertaken at present and in the past positively affects reduction of regression of physical fitness (e.g. explosive strength).

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Address for correspondence

Stanisław Gołąb
Katedra Antropologii
Akademia Wychowania Fizycznego
Al. Jana Pawła II 78
31-571 Kraków, Poland
e-mail: wagolab@cyf-kr.edu.pl



EFFECTS OF STRENGTH TRAINING ON PHYSICAL CAPACITIES OF THE DISABLED WITH CERVICAL SPINE INJURIES

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Rafał Tabęcki*, Andrzej Kosmol, Andrzej Mastalerz

The Józef Piłsudski University of Physical Education, Warsaw, Poland

ABSTRACT

Purpose. The aim of the study was to assess the effects of strength training on the physical capacities of disabled persons with cervical spine injuries. **Basic procedures.** The study sample consisted of four disabled subjects with C4–C6 cervical spine injury, who were active Paralympic athletes (one swimmer and three wheelchair rugby players) from the Foundation of Active Rehabilitation. The study was carried out over a period of 15 months. The Biodex System 3 Pro isokinetic dynamometer and an arm cycloergometer were used for measurements. The measurements of muscle torques at the shoulder joint were carried out at 8-week intervals using the Biodex dynamometer. **Main findings.** The test results revealed a correlation between the body's physical endurance and strength capacities of subjects with cervical spine injuries. The "Upperton" strength training equipment modified for tetraplegics allowed maximal loading of the disabled athletes' shoulder girdle. **Conclusions.** Strength training improves the maximal force of arms in tetraplegics and positively affects their physical endurance. Tetraplegics can take advantage of strength training only by using hand-fixed weights, due to the limited function of arm flexors, including the greatly reduced hand gripping function. Strength training is an indispensable element of rehabilitation of tetraplegics.

Key words: strength training, tetraplegia, spinal cord, muscle strength

Introduction

Rehabilitation through sports has so far failed to develop its own endurance standards and physiological indices of reactions of disabled persons undergoing intensive sport training. Especially, emotional reactions associated with sports rivalry can particularly affect the health condition of a disabled person. Unfortunately, sports for the disabled, despite their rapid development in recent years, still lack any proper scientific framework for assessment of their therapeutic efficiency.

Glaser et al. [1] suggested that an active lifestyle based on a special exercise program was necessary to break the "vicious circle" of passive existence for persons with spinal cord injuries. An active lifestyle can also greatly improve their independent functioning and quality of life. Dallmeijer et al. [2] stress the particular role of physical education for people with cervical spine injuries. Thanks to improvement of their ability to undertake physical exercises, daily chores become less burdensome as they are performed with less power (as

percentage of maximum power), peak oxygen uptake and pulmonary ventilation [3].

The development of muscle strength due to training is a process involving two mechanisms. The first one, taking place in the initial period of the training cycle, is activation of a greater number of motor units in a given movement. It is indicative of the adaptability of the system to the training stimuli. The other mechanism is the hypertrophy of skeletal muscles, which takes place later in the cycle due to the increase in training loads. Muscular hypertrophy is caused by systematic training, mostly stimulated by isometric or dynamic high-intensity exercises. Hypertrophy results from the growth of individual muscle fibres caused by an increase in the quantity of muscle fibre protein and energy supplies [4].

Training increases the amount of nerve impulses transmitted from the brain to the muscles as well as activates a greater number of muscle fibres. It also extends the area of the muscle transverse cross-section, which directly enhances muscle strength. To ensure progressive growth of the area of muscle transverse cross-sections a regular increase in muscle training loads is required. With constant training loads muscles cease to

* Corresponding author.

grow once their force has been adjusted to the load. Muscles which are systematically trained with close to maximal loads, reveal an increase in the quantity of capillary vessels around muscle fibres. This is an indication of muscle adjustment to the training-induced increased oxygen demand [5, 6].

Proper physical development requires the knowledge of one's own muscle potential, principles of muscle growth as well as training methods. Thanks to the knowledge of the body's reactions to training one can avoid training of too low intensity as well as body's exhaustion [7].

The present study was aimed at an assessment of the effects of strength training on physical capacities of persons with cervical spine injuries. Three research questions were addressed in the study:

1. Does strength training improve physical capacities of tetraplegics?
2. Is strength training possible for persons with disorders of hand grip function?
3. Does strength training affect the body's physical endurance?

Material and methods

The subjects were four active Paralympic athletes with C4–C6 cervical spine injury (one swimmer and three wheelchair rugby players) from the Foundation of Active Rehabilitation. They participated in 2-hour strength training sessions three times a week. The testing station used during the training sessions consisted of the “Upperton” weight trainer specially modified for users with cervical spine injuries, dumbbells used in body building training workouts and elastic fitness bands.

The study was carried out over a period of 15 months. The Biodex System 3 Pro isokinetic dynamometer and an arm cycloergometer were used for measurements. The measurements of muscle torques at the shoulder joint were carried out at 8-week intervals using the Biodex dynamometer. Additionally, the Wingate test was performed on the arm cycloergometer connected to a PC. Finally, the subjects' body composition measurements were taken.

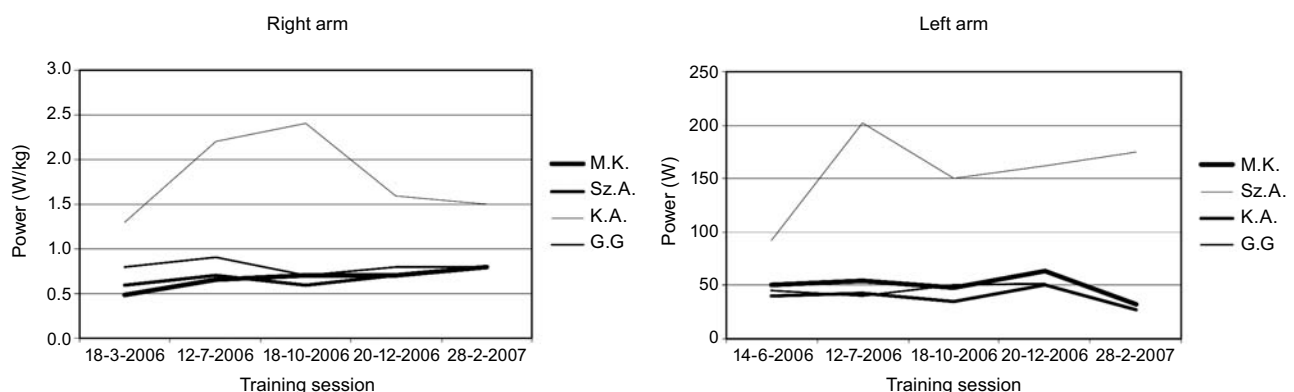


Figure 1. Mean power (W) of the right arm and the left arm in isokinetic conditions, with flexion movement at 300 deg/s

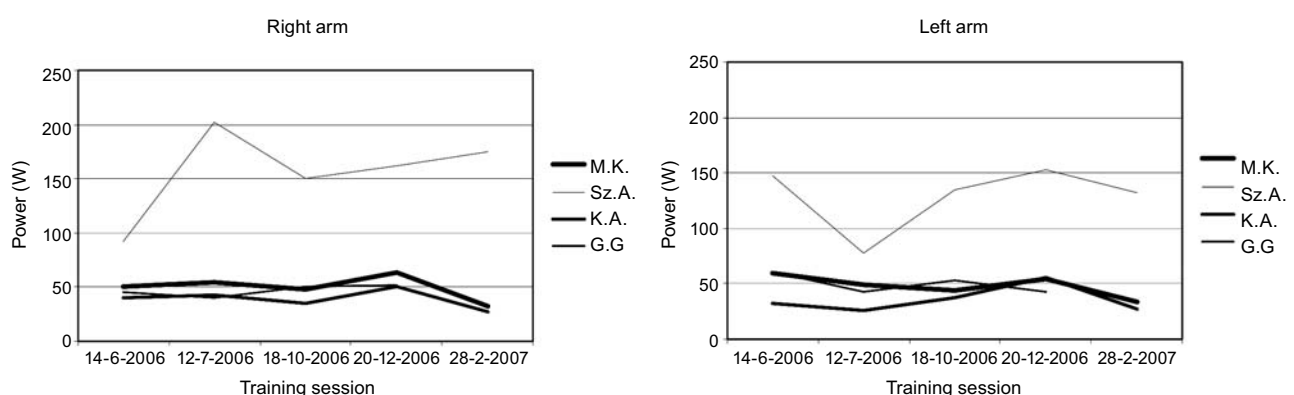


Figure 2. Mean power (W) of the right arm and the left arm in isokinetic conditions, with extension movement at 300 deg/s

Results

The test results revealed a correlation between the body's physical endurance and strength capacities of subjects with cervical spine injuries. The "Upperton" strength training equipment modified for tetraplegics allowed maximal loading of the disabled athletes' shoulder girdle. The obtained absolute muscle torque values at the shoulder joint (flexion and extension) in isokinetic conditions (at angular velocities of 30 and 300 deg/s) show a positive impact of strength training on the muscle strength of both arms (Fig. 1–4).

The use of elastic fitness bands in strength training allows extension of the ranges of movement at the shoulder joints. In tetraplegics the sedentary position and paralysis of the shoulder girdle muscles lead to a decrease of the range of movement and articular function as well as atrophy of shoulder extensors. Due to the loss of hand gripping function the loads were fixed on the subject's hand, which permitted maximal loading of the shoulder girdle muscles.

Throughout the entire testing period the athletes participated regularly in their swimming and wheelchair rugby training. During this period the swimmer, a member of the Polish National Swimming Team, set three national records in 50 m freestyle (1.53.51 s), 100 m freestyle (3.51.59 s) and 200 m freestyle (7.57.39 s). She won four gold medals during the European Swimming Cup in Antwerp.

The results of the 30-second Wingate test revealed a progress made by the subjects from the start of the strength training sessions (Fig. 5).

In the first test before the strength training program the swimmer from the Polish National Team achieved the mean power of 22.6 W with the maximal power of 26 W. After the nine-month training period her results were twice as high: 37.8 W and 46 W, respectively. As for her power results per kg of body mass the swimmer's results were 0.42 W/kg (mean power) and 0.48 W/kg (maximal power) before the commencement of training. After nine months the results were 0.7 W/kg and 0.8 W/kg, respectively.

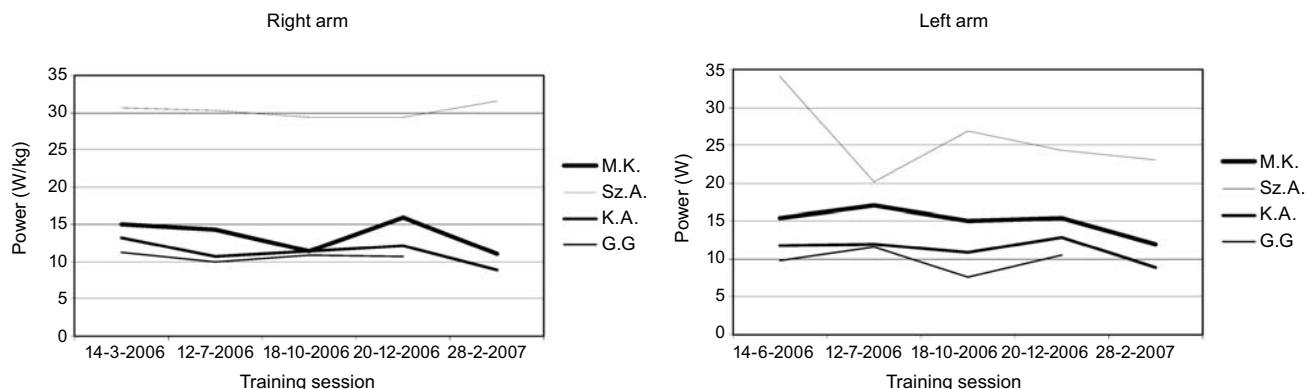


Figure 3. Mean power (W) of the right arm and the left arm in isokinetic conditions with flexion movement at 30 deg/s

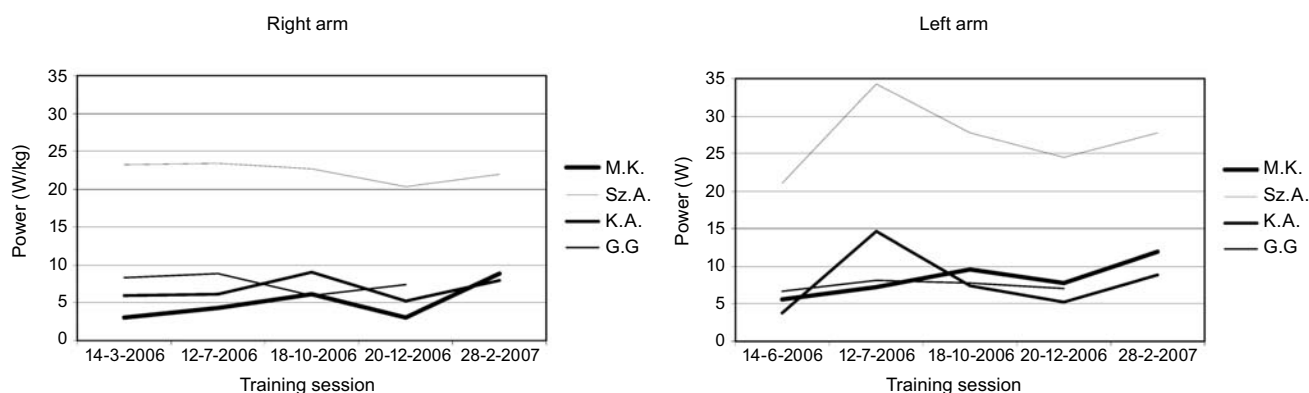


Figure 4. Mean power (W) of the right arm and the left arm in isokinetic conditions with extension movement at 30 deg/s

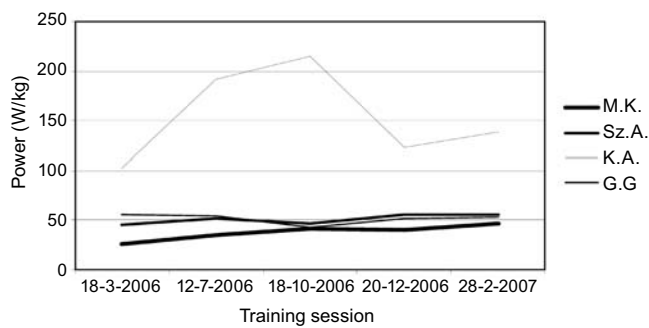


Figure 5. Maximal power (W) in 30-second Wingate test

Conclusions

1. Strength training improves the maximal force of arms in tetraplegics.
2. Strength training positively affects the body physical endurance in the disabled athletes.
3. Tetraplegics can take advantage of strength training only by using hand-fixed weights, due to the limited function of their arm flexors, including the greatly reduced hand gripping function.
4. Strength training is an indispensable element of rehabilitation of tetraplegics.

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Address for correspondence

Rafał Tabęcki

Zakład Sportu Niepełnosprawnych

Akademia Wychowania Fizycznego Józefa Piłsudskiego

ul. Marymoncka 34

00-968 Warszawa 45, Poland

e-mail: taba11@wp.pl



CONFIGURATIONS OF THE GRAF–BOKLEV (V-STYLE) SKI JUMPER MODEL AND AERODYNAMIC PARAMETERS IN A WIND TUNNEL

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Jerzy Maryniak¹, Edyta Ładyżyńska-Kozdraś^{2*}, Sławomir Tomczak³

¹ The Polish Air Force Academy, Dęblin, Poland

² Faculty of Mechatronics, Warsaw University of Technology, Warsaw, Poland

³ Faculty of Mechanical, Power and Aeronautical Engineering, Warsaw University of Technology, Warsaw, Poland

ABSTRACT

The paper discusses the results of wind tunnel tests for different angular configurations (φ_1 and φ_2) of a V-style (Graf–Boklev style) ski jumper model. The range of tested angles of attack was $\alpha = -10, 20, 30, 40$ (deg), depending on a configuration. The configurations of the Graf–Boklev style ski jumper model were compared with the classic parallel style of ski jumping with the ski-opening angle $\lambda = 0$. K1 as a configuration for the parallel style of ski jumping was used as the reference configuration for other configurations with different ski-opening angles, i.e. $\lambda = 0, 15, 25, 45$ (deg). The results obtained have been presented graphically as aerodynamic parameters within a specific angle of attack.

Key words: ski jumping, Graf–Boklev configuration, V-style, aerodynamic characteristics

Introduction

Ski jumper model tests for the parallel style (Daeschner technique) were carried out in a balance wind tunnel in the Institute of Aeronautics and Applied Mechanics of the Warsaw University of Technology in 1971 [1–3] and 1990 [4]. On the basis of those tests mathematical models were developed and various studies of the dynamics of a ski jumper in flight were performed [1, 2, 5–8]. The present study was carried out with a V-style (Graf–Boklev technique) ski jumper model (ski jumper + skis) [3, 4, 8–10]. The V-style of ski jumping so commonly used nowadays was first demonstrated by Polish ski jumper Mirosław Graf [10]. The V-style allows performing longer and safer ski jumps in different angular configurations and at different ski-opening angles.

The present study was aimed to examine the behavior of a ski-jumper in different configurations and to determine the impact of configuration test model parameters on aerodynamic characteristics.

Particular configurations were marked as $K_i_{\lambda v}$ (Tab. 1, Fig. 1, Fig. 2), where i denoted the ski jumper configuration number with the following angles: con-

figuration angle $\varphi_1 = 10, 20, 30$ (deg) and $\varphi_2 = 0, 10, 20, 30$ (deg); ski-opening angle $\lambda = 0, 15, 25, 45$ (deg); angle of roll $v = 0, 15, 30$ (deg). For example, K4_2515 was a configuration with the following angular values: $\varphi_1 = 20$ (deg), $\varphi_2 = 0$ (deg), $\lambda = 25$ (deg), $v = 15$ (deg). When the ski-opening angle λ amounted to 0 or the angle of roll v to 0, these values were not taken into consideration.

Table 1. Ski jumper test model angular configurations

Configuration	φ_1 (deg)	φ_2 (deg)	λ (deg)	v (deg)	α (deg)
K1_ λv	10	0	0, 15, 25, 45	0, 15, 30	-10 – 40
K2_ λv	10	10	15, 25, 45	0, 15, 30	-10 – 40
K3_ λv	10	20	15, 25, 45	0, 15, 30	-10 – 40
K4_ λv	20	0	15, 25, 45	0, 15, 30	-10 – 40
K5_ λv	20	20	15, 25, 45	0, 15, 30	-10 – 40
K6_ λv	30	0	15, 25, 45	0, 15, 30	-10 – 40
K7_ λv	30	30	15, 25, 45	0, 15, 30	-10 – 40

φ_1, φ_2 – configuration angles, λ – ski-opening angle,
 v – angle of roll, α – angle of attack

In configuration K1, a parallel ski jumping style was used with $\lambda = 0$ (deg). Since the parallel style used to be the most common ski jumping technique, K1 was regarded as the reference configuration.

The angles of attack α (Fig. 2), depending on the ski jumper configuration, ranged from -10 (deg) to 40 (deg).

* Corresponding author.

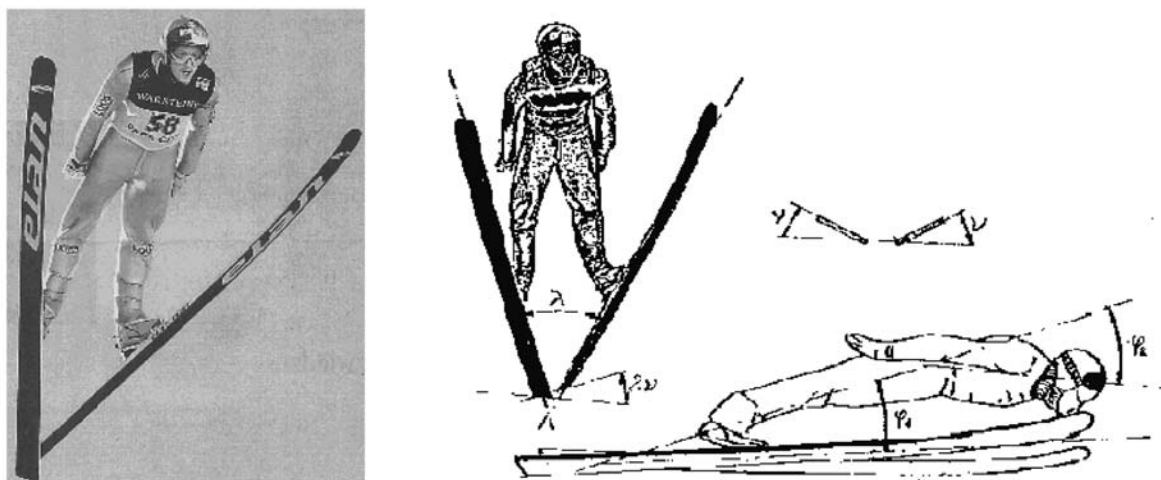


Figure 1. Angles in a ski jumper model configuration for the Graf-Boklev style (V-style)

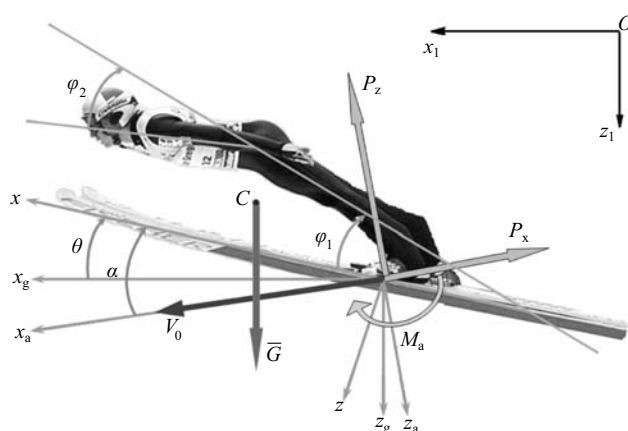


Figure 2. Frame of reference, angles and forces affecting a ski jumper in flight (φ_1, φ_2 – configuration angles, θ – angle of inclination, α – angle of attack, V_0 – flight velocity tangent to the flight trajectory, G – gravity force, P_z – the lift, P_x – the drag, M_a – the pitching moment)

Material and methods

Wind tunnel model ski jumper tests

The aerodynamic model ski jumper tests were carried out in Wind Tunnel 1 of the Department of Aerodynamics in the Institute of Aeronautics and Applied Mechanics of the Warsaw University of Technology (Fig. 3). The wind tunnel was equipped with an aerodynamic balance designed by Prof. C. Witoszyński. The measurement methods were taken from Litwińczuk et al. [11] and Tomczak, Maryniak [12].

The test section of the wind tunnel was connected to a PC with data processing software for measurement of the lift (P_z), drag (P_x) and pitching moment (M_a) (Fig. 2). Tests were carried out for different configurations of the

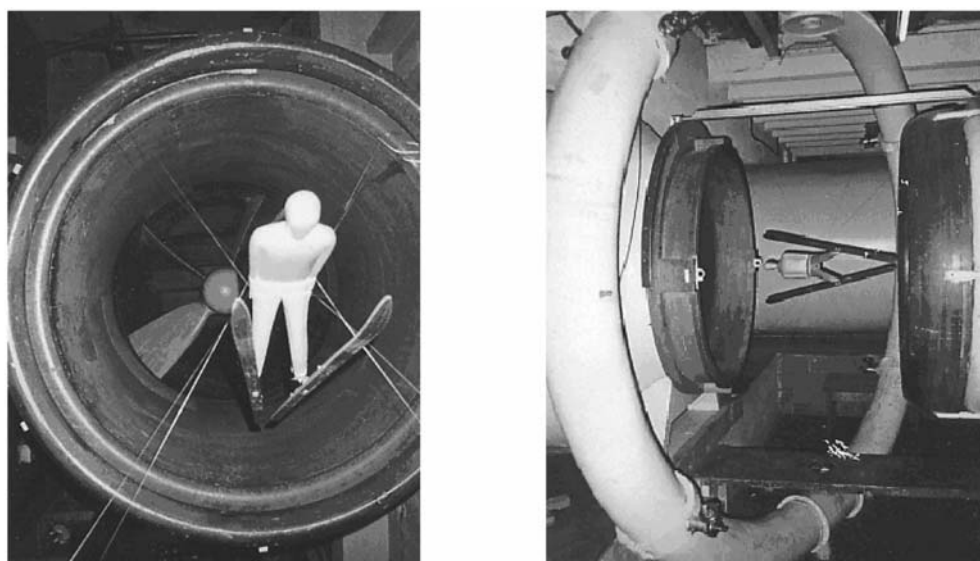


Figure 3. Ski jumper test model (a) inside the tunnel test section, (b) ski jumper model and the aerodynamic balance ring

ski jumper model (ski jumper + skis) in the full range of angles of attack α (Fig. 4) [1–9, 10, 12–14]. The configurations of the ski jumper model change during particular stages of a ski jump: **stage 1** – take off – skis parallel followed by a quick opening and formation of the V-shape and proper angle of attack α ; **stage 2** – V-style flight, maintaining the most favorable lift-to-drag ratio and proper angle of attack α ; **stage 3** – landing approach, moving from the V-formation to the parallel technique; **stage 4** – touch down, proper landing (telemark, or safe landing if the critical landing point is crossed).

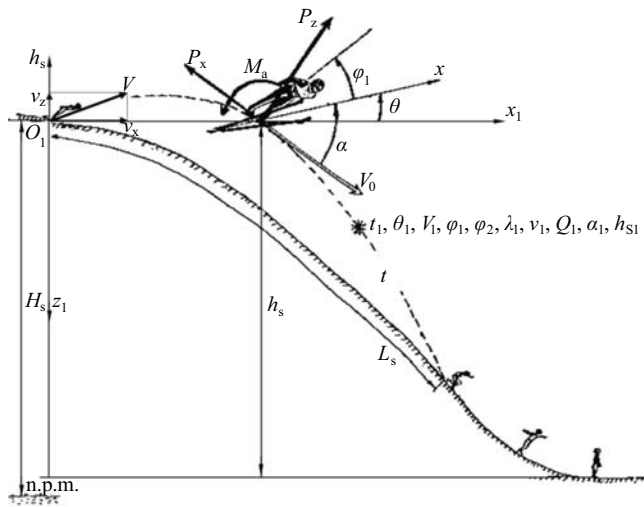


Figure 4. Ski jump stages

Results

Defining dimensionless aerodynamic coefficients

The study was aimed to determine dimensionless aerodynamic coefficients of the lift (C_z), drag (C_x) and pitching moment (C_{ma}) within the angle of attack α for a given ski jumper configuration (φ_1, φ_2), ski-opening angle (λ) and angle of roll (ν). The coefficients of the lift (C_z) and drag (C_x) were used to determine the lift-to-drag ratio K , which could be physically interpreted as the distance covered by a gliding object (sailplane, bird, ski jumper) in windless weather:

$$K(\alpha, \varphi_1, \varphi_2, \lambda, \nu) = C_z(\alpha, \varphi_1, \varphi_2, \lambda, \nu) / C_x(\alpha, \varphi_1, \varphi_2, \lambda, \nu). \quad (1)$$

The aerodynamic balance was used to determine first the drag (P_x), lift (P_z) and pitching moment (M_a), and then their dimensionless aerodynamic coefficients:

$$P_x = \frac{1}{2} \rho S V_0^2 C_x(\alpha, \varphi_1, \varphi_2, \lambda, \nu),$$

$$C_x = C_x(\alpha, \varphi_1, \varphi_2, \lambda, \nu) = \frac{P_x}{\frac{1}{2} \rho S V_0^2} \quad (2)$$

$$P_z = \frac{1}{2} \rho S V_0^2 C_z(\alpha, \varphi_1, \varphi_2, \lambda, \nu),$$

$$C_z = C_z(\alpha, \varphi_1, \varphi_2, \lambda, \nu) = \frac{P_z}{\frac{1}{2} \rho S V_0^2} \quad (3)$$

$$M_a = \frac{1}{2} \rho S l V_0^2 C_{ma}(\alpha, \varphi_1, \varphi_2, \lambda, \nu),$$

$$C_{ma} = C_{ma}(\alpha, \varphi_1, \varphi_2, \lambda, \nu) = \frac{M_a}{\frac{1}{2} \rho S l V_0^2} \quad (4)$$

V_0 – airflow velocity ($V_0 = 30$ m/s for wind tunnel tests),

S – surface area of ski jumper model skis ($S = 0.034739$ m²),

l – ski length ($l = 0.705$ m),

ρ – air density ($\rho = 1.225$ kg/m³).

Figures 5–11 present selected test results.

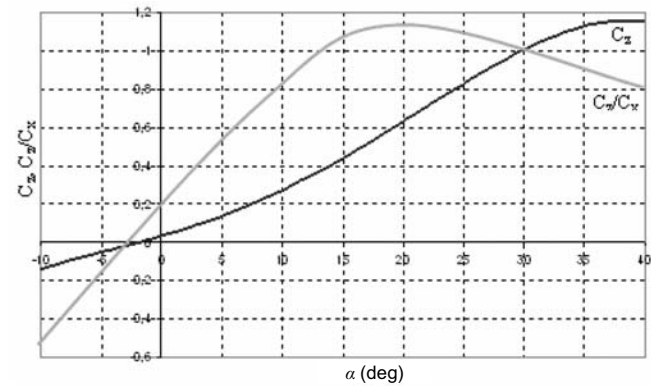


Figure 5. Changes of dimensionless coefficients of the lift (C_z) and lift-to-drag ratio (C_z/C_x) for configuration K1_0, i.e. with parallel skis ($\varphi_1 = 10$ (deg), $\varphi_2 = 0$ (deg), $\lambda = 0$ (deg), $\nu = 0$ (deg))

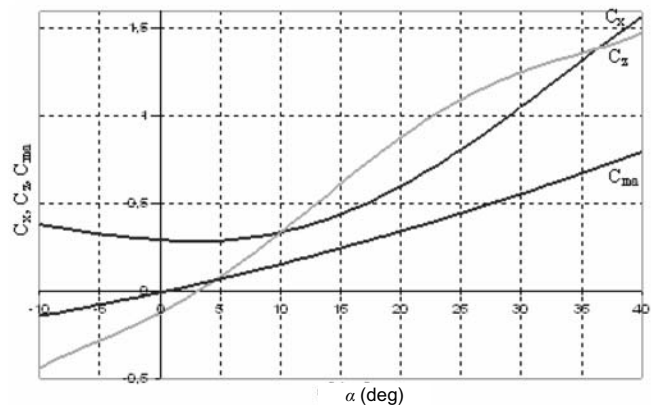


Figure 6. Changes of dimensionless aerodynamic coefficients (C_x, C_z, C_{ma}) within angle of attack α for configuration K1_4530 ($\varphi_1 = 10$ (deg), $\varphi_2 = 0$ (deg), $\lambda = 45$ (deg), $\nu = 30$ (deg))

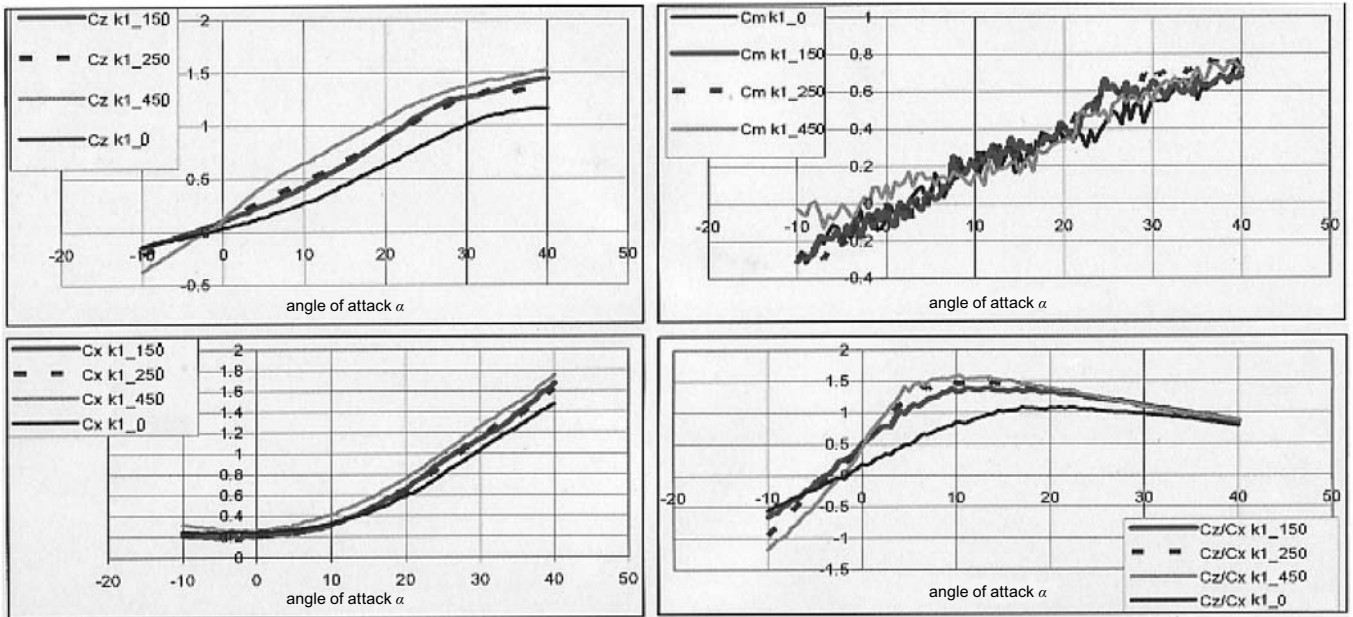


Figure 7. Changes of dimensionless aerodynamic coefficients of the drag (C_x), lift (C_z), pitching moment (C_{ma}) and lift-to-drag ratio (C_z/C_x) within angle of attack α for configuration K1 ($\varphi_1 = 10$ (deg), $\varphi_2 = 0$ (deg), $\lambda = 0, 15, 25, 45$ (deg), $\nu = 0$ (deg))

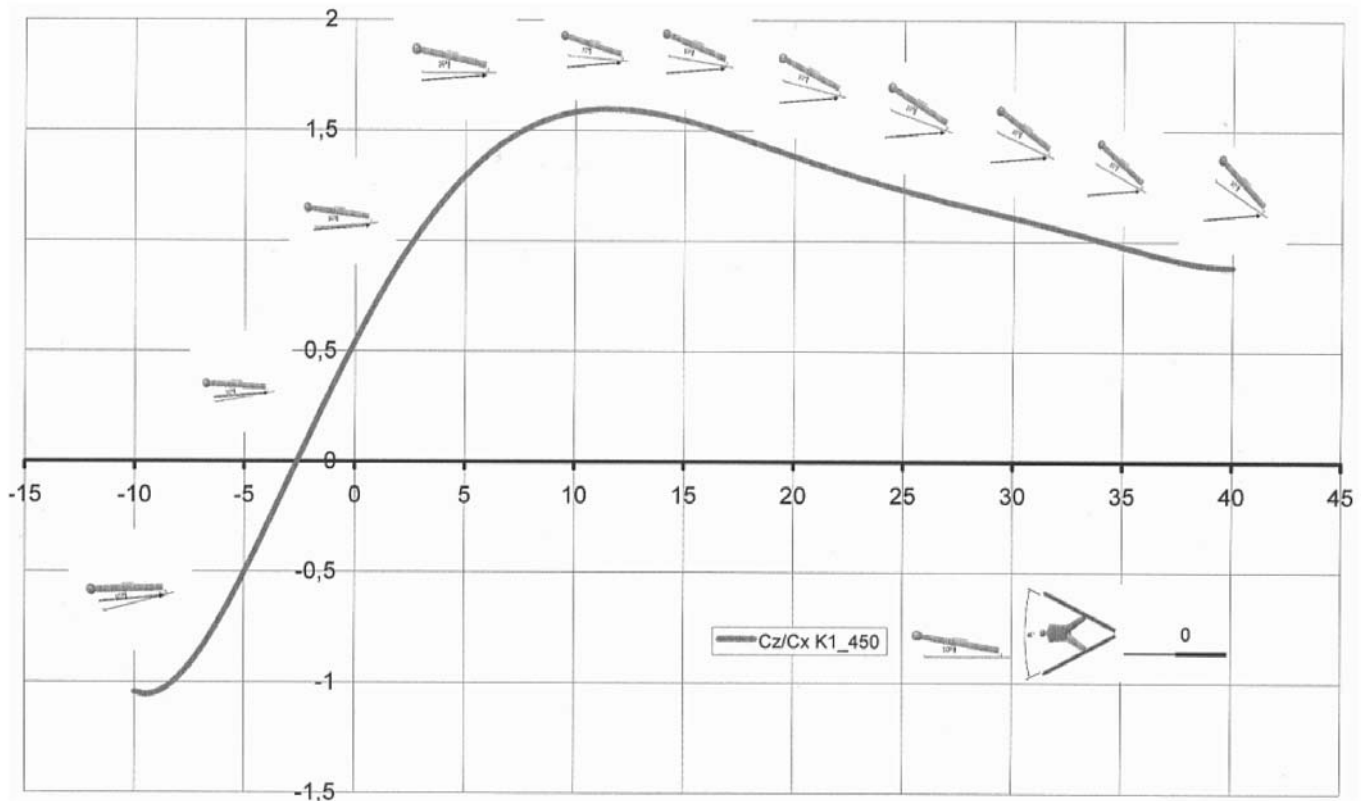


Figure 8. Changes of the lift-to-drag ratio (C_z/C_x) within angle of attack $-10 \leq \alpha \leq 40$ (deg), and a visual representation of the ski jumper test model (ski jumper + skis) for configuration K1_450 ($\varphi_1 = 10$ (deg), $\varphi_2 = 0$ (deg), $\lambda = 45$ (deg), $\nu = 0$ (deg))

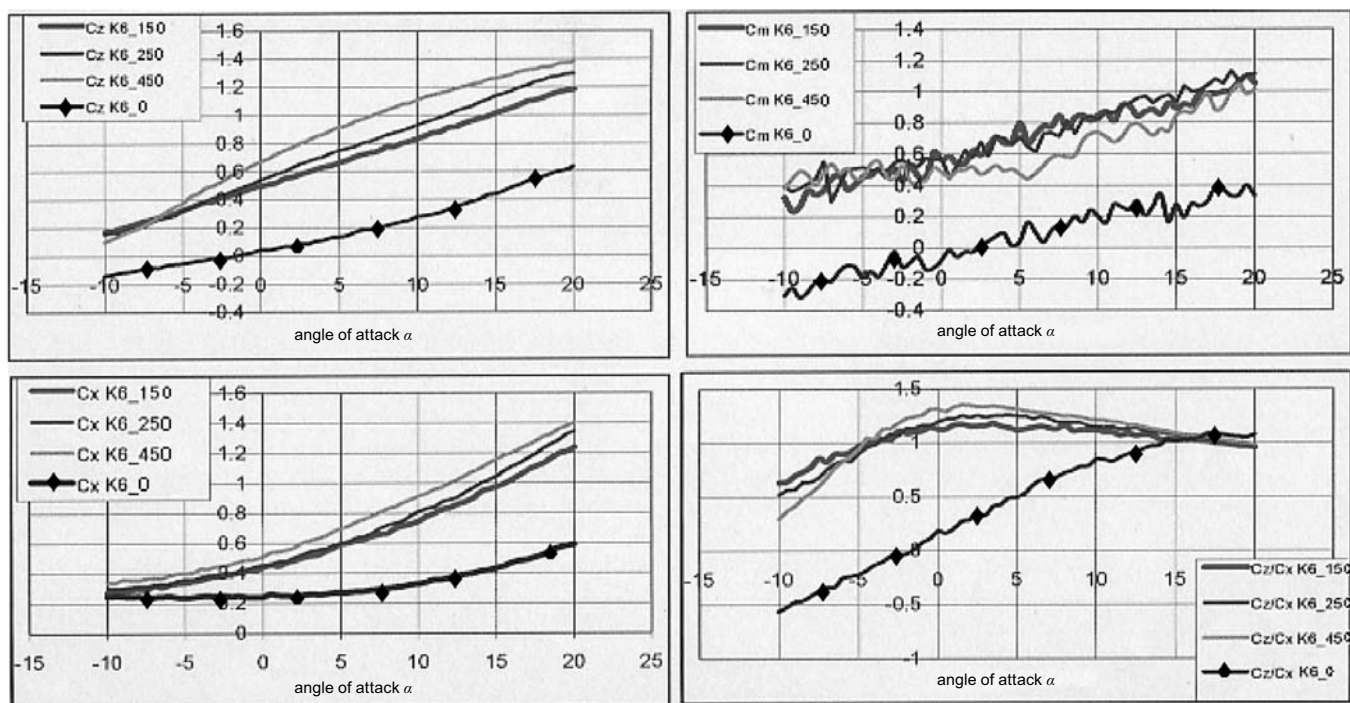


Figure 9. Changes of dimensionless aerodynamic coefficients of the drag (C_x), lift (C_z), pitching moment (C_{ma}) and lift-to-drag ratio (C_z/C_x) within angle of attack α for configuration K6 ($\varphi_1 = 30$ (deg), $\varphi_2 = 0$ (deg), $\lambda = 0, 15, 25, 45$ (deg), $\nu = 0$ (deg))

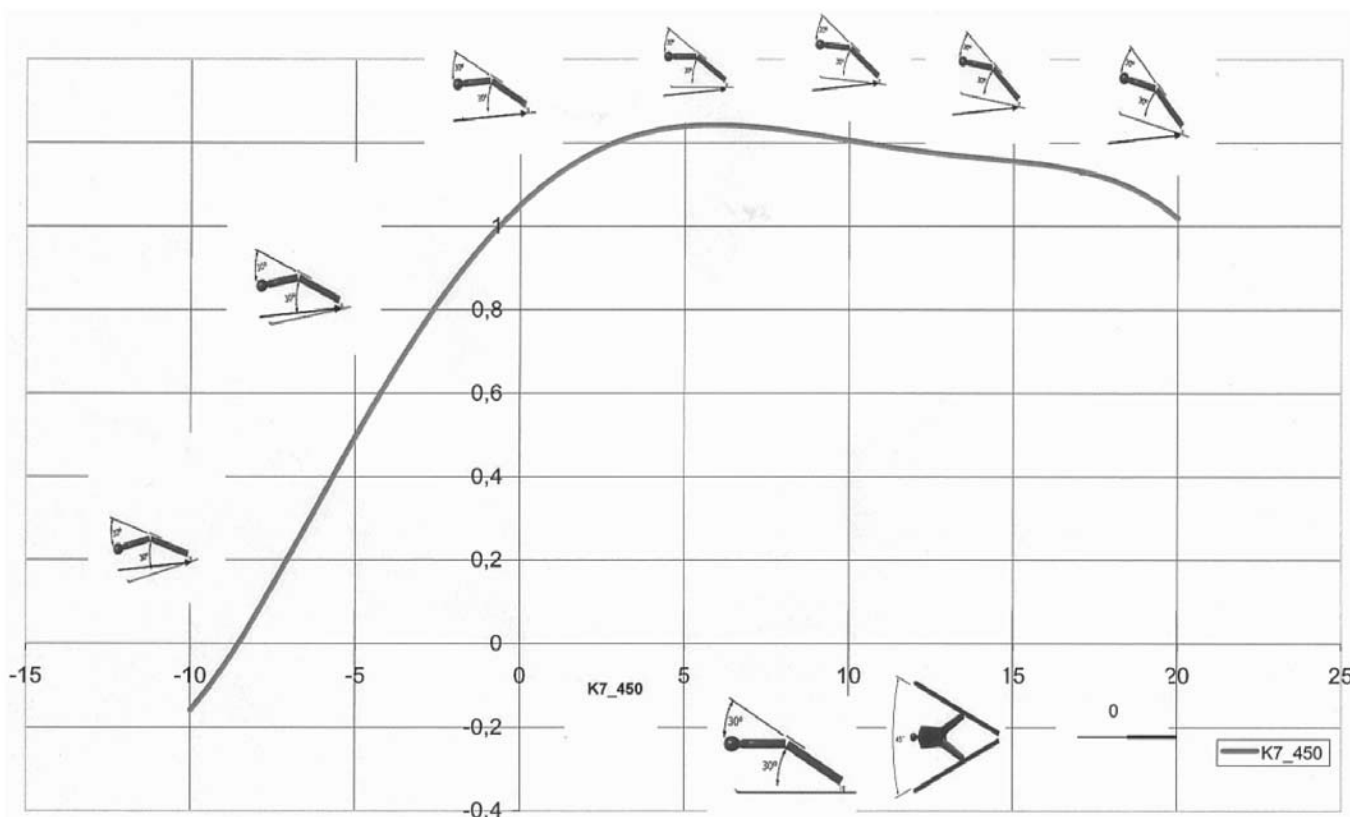


Figure 10. Changes of the lift-to-drag ratio (C_z/C_x) within angle of attack α , and a visual representation of the ski jumper test model (ski jumper + skis) for configuration K7_450 ($\varphi_1 = 30$ (deg), $\varphi_2 = 30$ (deg), $\lambda = 45$ (deg), $\nu = 0$ (deg))

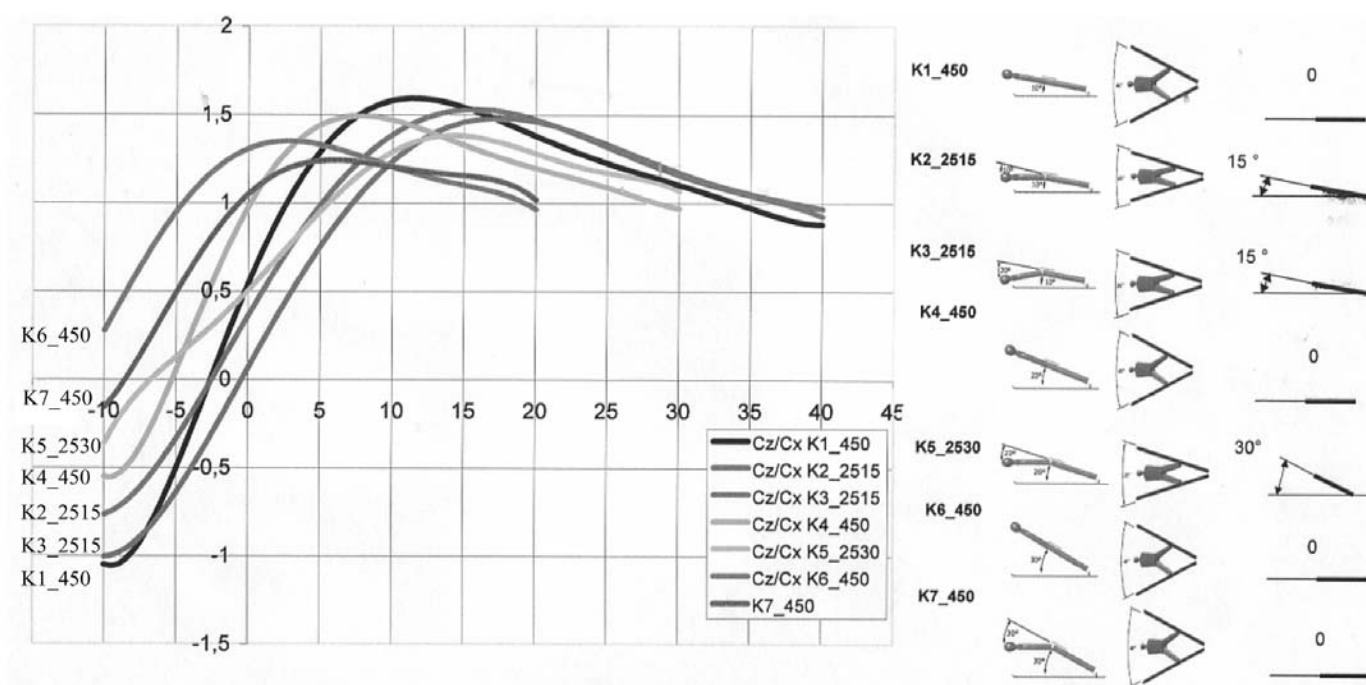


Figure 11. Changes of the lift-to-drag ratio (C_z/C_x) within angle of attack α for different configurations of the ski jumper model (ski jumper + skis)

Conclusions

The above study is the first such comprehensive ski wind tunnel research in professional literature. The wind tunnel tests of configuration K1 for the parallel style of ski jumping were performed to obtain reference values for the V-style configurations: for K1_0 $C_{zmax}(\alpha) = 1.16$ with $\alpha = 40$ (deg), and lift-to-drag ratio $K_{max}(\alpha) = 1.08$ with $\alpha = 21$ (deg) (Fig. 5). Configuration K1_450 featured the highest coefficient of the lift and lift-to-drag ratio, for $C_{zmax}(\alpha) = 1.53$ with $\alpha = 40$ (deg), and $K_{max}(\alpha) = 1.58$ with $\alpha = 10$ (deg) (Fig. 7, 8, 11). It should be emphasized that an excessive angle of roll ν reduces the measured aerodynamic parameters (Fig. 11). The jumping distance is also considerably influenced by changes of the angle of attack (α) during particular stages of the jump (Fig. 8, 10).

Acknowledgements

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Address for correspondence

Edyta Ładyżyńska-Kozdraś
Wydział Mechanotroniki, Zakład Mechaniki Stosowanej
Politechnika Warszawska
ul. św. A. Boboli 8
02-525 Warszawa, Poland
e-mail: e.ladyzynska@mchtr.pw.edu.pl



REPEATABILITY OF PRESSURE FORCE DURING ELBOW FLEXION AND EXTENSION BEFORE AND AFTER EXERCISE

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Marek Zatoń¹, Ryszard Błacha^{2*}, Agnieszka Jastrzębska¹, Krzysztof Słonina²

¹ Chair of Physiology and Biochemistry, University School of Physical Education, Wrocław, Poland

² Chair of Physical Activity in the Natural Environment, University School of Physical Education, Wrocław, Poland

ABSTRACT

Purpose. In most circumstances it is possible to provide the precise estimation of force and weight by means of kinesthetic differentiation. In some conditions, like physical effort or fatigue, kinesthetic differentiation can become reduced. The kinesthetic differentiation capacity can be expressed as repeatability of muscular contraction force or movement. The present study investigates the direction of changes in kinesthetic differentiation of force applied by both arms during elbow flexion and extension before and after exercise. **Basic procedures.** The study sample consisted of 23 cyclists (mean \pm SD) aged 18.1 ± 1.8 years, 17 rowers aged 18.1 ± 1.8 years, and a control group consisting of 32 subjects aged 21.3 ± 1.3 years. All subjects performed a progressive exercise test. Kinesthetic differentiation was measured as the repeatability of force applied during elbow flexion and extension. **Main findings.** The results obtained confirm that kinesthetic differentiation in both arms after exercise improved by means of elbow extension. Further research can contribute to the development of ways of control of adaptation changes in the central nervous system and the locomotor system on a general level, since the studies so far have described either local changes, e.g. EMG, or provided specific data related to typical patterns of activity in a given sport. **Conclusions.** The proposed method allows identification of effects of intense exercise on the kinesthetic differentiation capacity on a more general level.

Key words: kinesthetic differentiation, proprioception, physical effort

Introduction

The repeatability of force applied in motor actions depends on information delivered from receptors in muscles, tendons, ligaments and synovial capsules. The most important sensory receptors in muscles include muscle spindles and the Golgi tendon organs responsible for proprioception [1–3]. The proprioceptive sense allows precise control of motor actions “planned” in the cortical centers [4, 5].

Apart from the sensory proprioceptors also cutaneous receptors and exteroceptors of sight and hearing are highly significant in “sensing” movement. The cutaneous mechanoreceptors (Pacinian corpuscles, Meissner’s corpuscles, Merkel’s discs, and Ruffini corpuscles) respond to mechanical stimuli thanks to skin flexibility and receive precise information from the outside environment. Received stimulation is processed by the central nervous system, and in this way the body can respond quickly to a stimulus affecting the skin [3].

Among the receptors responsible for the kinesthetic sense, particularly important are the intrafusal muscle fibers enabling immediate changes of muscle tone at the level of spinal cord. However, fatigue developed during muscle work may distort generation of muscle force in voluntary contractions [6, 7].

The increasing physiological expense of muscular contractions is linked to the so-called “central fatigue”, which inhibits the function of some motor neurons and cortical motor centers loaded earlier [8]. The processes affecting central fatigue reduce the ability to continue exercise or increase its intensity. They do not reflect an exercise-induced dysfunction of the central nervous system [9] but rather constitute a mechanism of “active” defense against overload [8]. They are not associated exclusively with declining movement precision or strength, but also with metabolic changes.

Proprioception allows control of muscle tone in isometric or isotonic contractions and thus application of optimal force. The capacity of differentiation of the force applied enables repeatability and precision of performed motor actions at a lower physiological expense.

* Corresponding author.

The present study was to provide information about force applied during arm movement before and after exercise. It was aimed at assessment of changes in differentiation of the force applied during exercise-induced elbow flexion and extension. It was assumed that systemic physical effort changes local kinesthetic sensitivity. A test of this assumption can contribute to the diagnosis of the impact of exercise on the efficiency of the locomotor system.

Material and methods

The study was conducted in a test center in conformance with the PN-EN ISO 9001:2001 Certificate of Quality System. The experimental group consisted of right-handed male cyclists and rowers; the control group included students of the University School of Physical Education in Wrocław (Tab. 1).

Table 1. Profile of subjects

Group		Age	Body weight (kg)	Body height (cm)
Control group <i>n</i> = 32	\bar{x}	21.29	76.08	180.06
	SD	1.34	9.69	5.98
Cyclists <i>n</i> = 23	\bar{x}	18.13	67.43	177.39
	SD	1.84	7.38	5.27
Rowers <i>n</i> = 17	\bar{x}	18.06	74.79	180.41
	SD	1.85	9.22	6.20

Both study groups performed progressive exercise tests in accordance with the method used by MacDougall et al. [10]. The tests were performed on a cycle ergometer (Monark E895, Sweden) with an electronic sensor and software for registration of work results (kJ). Each subject performed the test at his chosen rate of movements, however not less than 60 cycles per minute. The initial load amounted to 10 N, and was increased for another 10 N every three minutes until the force of 70 N was attained. The exercise was interrupted once a subject was unable to maintain the minimal rate of cycles ($60 \text{ cycles} \cdot \text{min}^{-1}$), or the oxygen uptake was reduced ($\dot{V}O_2$) with increasing ventilation rate ($\dot{V}E$) and heart rate (HR).

At rest, during the entire exercise test, and for the first five minutes of restitution the subjects breathed through a face mask (Cosmed, Italy) and the exhaled air samples were processed in a K4b² portable gas analyzer

(Cosmed, Italy) equipped with an electrocardiograph. During the exercise tests the following measurements were taken:

- heart rate (HR) ($\text{cycle} \cdot \text{min}^{-1}$),
- respiratory minute volume ($\dot{V}E$) ($\text{dcm}^3 \cdot \text{min}^{-1}$),
- oxygen uptake $\dot{V}O_2$ ($\text{dcm}^3 \cdot \text{min}^{-1}$),
- rate of elimination of carbon dioxide $\dot{V}CO_2$ ($\text{dcm}^3 \cdot \text{min}^{-1}$).

The K4b² was calibrated daily with a standard gas mixture (Polgaz): O_2 (16%), CO_2 (5%), N_2 (79%). Additionally, before each test the gas analyzer was calibrated with atmospheric air: O_2 (20.9%), CO_2 (0.03%). The flowmeter measuring pulmonary ventilation ($\dot{V}E$) was calibrated with a hand pump (3 dcm^3). The cycle ergometer was computer-calibrated before each test.

The apparatus for measuring the repeatability of pressure force consisted of:

- two plates for measuring pressure of the upper right and left extremities,
- a tensometric bridge,
- an analog-digital signal converter (computer card),
- software for data processing (Kinestezjometr ver. 1.0),
- PC set (Celeron 2.54 GHz).

The kinesthesiometer with tensometric sensors for measuring differences in arm pressure force consisted of a base frame with an adjustable seat and backrest and two vertical platforms with metal rods supporting

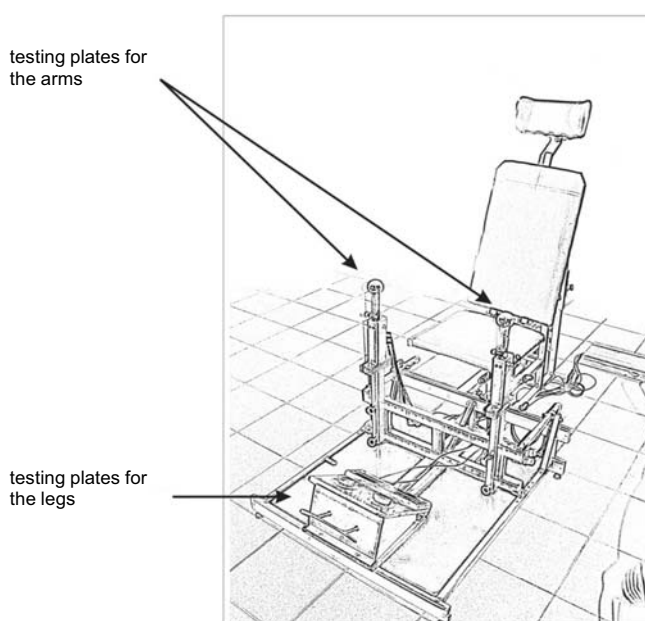


Figure 1. Kinesthesiometer for testing the force of the upper and lower limbs

round-shaped hand plates on top. The tensometers reacted to forward, backward (not applicable in the present study) sideways and downward elastic strains. The tensometers reacted to strains on the metal rod due to applied pressure force by emitting an analog signal, which was then enhanced and converted into digital data. The tensometric bridge had eight channels for measuring the pressure force of the upper and lower limbs in planned directions. The digital signal was then recorded and processed by the PC.

Before the tests the kinesthesiometer was calibrated with weights (1 kg, 5 kg, 10 kg). In the first part of the test subjects performed 5 to 10 free elbow flexions and extensions with the pressure force close to 10 kG (98 N), with intervals between the movements at their convenience. During the test subjects could follow the results of using the force of elbow extension and flexion on the computer screen. Each subject was to remember a chosen pressure force value.

During the main part of the experiment each subject performed 10 elbow flexions and extensions with the pressure force they remembered without seeing the results on the computer screen. During the test subjects sat straight without leaning against the backrest. The examined arm was bent at the elbow at the angle of 90° , with the hand overgripping the round plate, straight at the wrist. The other arm was resting on the thigh. The legs rested against the base of the kinesthesiometer. After each pressure the tested arm rested on the thigh. In the first measurement pressure was exerted on the plate by extending the elbow (pushing the plate), and in the second measurement by flexing the elbow (pulling the plate). The repeatability of the force applied was measured with the right arm and the left arm.

The results were then analyzed statistically. The mean pressure force (Nm) was calculated from ten elbow reps performed by each subject. The standard error was determined for pressure force repeatability on the basis of the sum of differences from the mean. From each pressure force value the mean value was subtracted ($N1 - Nm$, $N2 - Nm$, etc.). The results were presented as absolute values [11].

The kinesthesiometric measurements were taken before exercise and in the 5th minute of post-exercise restitution. The statistical parameters analyzed included the arithmetic mean (\bar{x}) and standard deviation (SD) of the sum of differences from the mean force (\bar{x}) and Student's t-test.

Results

The analysis of maximal oxygen uptake ($\dot{V}O_2 \text{ max}$) in the control group and in the study group of cyclists and rowers revealed significantly lower values of this parameter in the former (Tab. 2).

Table 2. Arithmetic mean (\bar{x}) and standard deviation (SD) of aerobic capacity and work in groups under study

Group		$\dot{V}O_2 \text{ max}$ (l · min ⁻¹)	$\dot{V}O_2 \text{ max}$ (cm ³ · kg · min ⁻¹)	Work (kJ)
Control group <i>n</i> = 32	\bar{x}	3.62	48.06	162.83
	SD	0.59	8.40	42.18
Cyclists <i>n</i> = 23	\bar{x}	4.39	65.93	267.75
	SD	0.44	4.90	42.77
Rowers <i>n</i> = 17	\bar{x}	4.25	57.05	173.66
	SD	0.72	8.10	68.05

Table 3. Student's t-test values in exercise parameters in groups under study

Exercise parameter	Group 1	Group 2	Mean Group 1	SD Group 1	Mean Group 2	SD Group 2	Student's t-test
$\dot{V}O_2 \text{ max}$ (l · min ⁻¹)	Control group	Cyclists	3.62	0.59	4.39	0.44	-5.27*
	Control group	Rowers	3.62	0.59	4.25	0.72	-3.27*
	Cyclists	Rowers	4.39	0.44	4.25	0.72	0.79
$\dot{V}O_2 \text{ max}$ (cm ³ · kg · min ⁻¹)	Control group	Cyclists	48.06	8.40	65.93	4.90	-9.13*
	Control group	Rowers	48.06	8.40	57.05	8.10	-3.61*
	Cyclists	Rowers	65.93	4.90	57.05	8.10	4.31*
Work (kJ)	Control group	Cyclists	162.83	42.18	267.75	42.77	-9.05*
	Control group	Rowers	162.83	42.18	173.66	68.05	-0.69
	Cyclists	Rowers	267.75	42.77	173.66	68.05	5.36*

* $p \leq 0.05$

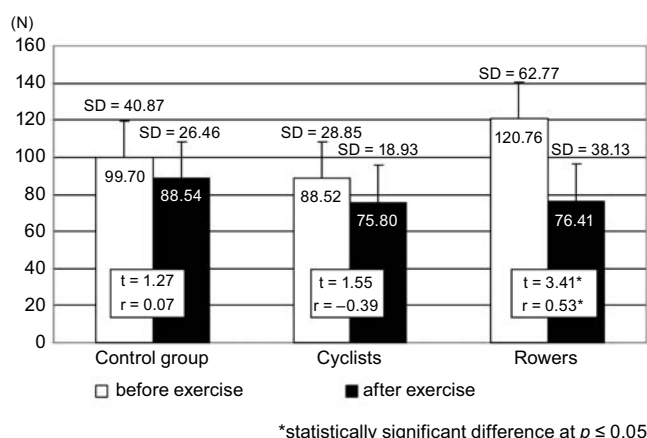


Figure 2. Arithmetic mean (\bar{x}) and standard deviation (SD) of the sum of differences from the mean (\bar{x}) of the force applied (N) in groups under study and Student's t-test (t) and coefficient of correlation (r) before and after the right elbow extension exercise test

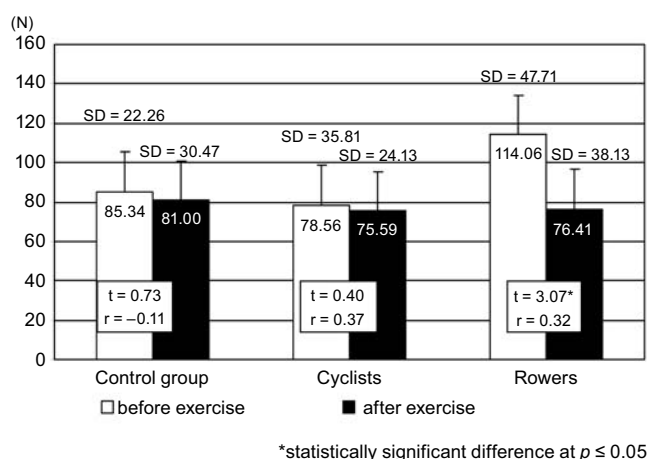


Figure 3. Arithmetic mean (\bar{x}) and standard deviation (SD) of the sum of differences from the mean (\bar{x}) of the force applied (N) in groups under study and Student's t-test (t) and coefficient of correlation (r) before and after the left elbow flexion exercise test

The highest absolute-max ($4.39 \text{ l} \cdot \text{m}^{-1}$) and relative-max per kg of body mass ($65.93 \pm 5 \text{ cm}^3 \cdot \text{kg}^{-1} \cdot \text{m}^{-1}$) were noted in the cyclists (Tab. 2). They also performed the biggest work ($W = 267.75 \pm 42.77 \text{ kJ}$), significantly greater than in the other groups of subjects (Tab. 3).

The groups examined differed in variability of the force applied (proprioception) during extension (pushing the kinesthesiometer plate) and flexion (pulling the kinesthesiometer plate) of the left and the right elbow (Tab. 2, 3).

The arithmetic mean of the sum of differences from the mean repeatability of force applied during extension of the right elbow was lower after exercise in all subjects.

In the group of rowers these differences were statistically significant (Fig. 2).

The arithmetic mean of the sum of differences from the mean repeatability of force applied during flexion of the right elbow was lower after exercise in all subjects. In the group of rowers these differences were statistically significant (Fig. 3).

During extension of the left elbow the repeatability of force applied was lower in the group of rowers and in the control group. In the group of cyclists the mean repeatability was significantly higher (Fig. 4).

A statistically significant decrease (improvement) of the capacity of the force repeatability in the left arm

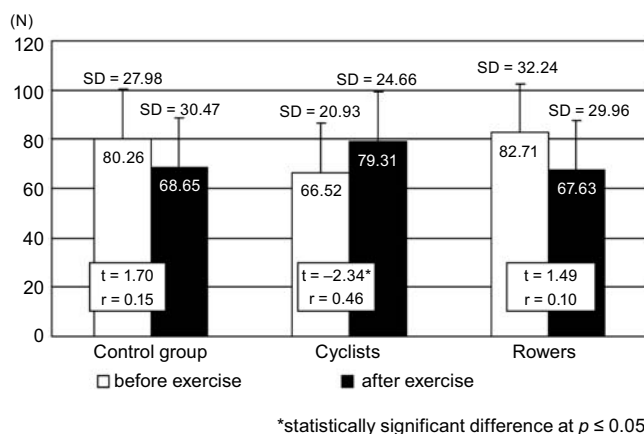


Figure 4. Arithmetic mean (\bar{x}) and standard deviation (SD) of the sum of differences from the mean (\bar{x}) of the force applied (N) in groups under study and Student's t-test (t) and coefficient of correlation (r) before and after the left elbow extension exercise test

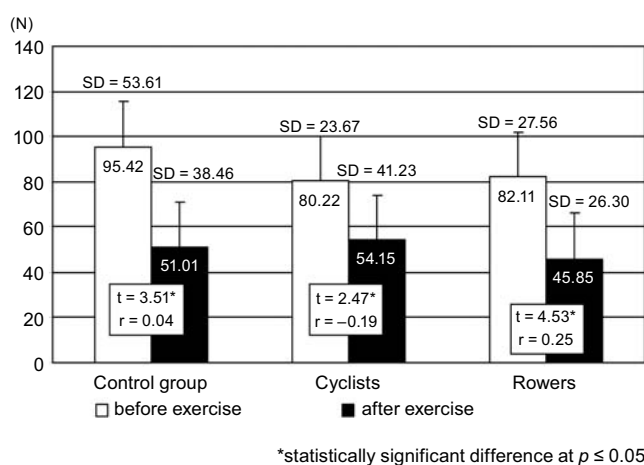


Figure 5. Arithmetic mean (\bar{x}) and standard deviation (SD) of the sum of differences from the mean (\bar{x}) of the force applied (N) in groups under study and Student's t-test (t) and coefficient of correlation (r) before and after the left elbow flexion exercise test

Table 4. Arithmetic mean (\bar{x}) and standard deviation (SD) of the sum of differences from the mean (\bar{x}) of the force applied (N) in groups under study and Student's t-test (t) before the exercise test

Elbow movement	Group 1	Group 2	Mean Group 1	SD Group 1	Mean Group 2	SD Group 2	Student's t-test
Right elbow extension	Control group	Cyclists	104.09	38.49	88.52	28.86	1.57
	Control group	Rowers	106.50	42.81	120.76	62.77	-0.71
	Cyclists	Rowers	86.42	30.66	120.76	62.77	-1.85
Right elbow flexion	Control group	Cyclists	87.15	18.83	78.56	35.81	0.89
	Control group	Rowers	89.36	19.87	114.06	47.71	-2.29*
	Cyclists	Rowers	82.47	39.41	114.06	47.71	-2.19*
Left elbow extension	Control group	Cyclists	80.51	28.11	66.52	20.94	1.92
	Control group	Rowers	81.50	31.40	82.71	32.24	-0.11
	Cyclists	Rowers	63.40	21.18	82.71	32.24	-1.66
Left elbow flexion	Control group	Cyclists	96.29	59.77	80.22	23.67	1.22
	Control group	Rowers	82.90	27.60	82.11	27.56	0.10
	Cyclists	Rowers	79.52	26.49	82.11	27.56	-0.34

* $p \leq 0.05$ Table 5. Arithmetic mean (\bar{x}) and standard deviation (SD) of the sum of differences from the mean (\bar{x}) of the force applied (N) in groups under study and Student's t-test (t) after the exercise test

Elbow movement	Group 1	Group 2	Mean Group 1	SD Group 1	Mean Group 2	SD Group 2	Student's t-test
Right elbow extension	Control group	Cyclists	85.64	26.63	75.80	18.93	1.61
	Control group	Rowers	86.75	26.56	76.41	38.13	0.77
	Cyclists	Rowers	77.77	21.46	76.41	38.13	0.15
Right elbow flexion	Control group	Cyclists	86.38	32.57	75.59	24.13	1.18
	Control group	Rowers	87.03	26.66	76.41	38.13	0.86
	Cyclists	Rowers	74.11	26.55	76.41	38.13	-0.22
Left elbow extension	Control group	Cyclists	70.49	32.29	79.31	24.66	-0.97
	Control group	Rowers	60.33	22.14	67.63	29.96	-0.88
	Cyclists	Rowers	81.79	27.17	67.63	29.96	1.41
Left elbow flexion	Control group	Cyclists	66.53	34.17	54.15	41.23	1.30
	Control group	Rowers	79.42	25.24	45.85	26.30	3.73*
	Cyclists	Rowers	67.31	39.61	45.85	26.30	1.84

* $p \leq 0.05$

during elbow flexion was noted in all groups under study (Fig. 5).

Before exercise the sums of arithmetic mean differences in the force applied varied significantly during elbow flexion between the cyclists and the control group, and between the cyclists and the rowers (Tab. 4). In two cases the rowers achieved higher results.

After exercise, in one case, a statistically significant difference in the parameter being studied during left elbow flexion was found between the control group (higher results) and the rowers (Tab. 5).

Discussion

Proprioception is a decisive factor in the process of controlling movement performance. The course of reception of stimuli from proprioceptors varies in the groups under study before and after exercise.

In the present study the exercise test performed was a stimulus to the body, which in extreme cases led to muscle fatigue. The progressive test was a considerable load to the body.

The statistical analysis revealed a reduction in standard deviation of the force applied during elbow flexion

and extension after exercise, and in many cases these changes were statistically significant (Fig. 2–5). Only during the left elbow extension test in the group of cyclists, an increase in standard deviation of the force applied was noted. It could have been a fatigue symptom as this group achieved the highest level of work.

The improvement of parameters of the force applied after exercise can be due to activation of the Golgi tendon organs made up of strands of collagen, as suggested by Loeb [12] and Gandevia [13]. The Golgi tendon organs are tonic sensory receptors (i.e. adapting slowly to a stimulus) and reveal discharges during the whole process of tendon stretching, which undoubtedly took place in the final part of the exercise test.

Also the observed change in the kinesthetic differentiation capacity is most likely a result of the activity of Golgi tendon organs. According to McCloskey et al. [14], Jones [15] and Gandevia [13] these organs can mobilize greater numbers of motoneurons engaged in heavy work and thus recruit more motor units in exercise. This all can lead to fatigue manifested by a simultaneous change in synaptic neurotransmission affecting the precision of a movement performed.

Elbow flexion is more precisely repeatable after exercise than elbow extension. This is most likely due to the modified stimulation of motoneurons of elbow flexors (biceps) and extensors (triceps) by afferent nerve fibers [16, 17]. A study by Butler et al. [17] revealed that afferent signals from type III and type IV sensory fibres do not inhibit the activity of elbow flexor motoneurons. Additionally, research results obtained by Martin et al. [16] showed that in conditions of fatigue the activity of type III and IV afferent fibers of flexors and extensors reduced the activity of elbow extensor motoneurons by means of hyperpolarization. At the same time the activity of flexor motoneurons increases as well. It is possible that the differences in reaction noted in the cyclists can be due to the similarity between the cycle ergometer test to their regular cycling training exercises. This, however, requires further research.

Another reason for better elbow flexion repeatability after exercise can be attributed to the fact that the effects of the monosynaptic corticospinal tract on motor units of the biceps brachii are greater than on the triceps brachii [18, 19].

The improvement in differentiation of the force applied after exercise in the left elbow flexion test is statistically significant in all groups under study. It might be a warm-up effect. A progressive exercise test cannot be

categorized as long-term physical exercise, since in the case of the most efficient subjects it barely amounts to 15–20 minutes of exercise, which is characteristic of a regular sport warm-up.

Conclusions

The study results point to the impact of exercise on the repeatability of force applied. Physical effort enhances local kinesthetic differentiation, especially during elbow flexion (left). Further research can indicate ways of control of adaptation changes in the central nervous system and the locomotor system on a general level, since the studies so far have described either local changes, e.g. EMG, or provided specific data related to typical patterns of activity in a given sport.

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Address for correspondence

Ryszard Błacha
Katedra Fizjologii i Biochemii
Akademia Wychowania Fizycznego
Al. I.J. Paderewskiego 35
51-612 Wrocław, Poland
e-mail: ryszardb@awf.wroc.pl



FORCE-VELOCITY PARAMETERS OF KNEE FLEXORS AND EXTENSORS IN 10–12-YEAR-OLD CHILDREN WITH SPINAL AND KNEE DISEASES

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Małgorzata Stefańska*, Dominika Zawadzka

Faculty of Physiotherapy, University School of Physical Education, Wrocław, Poland

ABSTRACT

Purpose. Assessment of the muscles force of knee flexors and extensors in children with a scoliosis of the first degree and knock-knees and comparison with healthy children. **Basic procedures.** Forty-nine boys and girls aged 10–12 years participated in this research project. The subjects were divided into three research groups. Group I included children with first degree scoliosis; Group II children with knock-knees; and Group III healthy children. An analysis of force-velocity parameters of knee flexors and extensors in isokinetic conditions (with the loads of 1.05 rad/s (60°/s), 3.14 rad/s (180°/s) and 4.19 rad/s (240°/s)) was carried out. Each subject had to perform flexion and extension movements of the knee five times, developing peak torque in the shortest time possible in each movement. **Main findings.** The research showed that healthy children obtained significantly higher values of peak torque, total work and mean power as compared with the other children. However, no significant differences between values obtained by scoliotic children and children with knock-knees were found. **Conclusions.** Corrective exercise programs for children with scoliosis and children with knock-knees should be accompanied by general fitness exercises directed at improvement of force and endurance of lower limb muscles.

Key words: scoliosis, knock-knee, peak torque, total work, average power, isokinetic tests

Introduction

In recent years a significant increase in the incidence of body postural defects in children can be clearly noticed. The main factor contributing to this increase is civilization progress responsible for reduction of physical activity. The dominant sedentary lifestyle observed among children is a result of low health awareness and common ignorance of disease prevention principles in society [1, 2].

Preventive care is highly significant in prophylaxis and correction of body posture defects. Primary prevention is aimed at identification and elimination of harmful environmental influences and propagation of a healthy lifestyle. Secondary prevention aims at early detection of postural defects (e.g. more screening examinations would make it much easier to commence the corrective process early enough). Tertiary prevention is to curb the development of postural defects with the aid of specialist help (orthopedic and physiotherapeutic) to make the corrective activities a long-term process [3].

One of the most frequent postural defects affecting the lower extremities is genu valgum also known as knock-knees. It is a deformity where the knees angle in and touch one another when the legs are straightened [4]. Knock knees are characterized by hypertrophy of the medial condyle of femur, increased pressure on the lateral condyle of femur inhibiting the growth of bones and enhancing asymmetry; external shank rotation; ligamentous and muscular twisting consisting of a stretching of the medial collateral ligament and other medial knee muscles, and of a contracture of the fibular collateral ligament and other lateral knee muscles [5]. Due to these changes the knee loses its compactness, which may lead to its total dysfunction.

Scoliosis is an abnormal lateral curvature of the spine. The condition can be categorized as side-to-side (frontal plane), rotoscoliosis (horizontal plane) and sagittal plane spinal deformity. In the first degree scoliosis the Cobb angle (curvature angle) does not exceed 30° and the condition affects only the muscular and ligamentous system without any deformities of the bone tissue. Scoliosis is classified as a systemic disease affecting the locomotor, circulatory and respiratory systems and limiting the function of other internal organs [6].

* Corresponding author.

The aim of the study was to examine force-velocity parameters of knee flexors and extensors in children with first degree scoliosis and knock-knees and compare them with those of healthy children. It was assumed that postural defects in children reduced the strength and endurance of lower limb muscles.

Material and methods

Material

The sample included 48 boys and girls aged 10–12 years. The subjects were divided into three study groups: Group I – children with first degree scoliosis, Group II – children with knock-knees, and Group III – healthy children. The subjects' profile is presented in Table 1.

Table 1. Profiles of children under study (mean \pm SD)

	Group I	Group II	Group III
<i>n</i> (♀ + ♂)	19 (10 + 9)	15 (8 + 7)	15 (7 + 8)
Age (years)	10.89 \pm 0.81	10.73 \pm 1.10	10.92 \pm 0.79
Body height (m)	1.46 \pm 0.09	1.49 \pm 0.09	1.46 \pm 0.12
Body weight (kg)	37.29 \pm 6.78	46.70 \pm 12.04	36.33 \pm 7.23

Group I – children with scoliosis, Group II – children with knock-knees, Group III – healthy children

Methods

The study was carried out in the Center for Function Tests (in conformance with the standard of PN-EN ISO 9001:2001 Certificate of Quality System) in the Faculty of Physiotherapy, University School of Physical Education in Wrocław. In each group force-velocity parameters of flexors and extensors of the knee of the dominant leg were assessed with the aid of the Biodex System 3 dynamometer (Biodex Medical System Inc., USA). The dynamometer recorded the times of muscle force development in different conditions of muscle work (Fig. 1). The assessment was carried out in isokinetic conditions with different loads.

Each subject performed five alternate flexion and extension movements of the knee at developing angular velocities of 1.05 rad/s (60°/s), 3.14 rad/s (180°/s) and 4.19 rad/s (240°/s) [7–9]. During each movement subjects attempted to develop maximal muscle force in the shortest time possible. Before each test the dynamometer station was adjusted so that the dynamometer axis formed an extension of the knee axis of rotation. Each time the range of knee movement was determined (mean range of 1.76 rad/s (101°): 0° – maximal extension

at the knee joint; 101° – maximal flexion at the knee joint). The subject's thigh and pelvis were stabilized with dynamometer straps to eliminate any facilitating movements. Before the test each subject flexed the knee to the maximum and performed three submaximal flexion and extension movements at the knee joint to get acquainted with a given load [10].

Peak torque – Mm (N \times m), total work – W (J) and mean power – P (W) were assessed during flexion and extension of the knee joint with consecutive loads. For each subject the relative muscle force was also calculated – Mm/mc (torque value per kg of body mass) (N \times m/kg).



Figure 1. Biodex System 3

The Shapiro–Wilk test was used in statistical analysis to check the distribution of all variables examined, which was close to normal distribution. Levene's test was applied to assess the equality of variance and thus the mean and standard deviation values for each group under study. Student's t-test was used to determine the statistical significance of mean differences between results obtained in particular groups.

Results

Figures 2–5 present arithmetic means obtained for each group, parameter and load. The subjects from Group III obtained higher values of muscle torque, relative force, mean power and total work for knee flexors and extensors with almost all the loads. The results of children with knock-knees and children with scoliosis revealed no significant differences between Group I and Group II. Statistically significant mean differences be-

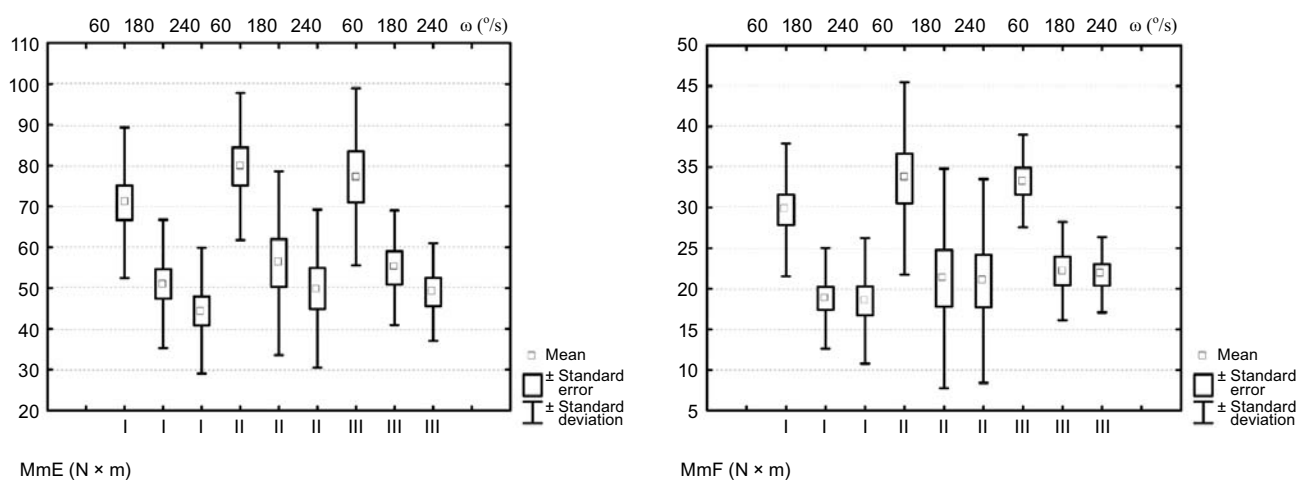


Figure 2. Mean peak torque values Mm ($N \times m$) of knee extensors (E) and knee flexors (F) in each study group (I, II, III) with the loads of $60^{\circ}/s$, $180^{\circ}/s$, $240^{\circ}/s$

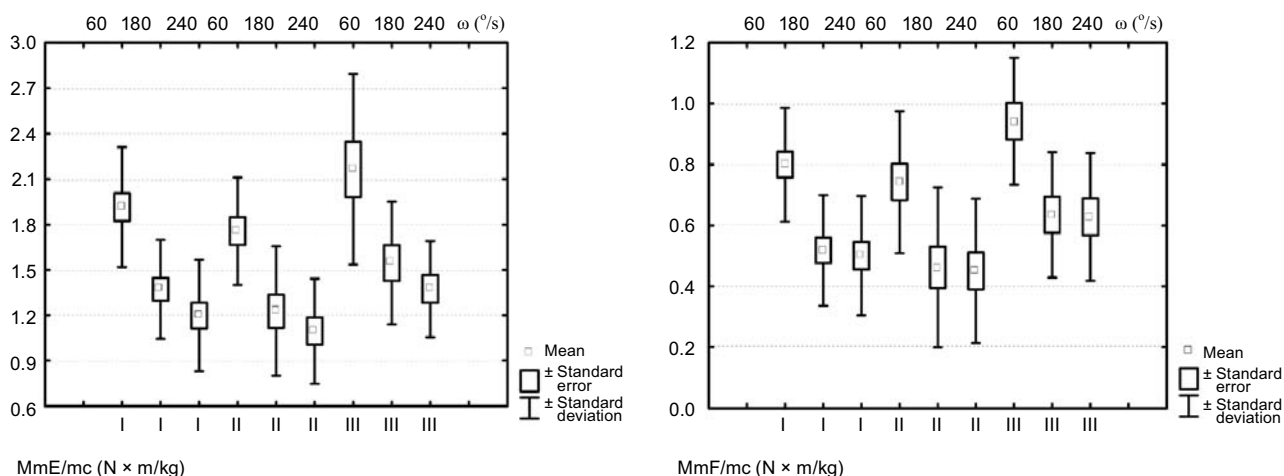


Figure 3. Mean relative torque values Mm/mc ($N \times m/kg$) of knee extensors (E) and knee flexors (F) in each study group (I, II, III) with the loads of $60^{\circ}/s$, $180^{\circ}/s$, $240^{\circ}/s$

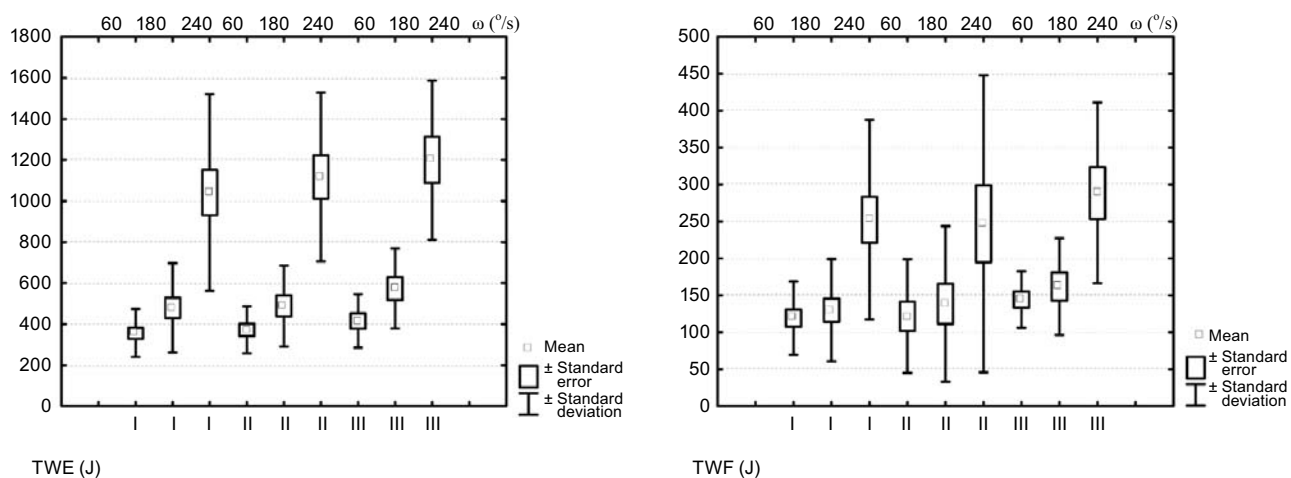


Figure 4. Mean total work values TW (J) of knee extensors (E) and knee flexors (F) in each study group (I, II, III) with the loads of $60^{\circ}/s$, $180^{\circ}/s$, $240^{\circ}/s$

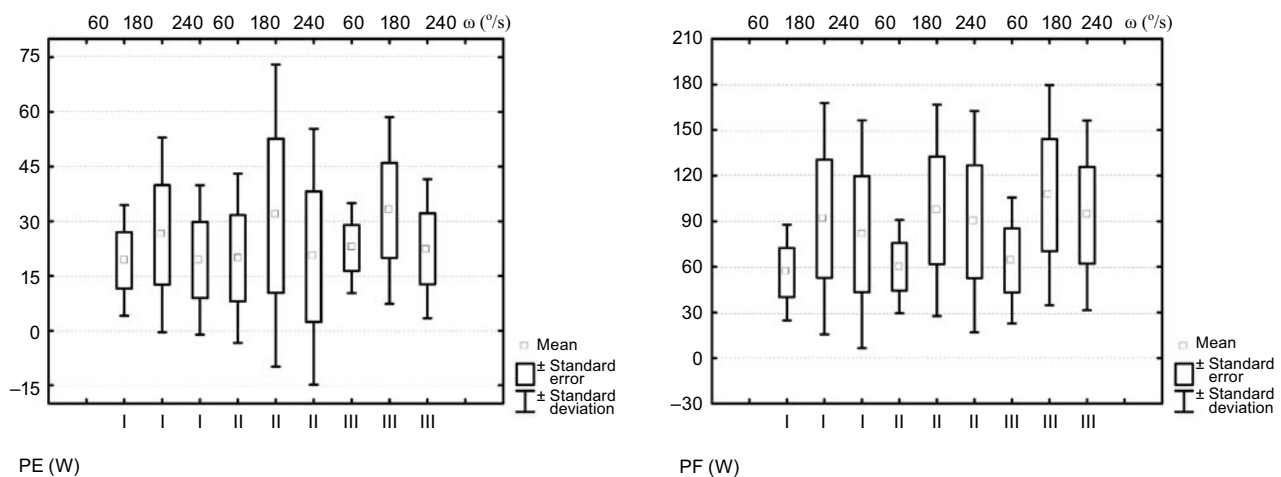


Figure 5. Mean power values P (W) of knee extensors (E) and knee flexors (F) in each study group (I, II, III) with the loads of $60^\circ/\text{s}$, $180^\circ/\text{s}$, $240^\circ/\text{s}$

Table 2. Student's t -test p values for differences between the three study groups (I, II, III) for knee extensors (E) and flexors (F) in all parameters studied

	Group I vs. Group II			Group I vs. Group III			Group II vs. Group III		
	$60^\circ/\text{s}$	$180^\circ/\text{s}$	$240^\circ/\text{s}$	$60^\circ/\text{s}$	$180^\circ/\text{s}$	$240^\circ/\text{s}$	$60^\circ/\text{s}$	$180^\circ/\text{s}$	$240^\circ/\text{s}$
MmE	0.17	0.44	0.37	0.01*	0.48	0.39	0.00*	0.88	0.90
MmE/mc	0.23	0.27	0.41	0.19	0.20	0.18	0.04*	0.06	0.04*
TWE	0.69	0.90	0.63	0.03*	0.03*	0.35	0.02*	0.04*	0.60
PE	0.49	0.22	0.53	0.24	0.03*	0.36	0.57	0.01*	0.76
MmF	0.27	0.48	0.49	0.00*	0.00*	0.20	0.00*	0.00*	0.84
MmF/mc	0.43	0.46	0.50	0.06	0.11	0.10	0.03*	0.07	0.05
TWF	0.90	0.78	0.92	0.15	0.16	0.46	0.36	0.17	0.53
PF	0.85	0.21	0.85	0.21	0.35	0.42	0.47	0.09	0.71

Mm – peak torque, Mm/mc – relative force, TW – total work, P – mean power, * $p < 0.05$

tween Group I and Group II were noted primarily at a low and medium velocity of movement. Table 2 presents the Student's t -test p values.

Discussion

The assessment of force-velocity parameters of large muscle groups determines the strength and endurance of the whole human body. The present study focused on the parameters of knee extensors as they constitute one of the largest and strongest groups of human muscles. A number of researchers have pointed to the fact that the assessment of the force and velocity properties of this muscle group reflects the strength and endurance of the whole body. Mameletzi et al. [8, 9] examined the relationships between the muscle strength of knee flexors and extensors and body composition in young swimmers. Suman et al. [11] assessed muscle strength in children with burn injuries before and after a 12-week exer-

cise program, using the parameters of knee extensors. Horvat et al. [12] used the results of an isokinetic test of knee flexors and extensors in their analysis of peak muscle force and work in youth with and without mental retardation. It should be emphasized that isokinetic tests of knee muscles feature a high level of reliability and repeatability. In studies by Deighan et al. [13] and De Ste Croix et al. [14] the coefficient of correlation for peak force values obtained during two independent measurements amounted to 0.9–0.83 for knee extensors and 0.76–0.74 for knee flexors, depending on the load.

Children from Groups I and II achieved lower F - v values of knee flexors and extensors than their healthy counterparts. The biggest differences were noted at a low ($60^\circ/\text{s}$) and medium ($180^\circ/\text{s}$) angular velocity, i.e. with loads demonstrating the strength capability of these muscles. The decrease in the strength of muscles of the lower extremity in children with knock-knees (Group II) can be explained by muscular lesions charac-

teristic of this condition (stretching of the medial collateral ligament of the knee and contracture of the fibular collateral ligament) and changes in the osteoarticular system (asymmetry of the epicondyles of femur, stretching of the medial collateral ligament and contracture of the lateral collateral ligament). The lower F-v parameters in this group can also be attributed to the subjects' larger body weight. The children with knock-knees were about 25% heavier than other children, while the body height differences were insignificant (Tab. 1). To make the obtained peak torque values independent of the subjects' body weight, relative force was calculated for each subject and each load [15]. On the average, the healthy subjects' values were 28% higher.

The results of peak torque, mean power and total work of knee flexors and extensors in Group I were similar to the results in Group II (children with knock-knees), i.e. also lower than results from Group III. The observed decrease in the F-v parameters of knee muscles cannot be rationally explained by ailments related to the postural defects. The observed reduced strength, power and work of the muscles of the lower limb can be caused by the low level of physical activities of children who are more prone to lead an "economical lifestyle". This is additionally evidenced by the very low level of knowledge and awareness of postural defects in children among their parents. A study by Nowotny-Czupryna et al. [16] revealed that among 77 parents of children with postural defects only 9 had a satisfactory knowledge about their children's condition. Almost 40% of parents were not able to identify their children's condition, and the majority of them could not enumerate situations and activities to be avoided by their children. More than 70% of parents admitted their children spent more than 10 hours a day in a sitting position.

Conclusions

1. Children with scoliosis of the first degree and knock-knees achieve significantly lower values of force and velocity parameters of knee flexors and extensors than their healthy counterparts.

2. Corrective exercise programs for children with scoliosis of the first degree and knock-knees should also involve strength and endurance training of muscles of the lower limbs.

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Address for correspondence

Małgorzata Stefańska

Wydział Fizjoterapii

Akademia Wychowania Fizycznego

ul. I.J. Paderewskiego 35

51-612 Wrocław, Poland

e-mail: malgorzata.stefanska@awf.wroc.pl



CHANGES OF POWER–VELOCITY RELATIONSHIP IN VOLLEYBALL PLAYERS DURING AN ANNUAL TRAINING CYCLE

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Krzysztof Buśko

Department of Anthropology, The Józef Piłsudski University of Physical Education, Warsaw, Poland

Department of Biomechanics, Institute of Sport, Warsaw, Poland

ABSTRACT

Purpose. The aim of the study was to follow the changes of maximal power output and power–velocity relationship in male volleyball players during an annual training cycle. **Basic procedures.** The study was conducted on six first-league volleyball players: age 25.0 ± 5.3 years, body height 195.2 ± 7.2 cm and body mass 91.2 ± 14.7 kg. Force–velocity and power–velocity relations were determined from five maximal cycle ergometer exercise tests, 10 s each, with increasing external loads amounting to 2.5, 5.0, 7.5, 10.0 and 12.5% of body weight, respectively. There were 2-min breaks between the tests. Maximal power output was computed from power–velocity curves. Maximal power output and power–velocity relationships were determined before the preparatory period (I), after the first competitive season (II) and after the second competitive season (III). **Main findings.** Significant increases occurred in the maximal power output from 12.80 ± 0.79 (preparatory period) to 13.11 ± 0.94 (after the first competitive season) and 13.44 ± 0.62 $\text{W} \cdot \text{kg}^{-1}$ (after the second competitive season). The mean optimal velocity (v_o) increased non-significantly from 122.2 ± 16.1 rpm (I) to 129.2 ± 14.9 rpm (II), and decreased non-significantly during the second competitive season (119.5 ± 18.5 rpm). **Conclusions.** In the annual training cycle under study a statistically significant increase of the power output with the external load of 7.5% of body weight was noted. The relative maximal power output increased significantly after the second competitive season as compared with the measurement before the preparatory period. The optimal velocity changed insignificantly in the entire annual training cycle.

Key words: power–velocity relationship, maximal power output, volleyball

Introduction

Volleyball is a sport involving short and intensive physical efforts during training and competition [1, 2]. Volleyball players' fitness relies on their force, power output and jumping ability [3, 4]. Although the players' power output is measured on a cycloergometer, its value depends, however, on the amount of external loading [2]. Different authors have examined the force–velocity ($F-v$) and power–velocity ($P-v$) relationships, measured during cycloergometer exercises in different groups of athletes [5, 6] and discussed the effects of specific training exercises on the force–velocity relationship [7–9]. Their results suggest that sport training can influence the correlation mentioned [5–7]. With the exception of Häkkinen's work [10] discussing changes of force and jumping ability in female volleyball players during the competitive season, there have been no studies, however, examining changes in the force–velocity and power–velocity relationships in volleyball players during an annual training cycle. The aim of the present study was to follow changes of the maximal power output and power–

velocity relationship in male volleyball players during an annual training cycle.

Material and methods

The study was granted approval of the Research Ethics Committee. The sample consisted of six male volleyball players from the Polish Volleyball League aged 25.0 ± 5.3 years, with body height of 195.2 ± 7.2 cm and body weight of 91.2 ± 14.7 kg. The measurements were performed before the preparatory period (I), after the first competitive season (II) and after the second competitive season (III).

The force–velocity ($F-v$) and power–velocity ($P-v$) relationships were determined on the basis of results of exercises performed on a Monark 874 E cycloergometer connected to a PC, using the MCE 4.0 software package. After adjusting the ergometer saddle and handlebars each subject performed the tests in a stationary position, without lifting off the saddle, with his feet strapped onto the pedals. Each player performed five 10-second maximal cycloergometer tests with increas-

Table 1. Absolute (P) and relative (P/mass) power outputs recorded for an external force–velocity relationship (mean values \pm SD) in volleyball players during the competitive season

Load (% BW)		I	II	D (%)	III	D (%)
P (W)	2.5	421.5 \pm 93.5	429.5 \pm 61.6	4.2	442.8 \pm 50.1	7.9
	5.0	796.5 \pm 133.3	815.3 \pm 119.8	2.7	811.7 \pm 112.6	2.4
	7.5	1021.0 \pm 153.4	1064.8 \pm 143.4	4.6	1049.7 \pm 110.9	3.5
	10.0	1144.2 \pm 181.9	1183.5 \pm 165.1	3.8	1170.2 \pm 136.9	2.9
	12.5	1110.8 \pm 113.1	1113.5 \pm 170.5	0.2	1189.8 \pm 160.4	6.8
P_{\max} (W)		1162.7 \pm 164.1	1191.2 \pm 163.2	2.6	1202.0 \pm 145.3	3.7
P /mass (W/kg)	2.5	4.60 \pm 0.55	4.72 \pm 0.28	3.8	4.95 \pm 0.19	9.2
	5.0	8.74 \pm 0.54	8.96 \pm 0.70	2.5	9.06 \pm 0.54 ^a	3.9^a
	7.5	11.24 \pm 0.96	11.72 \pm 0.84 ^a	4.4^a	11.75 \pm 0.51 ^a	4.9^a
	10.0	12.59 \pm 0.96	13.02 \pm 0.98	3.6	13.11 \pm 0.87	4.3
	12.5	12.29 \pm 0.82	12.29 \pm 1.47	0	13.28 \pm 0.64	8.5
P_{\max} /mass (W/kg)		12.80 \pm 0.79	13.11 \pm 0.94	2.4	13.44 \pm 0.62 ^a	5.1^a

^a mean values differ significantly ($p < 0.05$) between the I (before the preparatory period), II (after the first competitive season) and III (after the second competitive season) measurements; D – percent differences in relation to the values recorded before the preparatory period (I) and successive measurements during the first (II) and second (III) competitive seasons

ing external loads amounting to 2.5, 5.0, 7.5, 10.0 and 12.5% of body weight, respectively. There were 2-min breaks between the tests. The standard procedures of exercise performance were followed, and the subjects were verbally encouraged to achieve and maintain as quickly as possible the maximal pedaling velocity. With the use of MCE v. 4.0 the maximal power output at a given load (P_i ; i – load value) and velocity (v_i) necessary to achieve P_i were determined [11].

On the basis of the results obtained the force–velocity and power–velocity relationships as well as individual maximal power output (P_{\max}) and optimal pedaling velocity (v_o) were calculated for each subject [6]. The maximal power output and optimal pedaling velocity were computed from individual equations of the second degree polynomial describing the P – v relationship [5, 11]. The maximum of the curve (largest value of the function) was defined as maximal power (P_{\max}), and the pedaling velocity necessary to achieve it as optimal velocity.

The results were statistically processed using analysis of variance (ANOVA) with repeated measures. The statistical significance of the mean values was analysed using post-hoc Fisher's least significant difference test (LSD). The level of statistical significance was set at $p < 0.05$. All statistical calculations were made with the use of Statistica (v. 8.0, StatSoft) software package.

Results

Table 1 presents the results obtained. The changes of the absolute values of maximal power and the highest

velocity at a given load were statistically non-significant. In terms of relative values a significant increase of the maximal power output at the load of 7.5% of body weight was observed from 11.24 ± 0.96 W \cdot kg⁻¹ before the preparatory period (I) to 11.72 ± 0.84 W \cdot kg⁻¹ after the first competitive season (II) and 11.75 ± 0.51 W \cdot kg⁻¹ after the second competitive season (III). The relative maximal power output increased from 12.80 ± 0.79 W \cdot kg⁻¹ (I) to 13.44 ± 0.62 W \cdot kg⁻¹ (III). Furthermore, a non-significant increase of optimal velocity was noted from 122.2 ± 16.1 rpm (I) to 129.2 ± 14.9 rpm (II), and non-significant decrease after the second competitive season (III) (119.5 ± 18.5 rpm).

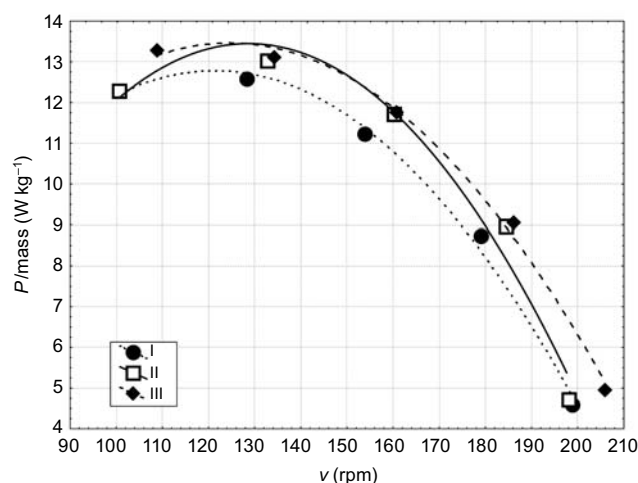


Figure 1. Changes of relative power–velocity curves in volleyball players during competitive season (I – the start of preparatory period, II – after the first competitive season, III – after the second competitive season)

Discussion

Volleyball is commonly classified as an “interval” sport, which uses both anaerobic and aerobic metabolism [3, 4, 12–14]; whereas volleyball players can be categorized as “power athletes” [15]. Thus volleyball training should develop the power of legs and improve players’ strength and/or velocity. The preparatory training period is usually devoted to the training of motor skills; while the competitive period focuses primarily on the improvement of volleyball technique and tactics [10].

A number of studies indicate that strength training consisting of exercises with high external loads and low velocity enhances the final course of the F – v curve (high power, low velocity), unlike the high velocity [8, 9, 16]. Training with low loads and high velocity improves the results in the entire course of the F – v curve [8, 16], or increases the force and power of movements performed with a high velocity [9, 16].

The present study showed that the volleyball training improved the players’ power–velocity relationship at a high force and low velocity between the preparatory period and the first competitive season. After the second competitive season a parallel shift of the power–velocity curve was noted (Fig. 1). During the entire season the values of relative maximal power increased. The changes in the P – v relationship and maximal power output were accompanied by a non-significant increase of the optimal velocity between the I and II measurements and a non-significant decrease after the second competitive season (III). Buško [17] reported a significant training-related increase of the optimal velocity after the first competitive season as compared with the measurement results from before the preparatory period. The present study revealed non-significant changes of the optimal velocity. Considering the fact that volleyball training aimed at the improvement of players’ force also enhances their power and jumping ability [18, 19], the results obtained are satisfactory. It must, however, be kept in mind that a study of female volleyball players by Häkkinen [10] revealed an increase in all measured parameters only until the completion of the first competitive period, after which a decrease was noted.

Conclusions

1. In the annual training cycle under study a statistically significant increase of the power output with the external load of 7.5% of body weight was noted.

2. The relative maximal power output increased significantly after the second competitive season as compared with the measurement before the preparatory period.

3. The optimal velocity changed non-significantly in the entire annual training cycle.

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Address for correspondence

Krzysztof Buśko
Zakład Biomechaniki
Instytut Sportu
ul. Trylogii 2/16
01-982 Warszawa, Poland
e-mail: krzysztof.busko@insp.waw.pl



POWER TRAINING EFFICIENCY AFTER SINGLE JOINT AND MULTIPLE JOINT EXERCISES

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Andrzej Mastalerz^{1,2*}, Grażyna Lutosławska¹, Czesław Urbanik¹

¹ The Józef Piłsudski University of Physical Education, Warsaw, Poland

² Institute of Industrial Design, Warsaw, Poland

ABSTRACT

Purpose. Single joint (open kinetic chain) and multiple joint (closed kinetic chain) exercises have been recommended in rehabilitation of patients with anterior knee pain. Single joint exercises are common exercises to strengthen selected muscle groups. The advantage of single joint exercises is a low risk of pain due to their limited technical complexity. Multiple joint exercises are more demanding from the standpoint of human motor performance. The efficiency of power training after single and multiple joint exercises was the aim of the study. **Basic procedures.** Forty eight men constituted the study sample (aged 22 ± 0.8 years, body weight – 78.3 ± 6.4 kg, body height 183 ± 5.6 cm). They were informed about the experimental procedure as well as the purpose of the study, and gave their consent to take part in the experiment. That study was approved by the local research ethics committee. After control measurements the participants were randomized into four groups ($n = 12$ each): two groups performing multiple joint exercises (A – jumps on an inclined plane, B – vertical jumps), and two single joint exercises (C – knee extensions with linear resistance load – elastic loads, D – knee extensions with inertial loads). The exercises were carried out in four-week exercise sessions, for five days a week. 4 sets of 10 reps (jumps or extensions) with 120-second intervals were applied during each session. The counter movement jump power (on a Kistler force plate with BioWare 4.0 software), during isokinetic knee motion at 240, 180, 60 and 30 deg/s (Biodex Medical System 3 Pro) and EMG (Mega Electronics System) of the Rectus Femoris and Vastus Lateralis muscles were recorded seven times (once before, three times during and three times after training). **Main findings.** The external load for single and multiple joint exercises was adjusted by individual power of motion. However the training volume (external work) was lowered twice during training with single joint exercises. Muscle force during isokinetic tests was significantly correlated with velocity achieved during training. Therefore the homogeneity of the movement structure between training and control exercises is required. **Conclusions.** Velocity of motion during exercise and time of muscle work are the most important factors determining efficiency of single- and multiple-joint exercises.

Key words: power, training, single- and multiple-joint exercises, EMG

Introduction

Muscles can be active both in static and kinetic conditions. In the former, during an isometric contraction, the muscle does not shorten; during a concentric contraction it shortens, and during an eccentric contraction it elongates. Human movement is never confined to muscle work involving only one type of muscular contraction. Very often external conditions affect the muscle length (running, jumping) before the mechanical work takes place. Most training programs are based on exercises in dynamic conditions and involve both concentric (CON) and eccentric (ECC) muscle actions. A great number of studies have shown that a combination of CON and ECC muscle actions yields the best training results [1, 2]. Training exercises can be grouped

into single joint movements or multiple joint movements; principal exercises or auxiliary exercises; and exercises of the whole body or a specific part of it. These oppositions are based on the number and area of engaged muscles. Single joint exercises are used for isolated strengthening of selected muscle groups [3]. Their main advantage is low risk of injuries due to their low technical complexity. Multiple joint exercises are more demanding from the standpoint of movement complexity, and their effectiveness is ensured by the external load of body weight. Prilutsky and Zatsiorsky [4] revealed differences in the action of proximal muscles of the legs, which consisted of absorbing landing energy and supporting distal muscles of the legs during extension. Mastalerz [5] in his EMG study proved that during high intensity exercise two joint muscles regulate the distribution of strength through the joints crossed by them, while a single joint muscle generates strength.

* Corresponding author.

Table 1. Mean (\pm SD) body weight and body height of subjects in four study groups at the start of training

Group	A	B	C	D
Body weight (kg)	80.3 \pm 7.3	78.2 \pm 6.1	80.8 \pm 9	82.7 \pm 8.5
Body height (cm)	181.4 \pm 5.2	180.1 \pm 6.1	178.5 \pm 6.4	178.4 \pm 7.8

Professional literature has lacked comparative studies of training exercises involving different groups of muscles. The aim of the present work was to assess the efficiency of power training involving single joint and multiple joint exercises.

Material and methods

The study sample consisted of 48 third-year students of the Józef Piłsudski University of Physical Education in Warsaw, aged 22–24 years, divided into four groups of 12 subjects each. Table 1 presents subjects' mean body mass and body height. No significant differences in subjects' body weight or body height were noted in regard of their membership in a given group or duration of the experiment ($F(18, 264) = 0.781, p = 0.722$).

Students from groups A and B performed multiple joint exercises, while students from groups 3 and 4 single joint exercises. Subjects from group A trained multiple jumps on an inclined plane, group B – multiple vertical jumps, group C – knee extensions with linear resistance load – elastic loads, and group D – knee extensions with inertial loads. External resistance was used in particular groups, allowing the subjects to develop peak power. During the initial measurements the amount of resistance was determined for each exercise group: extra weight for the exercises on the inclined plane (A), extra weight and adjustable height of the hurdle for multiple vertical jumps (B), the number of expanders for knee extensions with elastic loads (C) and the number of stacked weights for knee extensions with inertial loads (D).

The tests lasted seven weeks. For four weeks the subjects took part in exercises five times a week

(weekdays). Each Monday, before exercises the following measurements were taken: power and height of a vertical counter movement jump (CMJ) on a Kistler force plate; power of knee extensors in isokinetic conditions with the aid of Biodex System 3 Pro dynamometer, and bioelectrical activity of the Rectus Femoris (RF) and Vastus Lateralis (VL) muscles. The EMG was carried out with the aid of the ME 3000 P4 muscle tester (Mega Electronics System, Finland). The Average EMG signal (AEMG) and EMG Mean Power Frequency (MPF) were calculated using RAW spectrum analysis through the Fast Fourier Transform (FFT). The measurements were taken three times on the 32nd, 36th and 42nd days of the experiment. The duration of each measurement and the intervals between them excluded any possible impact of subjects' fatigue on the results obtained.

Mechanical work performed by all the groups was not identical (Tab. 2). The observed differences depended, first of all, on the mobility of the locomotor system and contribution of the muscles engaged. The highest concentric work was performed by subjects from group A. The results from group B were 21% lower, which was related to the greater mobility of the locomotor system during the multiple vertical jumps. The work results in groups C and D were 68% and 71% lower, respectively, which was connected with the limited activity of single joint exercises (Tab. 2). Besides the subjects from these groups did not perform eccentric exercises.

In the statistical analysis of mean results in the groups an analysis of variance (ANOVA) and multivariate analysis of variance (MANOVA) for repeated measures were carried out as well as the Friedman test

Table 2. Components of training loads

	Group A	Group B	Group C	Group D
Number of training units	20	20	20	20
Number of series in a training unit	4	4	4	4
Number of reps	40	40	40	40
Intervals between series (s)	120	120	120	120
Total training work (J)	CON	5780105 \pm 790	4166400 \pm 750	1912417 \pm 680
	ECC	4149822 \pm 524	3541440 \pm 554	1728764 \pm 560
	CON + ECC	9929927 \pm 1314	7707840 \pm 1221	–

CON – work for the concentric phase of muscles work, ECC – work for the eccentric phase of muscles work, CON + ECC – work for the total muscle activity

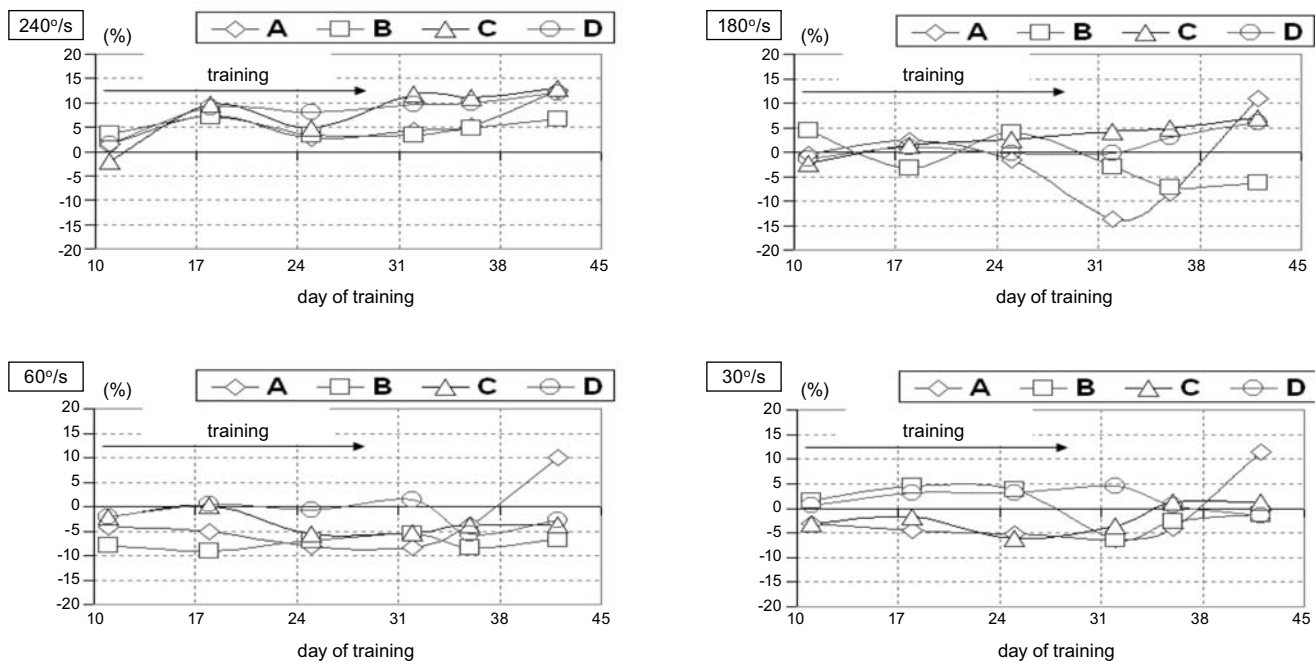


Figure 1. Development of power (%) on selected days of the experiment under isokinetic conditions at 240 deg/s, 180 deg/s, 60 deg/s and 30 deg/s

and the Wilcoxon signed rank test for EMG results, which were not normally distributed.

Results

An increase in power developed by the knee extensors in isokinetic conditions was observed during exercises with only one velocity of movement (Fig. 1).

During exercises with the velocity of 240°/s, an increment in power was noted from the third week. Statistically significant increases in power were noted in group C already in the first week after the completion of training ($p = 0.0246$). After the training the power results in groups C and D were 13% higher than at the beginning of the experiment ($p < 0.001$).

The lowest increase was noted in group B (7%), which was nevertheless statistically significant ($p = 0.0488$). During the exercise as well as a week after the training, results in particular groups point to some similarities in power increase, in terms of the structures of control

movement and exercise movement. This is particularly visible in groups performing single joint exercises (C and D).

The effects of training with different exercises were also assessed with measurements of power during counter movement jumps (CMJ) (Tab. 3). At the beginning the measurements did not differ significantly. The highest increase was noted in group B (16.3% on the 42nd day of training). In group A the peak increase of power was observed on the 36th day (15.6%), however by the end of training it decreased by about 7.6%.

The impact of training with loads allowing development of peak power on the coordination mechanisms of muscle contraction was assessed with two EMG indices for the concentric movement phase: the Average EMG (AEMG) and EMG Mean Power Frequency (MPF)

Figure 2 presents the mean increases of EMG MPF for the Rectus Femoris muscle (RF) and Vastus Lateralis muscle (VL). The EMG MPF changes for the RF muscle were statistically non significant. In the case of the VL

Table 3. Mean peak power (\pm SD) during counter movement jumps on individual days of training

Group	Day of training						
	1 st	11 th	18 th	25 th	32 nd	36 th	42 nd
A	2520 \pm 452	2660 \pm 382	2705 \pm 453 ^a	2734 \pm 510 ^b	2815 \pm 490 ^c	2914 \pm 497 ^d	2710 \pm 395 ^e
B	2735 \pm 450	2969 \pm 460 ^f	3018 \pm 510 ^g	2872 \pm 501	3033 \pm 523 ^h	3028 \pm 512 ⁱ	3182 \pm 504 ^j
C	3039 \pm 539	3054 \pm 513	3045 \pm 546	3057 \pm 481	3037 \pm 475	3109 \pm 459	3008 \pm 557
D	2823 \pm 436	2775 \pm 475	2849 \pm 532	2698 \pm 531	2886 \pm 541	2737 \pm 407	2761 \pm 419

^a $p = 0.0295$, ^b $p = 0.0146$, ^c $p = 0.0007$, ^d $p = 0.0001$, ^e $p = 0.0290$, ^f $p = 0.0001$, ^g $p = 0.0001$, ^h $p = 0.0001$, ⁱ $p = 0.0047$, ^j $p = 0.0076$

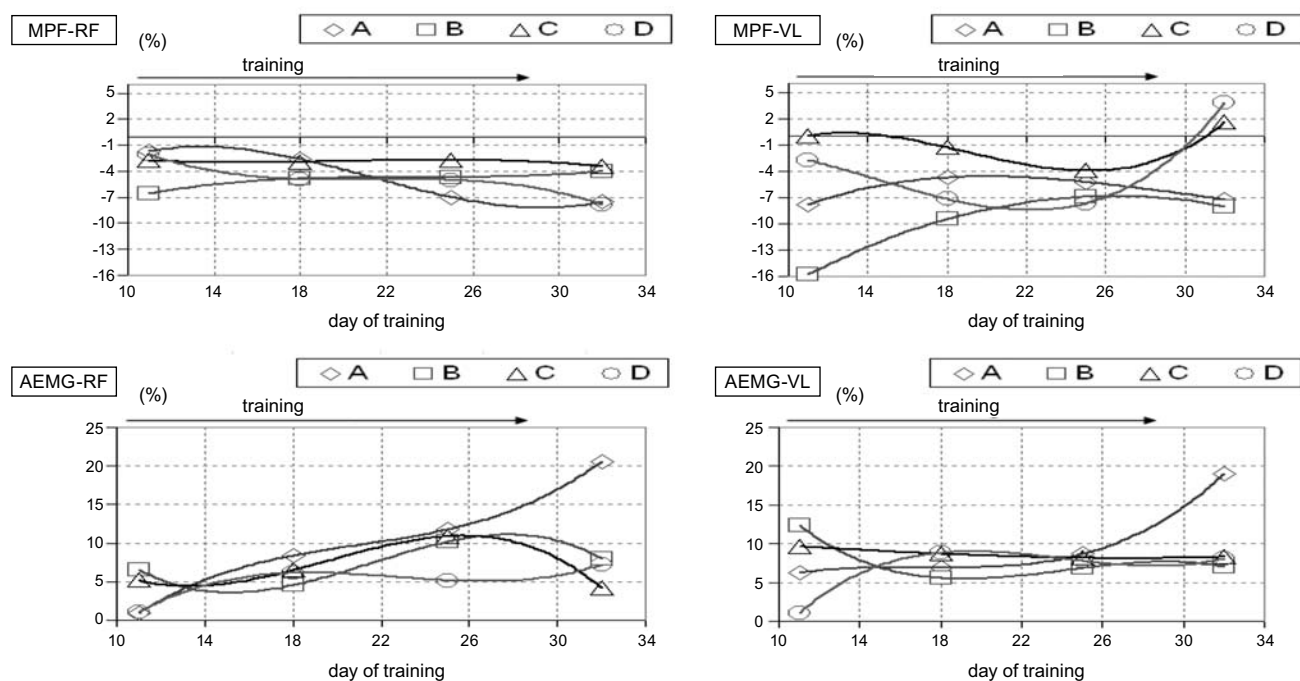


Figure 2. Mean increments of the EMG power frequency (MPF) and average amplitude of the EMG (AEMG) for the Rectus Femoris (RF) and Vastus Lateralis muscles (VL)

muscle the MPF increases noted can be divided into two exercise categories: multi joint exercises (A and B) and single joint exercises (C and D). In the early part of the training the MPF decreased significantly in groups A and B ($p < 0.05$). In group B the observed decrease was by 15%. This effect was not present in the first week of training in groups C and D, but after that the MPF also decreased reaching the lowest value on the last day of training. After the exercises the MPF was slightly higher than at the start of the training in groups C and D (1.6% and 3.8%, respectively). The MPF in groups A and B was lower on the 32nd day of training than at the start (7.5%). No MPF changes were statistically significant.

After the first week of training the AEMG increments were highly differentiated in the case of Vastus Lateralis muscle (VL) (Fig. 2).

The highest statistically significant increase was noted in group B (12%). The observed significant AEMG differences between the groups were related to the bioelectrical muscle activity in group A. The AEMG of the Rectus Femoris muscle (RF) and Vastus Lateralis muscle (VL) in the 32nd week of training in group A was significantly higher than in the other groups ($p = 0.002$ for AEMG-RF and $p = 0.003$ for AEMG-VL). Statistically significant AEMG changes were found for the RF in group A ($p = 0.00048$) and B ($p = 0.0158$), and in the case of VL only in group A ($p = 0.0069$).

Discussion

The statistically significant differences resulting from the mobility of the open kinetic chain are only noted in the values of power developed during counter movement jumps (CMJ) (Tab. 3). The highest peak power was developed by subjects from groups A and B, who performed multi joint exercises. The large difference in power results between groups A and B and groups C and D was related to the similarities between the mobility of training exercises with the ways the counter movement jumps are performed. The differences in results of power developed during an isolated knee movement in isokinetic conditions depended on the velocity of knee exercises. Mastalerz [5] showed in an earlier study with the use of the same exercises that the peak values of knee extension velocity on an inclined plate were two times higher than in other types of exercises. Although the subjects from group B failed to achieve the highest increase of mean power during knee extension, their velocity results of knee exercises confirm the impact discussed above.

Another factor determining the development of power in isokinetic conditions was the duration of the concentric phase of exercises as demonstrated by the EMG. To recruit effectively fast twitch fibers (Type II) an appropriately high level of stimulation frequency is necessary [6]. A short concentric phase of exercise in

group A could have prevented such nervous stimulation of the fast twitch muscle fibres. This effect may explain the decrease in EMG MPF during training also in the other groups of subjects. It can be also noted that the results varied, depending on the muscle (Vastus Lateralis or Rectus Femoris), which confirms results of earlier studies pointing to the functional differences of both muscles [4, 5]. Also Mastalerz and Urbanik [7] in their study of drop jumps considered the duration of contact with the floor during the swing and take-off phases (as well as a part of the shock absorption phase in drop jumps) to be the main factor affecting the exercise results. The key role in stretch-contraction muscle exercise is played by trained mechanisms associated with the reactivity of the system of locomotion to external stimuli. These mechanisms are skills of reducing the time of the shock absorption phase. A skill that would increase simulation frequency is contracting muscles before the landing phase. Such a mechanism was described by Komi and Gollhofer [8] in their examination of the triceps calf muscle, lateral vastus muscle and – in particular – soleus muscle whose activity preceded the phase of take off during a drop jump for 40 ms. Similar results were obtained by Voigt et al. [9] for multiple jumps with a short time of contact with the floor.

Conclusions

The test results achieved after training were affected by two characteristics of movement structure: velocity of movement and time of muscle work. After exercises on an inclined plane a significant increase in power was observed during knee extensions in isokinetic conditions. This was due to the subjects' development of the highest movement velocity at the knee joint during training. The other important factor affecting the power developed in isokinetic conditions is the time of the concentric phase of exercise as shown by the EMG. In the group of subjects performing multiple jumps, this time as well as insufficient recruitment of fast twitch fibres explain the decrease in EMG MPF for the Vastus Lateralis muscle. The MPF for the Rectus Femoris muscle was 50% lower, especially during training. This can be explained by the muscle's function as a stabilizer and controller of the movement. The significant differences resulting from the mobility of the locomotor system, determined by the number of joints involved in training,

were noted between the results of power reached during the counter movement jumps. In both groups performing single joint exercises only, the maximum increase of power amounted to 2.5%, whereas in groups with similar mobility performing control exercises it was higher than 15%.

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Address for correspondence

Andrzej Mastalerz
Zakład Biomechaniki
Akademia Wychowania Fizycznego Józefa Piłsudskiego
ul. Marymoncka 34
00-968 Warszawa 45 skr. poczt. 55, Poland
e-mail: andrzejmastalerz@poczta.onet.pl



EVALUATION OF TORQUE OF THE SHANK ROTATING MUSCLES AND THE RANGE OF ACTIVE INTERNAL AND EXTERNAL ROTATION OF THE KNEE JOINT IN PATIENTS AWAITING ACL RECONSTRUCTION

DOI: 10.2478/v10038-009-0017-z

Marcin Popieluch^{1*}, Jacek Zieliński¹, Marek Jędrzyk²

¹ Chair of Anatomy and Biomechanics, The Józef Piłsudski University of Physical Education, Warsaw, Poland

² Endoscopic Surgery Clinic, Żory, Poland

ABSTRACT

Purpose. The aim of the study was threefold: to determine the active rotation range of a healthy and post-traumatic knee joint; to evaluate the torque of muscles responsible for internal and external rotation of a healthy and post-traumatic knee joint; and to determine differences between a healthy knee joint and knee joint with the ruptured anterior cruciate ligament (ACL). Differences between active axial rotation and muscular strength of rotators in the healthy and post-traumatic knee joints of 40 hospitalized patients were examined. **Basic procedures.** The static torque evaluation of the shank rotating muscles included 40 patients of the Endoscopic Surgery Clinic in Żory, with the ruptured ACL of the right knee, qualified for surgery (ACL reconstruction). On the basis of a medical interview, the ACL ruptures were found to have occurred during football games. **Main findings.** ACL damage leads to an increased rotation range, with a subsequent decrease of the rotators' strength and increased joint instability. The patients examined showed a substantial level of thigh quadriceps atrophy – a typical symptom associated with an ACL rupture. Our findings indicate that the internal and external rotators in intact knees were stronger than the rotators in post-traumatic knees ($p < 0.05$). **Conclusions.** The analysis of the torque of the shank rotating muscles at two knee joint flexion angles was an attempt to proceed with a laboratory diagnosis of the condition of the motor system in 40 patients following severe trauma (such as the ACL rupture of the right knee) prior to surgical intervention, and, in a longer perspective, after treatment completion. The results obtained will supposedly be useful as indicators for future rehabilitation pathways, and of the condition of the motor system following treatment completion.

Key words: knee, rotator, axial, anterior cruciate ligament

Introduction

The knee joint is the largest joint of the human body. During an improper movement it is affected by considerable forces [1] which can often exert a destructive influence on the knee internal structure [2]. In the domain of professional sports, ruptured knee ligaments occur quite frequently [3], especially the anterior cruciate ligament (ACL) of the knee under extensive “overload” [4, 5]. In consequence, a ruptured ACL of the knee requires a surgical and orthopedic intervention [6].

During flexion and extension the knee joint lacks a stable axis of movement in the sagittal plane. The axis changes its position during an improper motion, e.g. frequent changes of running directions in football. The cruciate ligaments during such movements limit the range of knee flexion and extension, stabilize the knee joint in the sagittal plane as well as reduce the internal rotation of the shank [7]. A sudden change in the run-

ning direction or hitting an opponent with an extended leg may lead to a rupture of the ACL [8], loss of the knee joint stability in the coronal plane and increasing internal rotation of the shank [9].

The present paper is a biomechanical study of the torque of muscles responsible for internal and external rotation of the shank [10]. The applied method allows determination of muscle efficiency before and after rupture of the knee cruciate ligaments [11]. The analysis of muscle force, in particular knee joint movements (flexion, extension, internal rotation, external rotation) can be used for effective prevention of knee injuries, and it also provides valuable information about the post-operative leg condition.

Numerous research studies based on measurements of knee joint torques have mainly focused on torques of knee flexors and extensors. There have been very few studies concerning the torques of knee rotators.

The present study has a threefold aim:

- to determine the ranges of active rotation of a healthy and post-traumatic knee joint;

* Corresponding author.

- to compare the torques of muscles responsible for internal and external rotation of a healthy and post-traumatic knee joint (patients and control group);
- to analyze differences in anthropometric parameters of the lower extremities in patients under study (differences in the circumference of the right and the left thigh at rest).

Material and methods

The study sample consisted of 40 patients from the Endoscopic Surgery Clinic in Żory, Poland. The clinical diagnosis revealed an ACL rupture of the right knee in all the patients owing to a football injury. All patients were awaiting surgery, i.e. reconstruction of the anterior cruciate ligament.

Table 1. Profile of patients' age, body height and body weight

	Age (years)	Body height (cm)	Body weight (kg)
\bar{x}	27.36	177.86	79.25
SD	8.11	4.72	12.26

The control group consisted of 100 healthy, non-training first-year full time students from the University School of Physical Education. Their level of physical fitness was higher than average, which is typical of physical education students.

Table 2. Profile of control group students' age, body height and body weight

	Age (years)	Body height (cm)	Body weight (kg)
\bar{x}	21.33	175.8	72.5
SD	6.1	3.2	8.4

Active rotation was defined as maximal "rotation" of the shank with the use of subject's muscle strength (Fig. 1).

The peak torque of the shank pronation and supination was measured in static conditions using a specially designed testing station (Fig. 2) connected to a PC with the CPS/HMF software package allowing registration of torque development in the shank rotating muscles.

The torque measurements of shank rotating muscles were carried out at the flexion angles of 30° and 90°, respectively (Fig. 3).

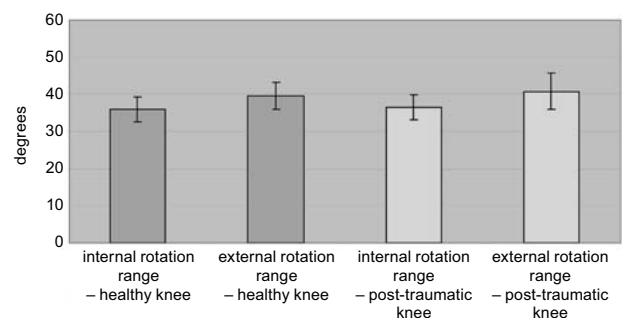


Figure 1. Ranges of active internal and external rotation of a healthy and post-traumatic knee joint

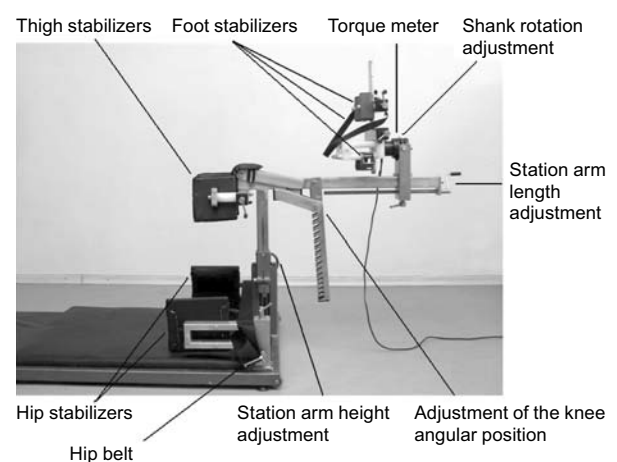


Figure 2. Testing station for measurements of torque of knee rotating muscles

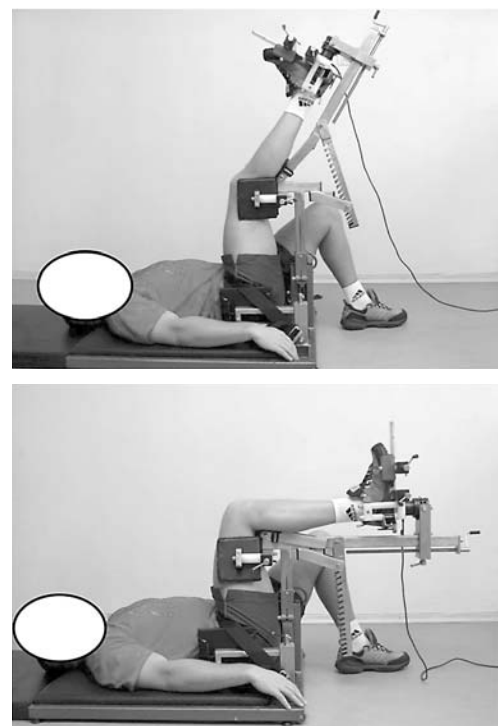


Figure 3. Knee flexion angles: 30° and 90°

For each subject under study the following adjustments were made:

- hip, thigh and foot stabilizers;
- height of the station rotational axis corresponding to the knee axis of rotation;
- length of the station arm corresponding to the length of shank and thigh;
- knee flexion angle;
- shank rotation angle.

During the measurement of torques of shank rotators the following angles were considered:

1. 0° – vertical foot position – the shank rotates inside (pronates), rests and rotates outside (supinates) (shank position: $p0^\circ$, $s0^\circ$);



Figure 4. Shank position $p0^\circ$, $s0^\circ$

2. 40° – turned foot position – the shank rotates inside (pronates) (shank position: $p40^\circ$);



Figure 5. Shank position $p40^\circ$

3. 30° – turned foot position – the shank rotates outside (supinates) (shank position: $s30^\circ$);



Figure 6. Shank position $s30^\circ$

Results

Table 3 presents the results of measurements of torques of rotating muscles in healthy and post-traumatic knee joints in the group of patients and the control group. In the statistical analysis of these results the arithmetic means and standard deviations were calculated (Tab. 3, Fig. 7). In order to compare the measurements at different shank angular positions (for pronation and supination) analysis of variance (ANOVA) was used. The level of statistical significance of differences between respective measurements was estimated with Duncan's test ($p < 0.05$).

Discussion

The results obtained reveal an increase in the range of active internal and external rotation in the post-traumatic knee joint (Fig. 1). This makes the force of pronating and supinating muscles decrease, which is a typical symptom associated with this knee joint injuries. The obtained shank torque values point to statis-

Table 3. Mean torque values (Nm) of shank rotators in the group of patients and the control group

		Right leg (post-traumatic)				Left leg (healthy)			
Angular position of shank rotation		$p0^\circ$	$s0^\circ$	$p40^\circ$	$s30^\circ$	$p0^\circ$	$s0^\circ$	$p40^\circ$	$s30^\circ$
Patients									
Knee flexion angle 90°	\bar{x}	33.6	31.4	45.4	39.1	41.8	33.8	55.5	44
	SD	9.5	6.8	11.1	8.2	10.6	6.3	11.0	8.7
Knee flexion angle 30°	\bar{x}	29.9	25.1	42.3	32.4	38.1	26.9	49.1	36.7
	SD	7.2	5.5	9.9	8.0	7.9	5.6	8.7	8.4
Angular position of shank rotation		$p0^\circ$	$s0^\circ$	$p40^\circ$	$s30^\circ$	$p0^\circ$	$s0^\circ$	$p40^\circ$	$s30^\circ$
Control group									
Knee flexion angle 90°	\bar{x}	67.6	71.2	77.8	69.1	61.6	63.3	65.7	64.0
	SD	7.5	8.8	9.1	9.2	6.8	8.7	9.6	6.9
Knee flexion angle 30°	\bar{x}	69.9	66.1	74.3	62.6	58.1	66.9	69.1	66.3
	SD	8.2	8.5	7.9	8.0	6.6	7.4	6.7	7.2

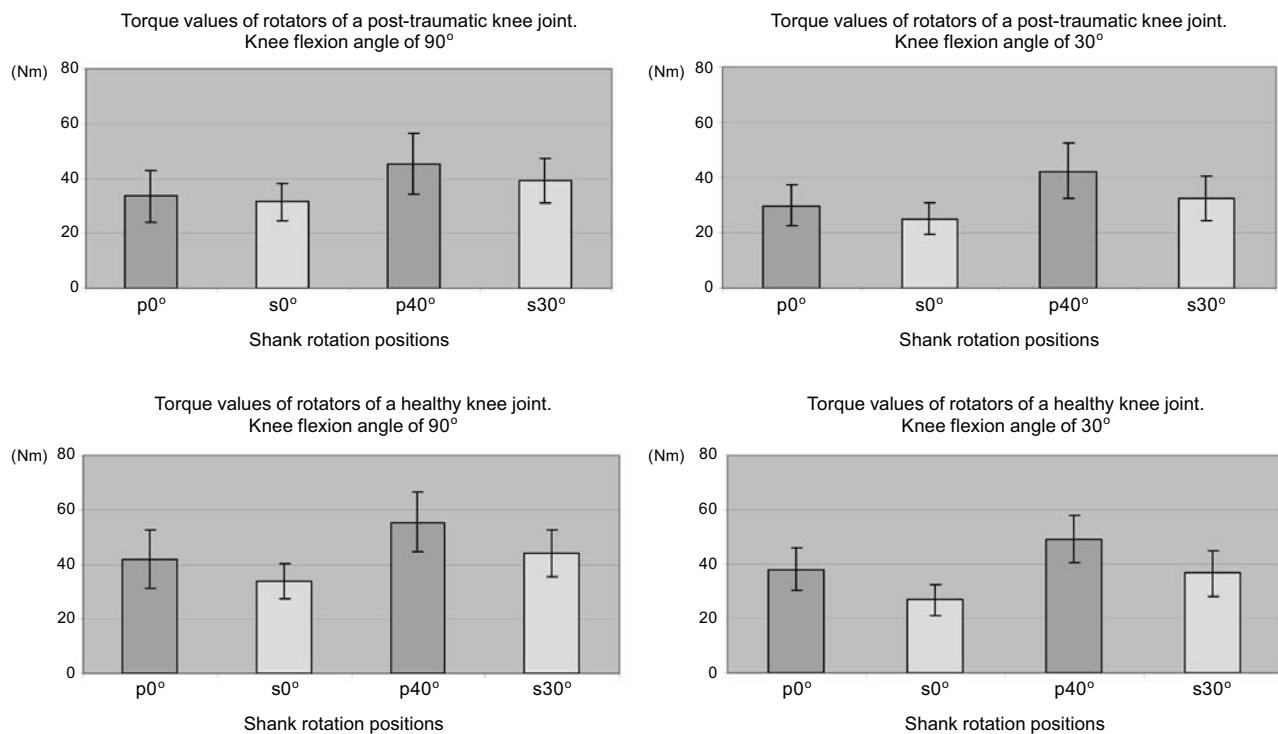


Figure 7. Torque values of rotating muscles in the patients' healthy (left) and post-traumatic (right) knee joints

tically significant differences between the post-traumatic leg (right) and healthy leg (left) ($p < 0.05$). The rotating muscles in the knee joint with the ruptured ACL developed significantly lower torque values than muscles in the knee joint with the healthy ligament (about 30%).

Figure 7 presents the torque values of shank rotators in the group of patients. The subjects achieved significantly higher torques at the knee flexion angle of 90° amounting to about 40–50 Nm. In the control group these values were significantly higher amounting to over 70 Nm (in some cases the torque value difference between the patients and the control group was even 50%) (Tab. 3). The measurement of the circumference of the right and left thigh in the patients revealed a decreasing tendency in the circumference of the post-traumatic thigh, which is indicative of thigh quadriceps atrophy. This is due to patients' "subconscious saving" of the post-traumatic leg before surgery.

The results obtained are difficult to compare with results of other studies, as similar tests are usually carried out in isokinetic conditions. It is also difficult to compare the knee muscle torque values obtained in static conditions with isokinetic results. However, the question of rotating movements attracts considerable

research interest, and future studies of the strength capacities of rotating muscles (involving earlier determination of biomechanical capacities of knee flexors and extensors) will definitely contribute to a comprehensive assessment of the function of the whole knee joint.

Conclusions

1. The present research is an attempt to evaluate the efficiency of the lower extremity (on the example of knee joint) following a severe trauma and before surgery and – in a longer perspective – after treatment completion. The obtained results can be used as important additional information in therapy documentation and for rehabilitation purposes.

2. A rupture of the anterior cruciate ligament leads to a disruption of knee movements and instability of the knee joint (anterior dislocation of the tibia).

3. An ACL rupture increases the range of shank rotation, reduces the strength of the pronators and supinators, and increases the knee joint instability.

4. Significant thigh quadriceps atrophy was observed in patients under study, which is a typical symptom associated with the ACL rupture.

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Address for correspondence

Marcin Popieluch
Zakład Anatomii
Akademia Wychowania Fizycznego Józefa Piłsudskiego
ul. Marymoncka 34
00-968 Warszawa, Poland
e-mail: marcin.popieluch@awf.edu.pl



CHANGES IN MOOD STATES AND SELECTED PERSONALITY TRAITS IN WOMEN PARTICIPATING IN A 12-WEEK EXERCISE PROGRAM

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Monika Guskowska^{1*}, Sylwia Sionek²

¹ Department of Psychology, The Józef Piłsudski University of Physical Education, Warsaw, Poland

² Ph.D. student, The Józef Piłsudski University of Physical Education, Warsaw, Poland

ABSTRACT

Purpose. The aim of the study was: (1) to investigate changes in mood and chosen personality traits in women participating in a 12-week exercise program; (2) to establish relationships between mood and personality traits; (3) to find personality factors predicting mood changes. **Basic procedures.** Subjects included 39 healthy female volunteers, aged 18–43, participating in a 12-week aerobic exercise program. The aerobics classes lasted 50 min each, including warm-up and cool-down, three times a week. Assessments of mood (UMACL by Matthews, Chamberlain & Jones), trait anxiety (STAI by Spielberger et al.), self-efficacy (GSES by Schwarzer, Jerusalem & Juczyński) and dispositional optimism (LOT-R by Scheier, Carver & Bridges) were obtained in the first and last weeks of the program. **Main findings.** The obtained results showed that (1) subjects' mood improved following the 12-week aerobic exercise program – tense arousal decreased, whereas hedonic tone and energetic arousal increased; (2) personality traits changed toward better personal adjustment: trait anxiety decreased, self-efficacy and optimism increased; (3) there were no significant relationships between changes in positive mood dimensions (hedonic tone and energetic arousal) and the negative one (tense arousal); (4) there were no correlations between mood changes and personality changes, but mood correlated with trait anxiety, self-efficacy and optimism in both measurements. **Conclusions.** Mood of healthy adult women improves significantly following a three-month aerobic exercise program, irrespective of positive changes in personality traits.

Key words: exercise, mood, personality, chronic effect, women

Introduction

Results of experimental and correlative studies point to relationships between physical recreational activity and mood. Psychological benefits, especially emotional ones, such as reduction of anxiety or depressiveness can be observed even after one-time physical exercise. This is illustrated by results of studies on the so-called acute effects of exercise. Researchers have also been interested in chronic exercise effects, i.e. long-term outcomes after weeks or months of regular exercise. Chronic effects are mostly sought in mood states, i.e. affective states maintained for a moderately long time (hours or days) and states unrelated to any triggering stimuli.

A number of experimental studies have revealed that the mood state of participants in programs of systematic physical exercises for some weeks improves considerably. Mood improvement was noticed after aerobic exer-

cises in healthy subjects [1–3] or clinical subjects. A survey conducted by McDonald and Hodgdon [4] showed the biggest improvement in terms of vigor, confusion and tension. Not all studies, however, confirm the improvement in the mood state of regularly exercising individuals. Cramer, Nieman and Lee [5] did not observe any mood changes in women participating in a 15-week program of aerobic exercises of moderate intensity, during the sixth and the last week. The emotional state of women participating in an aqua-aerobics program did not change significantly after the 6th, 12th, 18th and 24th week of exercise; however, it greatly improved in comparison with the control group consisting of physically passive women [6].

Experimental studies allow establishing cause and effect relationships and controlling mediating and disturbing variables. They also reveal the efficiency of physical exercises of various character, intensity, duration and techniques aimed at improvement of psychological well-being such as relaxation or cognitive responses. Some researchers are ready to focus more on

* Corresponding author.

external rather than internal accuracy of their studies and stress the significance of research in natural conditions. Their results confirm improvement of mood in individuals exercising regularly on their own [7] or participating in exercise groups [8], and give proof of the beneficial influence of physical exercise on diurnal variations in mood states in women [9]. In our earlier study carried out during a two-week recreation camp for exercising elderly women, a significant reduction of tension and confusion, and increase in vigor and friendliness was observed; however, these changes disappeared after completion of exercises [10]. An improvement in mood after a month of regular exercising was also noted in two groups of women practicing aerobics once and three times a week, respectively. In the former, positive emotional states improved (vigor, friendliness); in the latter, a decrease in the level of negative states (anger, confusion, tension, fatigue, depression) and an increase in vigor were observed [11].

Correlative studies focusing on relationships between physical activity and psychological well-being [12] or mental health [13] have also yielded interesting results. In a Finnish population study [14] it was noted that more physically active individuals experienced a much lower level of stress, displayed fewer symptoms of depressiveness, anger and hostility. College students who were physically active were less stressed and in a better mood [15]. Also active women during the menopause were in a better emotional state than their physically passive counterparts [16]. Physical activity is an important predictor of negative mood states in high school students: those more physically active featured a higher level vigor correlated with the amount of time devoted to physical exercises [17].

One of the most common diagnostic tools used in studies of the effects of physical activity on mood states is the Profile of Mood States (POMS) developed by McNair, Lorr and Droppleman to assess psychotherapeutic progress. The POMS was used in the study by Morgan [18], who noted that the profile of athletes' mood as compared with population norms and physically passive subjects resembled an "iceberg": athletes featured a higher level of vigor and lower than average level of negative mood states (anger, confusion, depression, fatigue and tension). The POMS allows monitoring acute and chronic exercise-induced changes. Unfortunately, the POMS authors failed to define the examined emotional states and the concept of mood itself. Thus the accuracy of the POMS scale can be question-

able. The Polish adaptation of the POMS [19] is an experimental version of the test rather than a satisfactory psychometric tool. It has been used in various studies for two reasons: first, it allows a comparison of the obtained results with results of other research studies in the area of sport psychology and physical activity; second, there had been no other versatile diagnostic tool for mood assessment. The latter problem was solved by Goryńska's Polish adaptation of the UWIST Mood Adjective Checklist (UMACL) developed by Matthews, Chamberlain and Jones [20]. The UMACL is based on a tri-dimensional model of mood involving three correlated bipolar factors: hedonic tone, tense arousal and energetic arousal. The last two dimensions were also considered in Thayer's model [21] which is sometimes referred to by researchers in their explanations of improvement of psychological well-being after exercise [22].

Comparative studies often reveal significant personality differences between physically active and sedentary subjects. Individuals who are highly and moderately physically active show a significantly higher level of optimism and physical self-efficacy as well as lower inclination towards anxiety than subjects who are passive or little physically active [23]. Correlative research can also reveal reverse relationships. More optimistic individuals may undertake physical activity more often because they engage more willingly in pro-health behaviors. A strong sense of physical self-efficacy leads to undertaking exercises more eagerly because we are convinced we can execute the exercises effectively.

Experimental studies point to insignificant personality changes or their absence in subjects who exercise regularly [24]. The changes examined in different studies concerned the emotional sphere. A review of studies on the impact of physical activity on emotional responses shows significant, however, weak anxiety-reducing chronic effects of regular exercise [25, 4]. The effects were more pronounced in the case of exercise programs longer than 10 weeks.

The aim of the present study was to determine changes in mood and chosen personality traits in women taking part in a three-month exercise program. The study also aimed at finding correlations between dimensions of mood and personality traits and personality predictors of mood changes. It also examined the applicability of the UWIST Mood Adjective Checklist (UMACL) in research of subjects undertaking physical activity.

Material and methods

The study was quasi-experimental. The sample consisted of 39 women aged 18–43 years ($M = 27.49$; $SD = 5.642$), who volunteered to take part in a three-month program of aerobics training. The exercise sessions were 50 min each and took place twice a week. Initially, the sample included 50 subjects; however, 11 resigned from the program before its completion. The results of subjects who participated in at least 75% of the training program were analyzed.

The following psychological tests were applied in the study:

1. UWIST Mood Adjective Checklist (UMACL) (Polish adaptation by Goryńska) [20];
2. General Self-Efficacy Scale (GSES) by Schwarzer, Jerusalem and Juczyński [26];
3. Life Orientation Test – Revisited (LOT-R) by Scheier, Carver and Bridges (Polish adaptation by Juczyński) [26];
4. State Trait Anxiety Inventory (STAI) by Spielberger et al. [27].

The first measurement of variables (pretest) took place in the first week of the exercise program, the second measurement (posttest) in the last week, after three months of regular exercises.

Results

Table 1 presents the pretest and posttest results for all the psychological variables under study. A comparative analysis of these results points to significant changes after three months of systematic aerobic training. The level of tense arousal was significantly reduced after three months of exercises. Tense arousal is a continuum ranging from calmness to anxiety. A reduction of tense arousal can be regarded as a positive change indicative of improvement of psychological well-being of women participating in the exercise program. The effect size

was calculated following the formula: $ES = (M_{\text{pretest}} - M_{\text{posttest}}) / SD_{\text{pretest}}$. The effect size below 0.39 was considered low, between 0.40–0.69 moderate, and over 0.70 high. In the case of tense arousal the ES amounted to 0.59 indicating a moderate reduction in tense arousal.

A statistically significant and high increase of energetic arousal ($ES = -1.14$) was observed. Energetic arousal is a continuum ranging from tiredness to energy and its high level is indicative of a high level of vigor. There was also a higher level of hedonic tone ($ES = -0.85$), i.e. measurement of subjective pleasantness (unpleasantness). All these changes are evident of improvement of mood of women taking part in the program.

The personality traits studied were also affected by the exercises, for example, the level of self-efficacy ($ES = -1.04$), i.e. one's conviction about one's capacities to act pursuing a specific goal, regardless of any obstacles. The observed increase in self-efficacy suggests that the women improved their sense of control of their own behavior and environment as well as conviction about their problem-solving skills.

The obtained results also reveal an increase in the level of optimism ($ES = -0.96$), understood as a personality trait expressing general expectations of positive occurrences combined with a tendency to experience positive feelings and life satisfaction. Optimism affects one's coping with stress and is associated with perseverance to act, readiness to face the reality of the situation, seeking social support and emphasizing positive aspects of stressful situations. The achieved results point to a significant but moderate ($ES = 0.47$) decline in readiness of the women under study to react with anxiety (trait anxiety).

All changes in subjects' personality observed during the three-month exercise program can be considered positive from the standpoint of psychological adaptation.

The increase in hedonic tone and energetic arousal were estimated by subtracting the pretest results from

Table 1. Changes of mood and personality traits during a three-month exercise program

Variable	Measurement	Pretest		Posttest		Student's t-test	
		M	SD	M	SD	<i>t</i>	<i>p</i>
Tense arousal		18.08	4.157	15.64	3.937	7.470	0.0001
Energetic arousal		30.10	3.409	34.00	4.431	8.757	0.0001
Hedonic tone		30.33	4.573	34.23	5.584	6.660	0.0001
Trait anxiety		40.05	7.086	36.67	6.470	6.691	0.0001
Self-efficacy		28.69	3.388	32.21	3.833	13.967	0.0001
Optimism		15.64	2.879	18.41	3.118	15.563	0.0001

Table 2. Results of stepwise regression analysis for mood changes

Dependent variable	Predictor	β	t	p	R^2	$F; p$
Increase in hedonic tone	Increase in energetic arousal	0.613	4.718	0.0001	0.359	22.258; 0.0001
Increase in energetic arousal	Increase in hedonic tone	0.613	4.718	0.0001	0.359	22.258; 0.0001

Table 3. Results of stepwise regression analysis for mood in the pretest

Dependent variable	Predictor	β	t	p	R^2	$F; p$
Tense arousal	Hedonic tone	-0.457	2.965	0.005	0.635	33.991; 0.0001
	Energetic arousal	-0.403	2.614	0.013		
Hedonic tone	Energy level	0.351	2.604	0.013	0.719	33.426; 0.0001
	Tense arousal	-0.452	3.445	0.002		
	Optimism	0.272	3.018	0.005		
Energetic arousal	Hedonic tone	0.467	3.079	0.004	0.640	34.789; 0.0001
	Tense arousal	-0.396	2.614	0.013		

Table 4. Results of stepwise regression analysis for mood in the posttest

Dependent variable	Predictor	β	t	p	R^2	$F; p$
Tense arousal	Energetic arousal	-0.454	3.383	0.002	0.455	16.857; 0.0001
	Self-efficacy	-0.360	2.678	0.011		
Hedonic tone	Energy level	0.748	8.000	0.0001	0.747	57.129; 0.0001
	Trait anxiety	-0.213	2.279	0.029		
Energetic arousal	Hedonic tone	0.852	9.897	0.0001	0.718	97.954; 0.0001

the posttest results. Additionally, an index of reduction of tense arousal was calculated (pretest – posttest). Analogically, the values of decline of trait anxiety and increase of optimism and self-efficacy were assessed. It was noted that the increase in energetic arousal is associated with the increase in hedonic tone ($r = 0.613$; $p < 0.001$), but not with the decrease in tense arousal ($r = -0.020$; $p = 0.905$). No significant correlations were found between the changes of tense arousal and hedonic tone ($r = -0.057$; $p = 0.728$). Only the increase in hedonic tone was correlated with the decrease in trait anxiety ($r = 0.386$; $p = 0.015$): the higher the level of trait anxiety, the higher the increase of the sense of pleasantness. The remaining indices of changes of personality traits do not reveal significant correlations with the indices of mood change.

The study also focused on predictors of mood changes among the personality traits examined. For this purpose a stepwise analysis of regression was carried out, with indices of changes of particular mood dimensions as dependent variables, and indices of changes of

other mood dimensions, changes of personality traits and age as factors (Tab. 2). An increase in hedonic tone can be predicted by an increase in energetic arousal and vice versa. No predictors of decline of tense arousal were found. No indices of changes of personality traits can be regarded as predictors of mood changes.

Correlations were also established between indices of mood and personality during the first measurement at the beginning of the exercise program (pretest). In line with expectations related to the tri-dimensional model of mood, negative correlations between tense arousal and energetic arousal ($r = -0.754$; $p < 0.0001$) and hedonic tone ($r = -0.767$; $p < 0.0001$) were noted. The last two dimensions were positively correlated ($r = 0.771$; $p < 0.0001$). The strength of these correlations was similar. Trait anxiety is positively correlated with tense arousal ($r = 0.546$; $p < 0.0001$), and negatively correlated with hedonic tone ($r = -0.623$; $p < 0.0001$) and energetic arousal ($r = -0.517$; $p < 0.0001$). The strong sense of self-efficacy is related to high hedonic tone ($r = 0.392$; $p = 0.014$) and low tense arousal ($r = -0.348$; $p = 0.030$).

Optimism is only correlated with hedonic tone ($r = 0.457$; $p = 0.003$).

In the analysis of the pretest results (Tab. 3) the predictors of mood dimensions are the remaining mood variables. Only the level of hedonic tone can be predicted through optimism. The analysis included results of the first measurement of mood states, personality traits and age.

The posttest results revealed a negative correlation between tense arousal and energetic arousal ($r = -0.617$; $p < 0.0001$) and hedonic tone ($r = -0.573$; $p < 0.0001$). Energetic arousal and hedonic tone are strongly positively correlated ($r = 0.852$; $p < 0.0001$). Similarly to the results of the first measurement, trait anxiety was correlated with all mood dimensions: positively with tense arousal ($r = 0.546$; $p < 0.0001$); and negatively with hedonic tone ($r = -0.578$; $p < 0.0001$) and energetic arousal ($r = -0.488$; $p = 0.002$). The correlations between mood dimensions and self-efficacy were strong. Self-efficacy was positively correlated with energetic arousal ($r = 0.452$; $p = 0.004$) and hedonic tone ($r = 0.363$; $p = 0.023$); and negatively correlated with tense arousal ($r = -0.565$; $p < 0.0001$). Optimism shows positive correlations with hedonic tone ($r = 0.529$; $p = 0.001$) and energetic arousal ($r = 0.434$; $p = 0.006$), and a negative correlation with tense arousal ($r = -0.301$; $p = 0.063$).

Mood predictors were also determined during the posttest, i.e. after three months of regular exercise. The analysis included results of the second measurement of individual variables and age (Tab. 4). Negative predictors of tense arousal in the posttest were energetic arousal and self-efficacy. Strong tense arousal can be predicted in women displaying a low level of energetic arousal and self-efficacy.

Predictors of hedonic tone include energetic arousal (positive predictor) and trait anxiety (negative predictor). Positive mood can be predicted in women with a high level of energy, who are less inclined to react with anxiety. The only (positive) predictor of energetic arousal in the posttest was hedonic tone.

During the first measurement, before the commencement of the exercise program, stronger correlations were noted between mood dimensions which can be regarded as predictors of one another in about 60–70%. During the second measurement (after three months of regular exercise) the correlations between mood dimensions become weaker but are stronger between mood dimensions and personality traits. The re-

gression models based on the stepwise analysis are the weakest in the case of indices of mood changes.

Discussion

The obtained results indicate a significant improvement of mood states in women taking part in a three-month aerobics training. It was manifested by a significant decrease in tense arousal along increasing energetic arousal and hedonic tone. These results correspond to results of earlier experimental [1–4, 24] and quasi-experimental studies [7, 8, 10, 11] confirming the so-called chronic effects of exercise in the emotional sphere manifested by a low level of negative states and high level of positive states. Certainly, research studies carried out in natural conditions and not meeting the requirements of an experiment (no control group or randomization) failed to produce any cause and effect relations. Therefore, a significant improvement in mood states of the program participants was noted; however, regular aerobic exercises cannot be considered to be a causative factor.

The UWIST Mood Adjective Checklist (UMACL) turned out to be a tool sensitive to changes with time. The observed correlations between the dimensions of mood in the pretest and the posttest are in line with expectations related to the three-dimensional model of mood, and correspond with results obtained during the elaboration of the Polish version of the test. However, the coefficients of correlation between the scales in physically active women were significantly higher than the results attained by the author of the Polish adaptation [20], especially in the case of the negative correlation between tense arousal and energetic arousal ($r = -0.27$ in Goryńska [20]). The obtained results prove a strong mutual correlation between the dimensions of mood: hedonic tone and energetic arousal being negatively correlated with tense arousal and positively correlated with each other.

These correlations could be seen during both measurements (pretest and posttest), however, not all of them were present between indices of changes of individual mood factors. The increase in hedonic tone was strongly correlated with the increase in energetic arousal, however, the changes in these two dimensions were independent of energetic arousal changes. Such results remain contrary to the predictions associated with Thayer's concept of mood [21] involving energetic arousal and tense arousal. Energetic arousal as a continuum ranging from

tiredness to energy is affected by physical and cognitive activity and changes in accordance with the diurnal rhythm of sleep and awakesness. Tense arousal as a continuum ranging from calmness to anxiety, associated with the reception of threat, is affected by psychological stress. According to Thayer the correlation between these two dimensions is inversely proportional. With the use of this concept researchers attempted to explain the improvement of mood states in subjects undertaking physical activity [22]. Physical activity has a direct positive impact on energetic arousal, which leads to a decrease in tense arousal. Energetic arousal has a positive emotional implication, whereas tense arousal a negative one. Thus exercise-induced changes are felt as mood improvements.

The present study however fails to reveal any significant correlations between changes in energetic arousal and tense arousal. These changes take place irrespective of each other, however, their direction remains in line with expectations. The fact of both mood dimension changes being independent of each other is confirmed by the regression analysis results. Significant positive correlations were found between the increase in energetic arousal and hedonic tone, as evidenced by coefficients of correlation between the indices of change and the regression analysis results. These issues require, however, further research.

The mood (not its changes) of the women under study is also related to the examined personality traits. In accordance with theoretical premises and results of earlier studies [20] trait anxiety was positively correlated with tense arousal, and negatively with hedonic tone and energetic arousal (pretest and posttest). These two correlations were slightly weaker during the posttest, however, still higher than correlations found by Goryńska [20]. The correlations between the remaining personality traits (self-efficacy, dispositional optimism) with mood dimensions were stronger during the second measurement. It is impossible to state whether this might be a general tendency or an effect confined to a specific sample. This issue also requires further research.

The last aspect of the study concerned personality changes in women undertaking regular physical activity. Despite reservations expressed by a number of authors who claim that personality traits are simply too solid to change during a long term exercise program, significant changes in all examined personality traits were observed. A declining tendency to respond with

anxiety has been noted in earlier research, also including experimental studies; however, the mean effect sizes in those studies were lower than in the present study [25 (ES = 0.34), 4 (ES = 0.25)]. Leith [24] claims that the declining tendency to react with anxiety can be predicted in participants in exercise programs lasting at least 9–10 weeks. Researchers have also underlined that in individuals with a normal level of trait anxiety, significant changes are not expected (floor effect). The mean pretest results in the present study are at the level of mean results (Sten 5) for women aged 21–40. The mean posttest results were, however, below average (Sten 4). Despite this moderate tendency to react with anxiety, a slight but nevertheless statistically significant reduction in trait anxiety was found. Certainly, the accepted research model is not sufficient grounds for stating that this was a purely exercise-induced change.

The obtained results indicate an increased level of optimism in the women under study. According to Kavussanu and McAuley [23] long-term and regular physical activity can contribute to the development of optimism. A physically active individual becomes “fluent” in performing exercises and thus physically self-efficacious. The GSES tool which allows determining the strength of general self-efficacy, also revealed a significant increase of this component. However, no correlation was found between the increase in optimism and self-efficacy (either in correlation coefficients or analysis of regression for the indices of change of personality traits). Positive correlations were found between absolute indices (optimism and self-efficacy scales) in the pretest ($r = 0.301$; $p = 0.62$) and posttest ($r = 0.292$; $p = 0.71$). Kavussanu and McAuley [23] also discussed a reduction in the anxiety and depression levels and displaying positive emotions associated with energetic arousal. No correlations between indices of mood change and dispositional optimism were, however, observed.

Precise determination of the significance of individual personality variables and correlations between them and mood requires further experimental studies and more advanced statistical analysis. The present research was a pilot study to verify the applicability of a new diagnostic tool in the area of psychology of physical activity. The study also aimed to examine whether group aerobic exercises can be used as potential means of improvement of the self-efficacy level. They are a significant factor of changes of pro-health behaviors [28], but they might also be used as ways of improving recreational physical activities of adult women and their

families. These questions will be addressed in our future research.

Conclusions

1. The mood of adult women participating in a three-month aerobic exercise program improved significantly, regardless of changes of personality traits.

2. During the three-month exercise program the participants experienced beneficial personality changes from the standpoint of psychological adaptation.

3. Mood dimensions in a three-dimensional mood model are strongly correlated with one another, however, changes with time are irrespective of them.

4. After three months of regular exercises adult women reveal stronger correlations between mood dimensions, optimism and self-efficacy.

5. The UWIST Mood Adjective Checklist (UMACL) is sensitive to mood changes in subjects who exercise regularly.

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Address for correspondence

Monika Guskowska

Zakład Psychologii

Akademia Wychowania Fizycznego Józefa Piłsudskiego

ul. Marymoncka 34

00-968 Warszawa, skr. poczt. 55, Poland

e-mail: mguskowska@wp.pl



PERCEPTION OF SELF-EFFICACY AND PROFESSIONAL BURNOUT IN GENERAL EDUCATION TEACHERS*

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Maria Brudnik

Chair of Theory and Methodology of Physical Education, University School of Physical Education, Cracow, Poland

ABSTRACT

Purpose. The objective of the study was to determine to what degree general perception of self-efficacy protects general education teachers in Poland (educational stages II–IV) against professional burnout, and whether teachers of various subjects display any differences in this respect. **Basic procedures.** The study was carried out between April and June 2005 on a sample of 404 teachers (women $n = 310$, men $n = 94$). The diagnosis of the burnout syndrome was based on the Maslach Burnout Inventory (MBI). The perception of coping competences in teachers facing professional stress was measured with the General Self-Efficacy Scale (GSES) (Polish version) by R. Schwarzer, M. Jerusalem and Z. Juczyński. **Main findings.** Teachers are characterized by a high level of self-efficacy perception. **Conclusions.** As a factor preventing development of the three-dimensional burnout syndrome, perception of self-efficacy protects teachers against a loss of professional satisfaction, increasing emotional exhaustion and a tendency to depersonalize their pupils. Teachers of various subjects perceive the preventive role of self-efficacy differently.

Key words: teacher, professional burnout, self-efficacy

Introduction

Teachers constitute a group classified as one of the so-called helping professions, which are risk groups particularly vulnerable to the professional burnout syndrome. The consequences of the syndrome have a negative effect on burned out teachers whose health deteriorates and who work less effectively. The resulting loss of social competences also disrupts teacher–student relations crucial in the educational process. The decreasing involvement of burned out teachers due to the lack of professional satisfaction produces no new solutions and fails to improve the effectiveness of teachers' work.

In her analysis of pre-disposing and preventive factors in teachers, Sęk [1] confirmed the preventive role of perception of self-efficacy in the professional burnout syndrome in teachers. “The conviction of self-efficacy is confidence in possibilities of effective action in new, ambiguous, unpredictable or even stressful sit-

uations” [2, p. 213]. Perception of self-efficacy must be discriminated from expectation of specific outcomes. It is a belief that we can cope with any unfavorable conditions. For example, a teacher can be convicted that he/she knows how to teach chemistry the best way, but he/she may be uncertain whether his/her students can learn it [2].

Perception of self-efficacy is a component of the cognitive system structure of each individual. According to Bandura [2] it plays a key role in human motivation. In intentional acts, the perceived self-efficacy affects one's aspirations, efforts, endurance, resistance to failures and the level of experiencing stress. A strong conviction of self-efficacy corresponds to good mood and higher immunity of the body [2]. Perception of self-efficacy consists of the specific part, i.e. perception of one's specific professional competences, and the general part, i.e. general perception of self-efficacy. The problem of perception of professional efficacy was thoroughly analyzed by Gaś [3].

Professional burnout occurs in conditions of chronic stress, the source of which is another individual. Stress depends on the actual context and conditions of performed work, so for different professions different stressors and loads can be distinguished [4, 5]. Few re-

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search studies have been devoted to the scale and specificity of workloads of teachers of particular subjects. Tucholska [6] in her analysis of burnout causes in Polish teachers introduced the variable *taught subject*. Studies on professional burnout in PE teachers were also carried out by Brudnik [7, 8] and Pec [9].

The aim of the present study was to determine to what degree general perception of self-efficacy protects general education teachers in Poland (educational stages II–IV) against professional burnout, and whether teachers of various subjects display any differences in this respect.

Material and methods

The study consisted of a diagnostic survey and was carried out between April and June 2005 on a sample of teachers of various subjects from state comprehensive schools from the Małopolska and Śląsk Provinces in Poland. In total 22 schools participated in the study (educational stages II–IV) from the provincial and district capitals as well as from smaller towns. The sample consisted of 404 teachers (310 women (76.7%) and 94 men (23.3%)).

The teachers' professional burnout syndrome was diagnosed using the Maslach Burnout Inventory (MBI) (Polish version by Noworol; unpublished) which allows assessment of the level of professional burnout due to chronic emotional stress. The MBI is a three-scale questionnaire consisting of 22 items: Emotional Exhaustion (EE) – 9 items, Sense of Negative Personal Accomplishment (PA) – 8 items, and Depersonalization (DP) – 5 items. The subjects give their responses to each item on a seven-point scale: 0 = *never*, 1 = *several times a year*, 2 = *once a month*, 3 = *several times a month*, 4 = *once a week*, 5 = *several times a week*, 6 = *every day*. Subjects considered to be burned out were those with all three components of the syndrome present.

The teachers' perception of coping competences while managing professional stress was measured with the aid of the General Self-Efficacy Scale (GSES) (Schwarzer, Jerusalem, Juczyński; Polish version [10]). It is a 10-item scale measuring general perception of self-efficacy in coping with difficult situations and adversities. Subjects' responses are made on a four-point scale: 1 = *not at all true*, 2 = *hardly true*, 3 = *moderately true*, 4 = *exactly true*. The sum of responses to the 10 items yields the composite score, i.e. the Index of General Self-Efficacy.

The taught subjects were grouped into the following categories¹:

- humanities: Polish, history, civics, civil defense training, personal health and social education, religious instruction, pedagogy and history of education, arts;
- sciences: mathematics, physics, chemistry, IT, technical education, music;
- natural sciences: biology, natural science, geography, chemistry;
- foreign languages: English, French, German, Russian, Italian, Latin;
- physical education: PE, remedial exercises.

The collected data was statistically processed with the use of k-means clustering, Kruskal–Wallis one-way analysis of variance and the Pearson correlation coefficient [11]. All calculations were made by the Rutkowski Biuro Oprogramowania GEM using the SPSS/12 software package.

Results

The vast majority of subjects had a university degree with a teaching major (95.5%); mean age: $\bar{x} = 38.4$ years (women $\bar{x} = 38.9$, men $\bar{x} = 36.8$); job seniority: $\bar{x} = 13.6$ years (women $\bar{x} = 14.2$, men $\bar{x} = 11.8$).

In the analysis of the teachers' professional burnout syndrome four homogenous clusters were distinguished, each grouping individuals with similar values of the burnout components: emotional exhaustion (EE), sense of negative personal accomplishment (PA), depersonalization (DP) (Tab. 1, 2).

Non-burned out teachers constituted one-third of the sample (Cluster II, $n = 153$, 37.9%). For them their work brought them real satisfaction, and with slight emotional exhaustion they related to their students very well (Tab. 2). Cluster IV ($n = 51$, 12.6%) included burned out teachers deeply frustrated with their work at school, with visible symptoms of emotional exhaustion and depersonalization. The teachers from Cluster I ($n = 104$, 25.74%) and Cluster III ($n = 96$, 23.76%) displayed different levels of the burnout syndrome (Tab. 2).

The progressive burnout noted among the teachers from Cluster I is indicative of the first crisis in profes-

¹ As there were only 10 teachers of arts and 15 of religious instruction (clergymen and laymen) in the sample, religious instruction and arts were included in the humanities category and music in the sciences category.

Table 1. Profile of teachers in clusters ($n = 404$) with regard to their sex, age and job seniority

Cluster		Sex				Age		Job seniority	
		Women		Men		\bar{x}	SD	\bar{x}	SD
		n	%	n	%				
I	$n = 104$	78	75.0	26	25.0	36.07	9.123	11.26	8.827
II	$n = 153$	124	81.0	29	19.0	39.49	8.836	14.69	9.221
III	$n = 96$	72	75.0	24	25.0	39.96	9.507	15.41	9.480
IV	$n = 51$	36	70.6	15	29.4	37.12	9.175	12.02	9.229
Total:	$n = 404$	310	76.7	94	23.3	38.42	9.226	13.64	9.312

Table 2. Statistical analysis of the three components of the professional burnout syndrome within clusters

Cluster		Professional burnout											
		EE				PA				DP			
		Emotional exhaustion				Sense of negative personal accomplishment				Depersonalization			
		\bar{x}	SD	Min	Max	\bar{x}	SD	Min	Max	\bar{x}	SD	Min	Max
I	$n = 104$	13.4	5.14	0	23	22.1	5.28	15	46	3.9	3.53	0	16
II	$n = 153$	9.6	4.44	0	18	7.3	4.13	0	16	2.75	2.51	0	11
III	$n = 96$	24.4	5.20	17	43	11.1	4.78	1	20	5.32	3.98	0	16
IV	$n = 51$	32.4	7.28	22	53	24.5	6.34	13	47	9.73	5.31	0	24
Total:	$n = 404$	17.0	9.73	0	53	14.2	8.58	0	47	4.55	4.20	0	24

sional work (mean age $\bar{x} = 36$ years) (Tab. 2). With a low level of emotional exhaustion and average level of depersonalization, teachers who are disappointed with their work at school begin to lose the sense of value and usefulness of their work. Cluster III encompasses teachers who react to professional stress with emotional tension (Tab. 2). A high level of emotional exhaustion along with an average level of the sense of personal accomplishments at work yields a high level of depersonalization.

The male teachers under study, constituting a minority in the highly feminized school teaching community, experience professional burnout more often than their

female counterparts. It is manifested by the higher percentage of male teachers in Cluster IV and their lower percentage in Cluster II (Tab. 1).

The analysis of professional burnout level with regard to taught subjects revealed diverse tendencies. The most numerous group of respondents (burned out and non-burned out) were the PE teachers (48.4% and 17.7%, respectively). There was also a high percentage of teachers of sciences in the cluster of non-burned out teachers; but only three burned out teachers of natural sciences (5.4%) (Tab. 3).

One-fourth of the examined physics teachers ($n = 15$) exhibited visible burnout symptoms (26.7%); as well

Table 3. Professional burnout of general education teachers ($n = 404$) – categories of school subjects

Categories of taught subjects	Professional burnout of general education teachers									
	Non-burned out teachers		Partially burned out teachers				Burned out teachers		Total	
	Cluster II		Cluster I		Cluster III		Cluster IV		n	%
	n	%	n	%	n	%	n	%		
Humanities	47	37.0	29	22.8	34	26.8	17	13.4	127	100
Sciences	37	41.6	27	30.3	16	18.0	9	10.1	89	100
Natural sciences	20	35.7	16	28.6	17	30.4	3	5.4	56	100
Foreign languages	19	27.1	20	28.6	20	28.6	11	15.7	70	100
Physical education	30	48.4	12	19.4	9	14.5	11	17.7	62	100
Total	153	37.9	104	25.7	96	23.8	51	12.6	404	100

Table 4. General self-efficacy and professional burnout of general education teachers

Categories of taught subjects	General self-efficacy of teachers									
	Non-burned out teachers		Partially burned out teachers				Burned out teachers		Total	
	Cluster II		Cluster I		Cluster III		Cluster IV			
	<i>n</i>	\bar{x}	<i>n</i>	\bar{x}	<i>n</i>	\bar{x}	<i>n</i>	\bar{x}	<i>n</i>	\bar{x}
Humanities	46	32.04	29	30.48	34	31.56	17	28.71*	126	31.00
Sciences	37	32.43	26	29.31*	16	31.44	9	28.22*	88	30.90
Natural sciences	20	32.65	16	31.00	17	31.53	3	30.67	56	31.73
Foreign languages	19	31.53	20	31.35	20	30.20	11	28.82*	70	30.67
Physical education	30	32.73	12	31.08	9	32.00	11	27.55*	62	31.39
Total	152	32.29	103	30.50	96	31.29	51	28.51*	402	31.11

* average values (high values above 30.00)

Table 5. Correlations between general self-efficacy and components of the burnout syndrome in general education teachers

Perception of self-efficacy in general education teachers			Professional burnout syndrome in teachers		
Categories of taught subjects	Sex	<i>n</i>	EE	PA	DEP
			Emotional exhaustion	Sense of negative personal accomplishment	Depersonalization
Humanities	Women	95		−0.377**	
	Men	31	−0.459**	−0.593**	
	Total	126	−0.236**	−0.431**	
Sciences	Women	70		−0.570**	
	Men	18		−0.565*	
	Total	88		−0.512**	
Natural sciences	Women	49		−0.378**	
	Men	7			
	Total	56		−0.283*	
Foreign languages	Women	62	−0.268*		
	Men	8			
	Total	70	−0.273*		
Physical education	Women	33		−0.382*	−0.379*
	Men	29	−0.629**	−0.662**	−0.527**
	Total	62	−0.510**	−0.529**	−0.458**
General education teachers	Women	309	−0.233**	−0.403**	−0.123*
	Men	93	−0.421**	−0.452**	−0.383**
	Total	402	−0.282**	−0.399**	−0.179**

values of Pearson correlation coefficient at * $p < 0.05$ and ** $p < 0.01$

as 17.7% of all PE teachers ($n = 62$). The most numerous groups in the category of humanities were teachers of Polish ($n = 77$), and in the foreign languages category, teachers of English ($n = 51$); the number of burned out teachers in these two groups amounted to 15.6% and 13.7%, respectively (Tab. 3).

The examined general education teachers featured a high index of general self-efficacy ($\bar{x} = 31.11$: women $\bar{x} = 30.87$; men $\bar{x} = 31.91$). The sex variable did not differentiate the subjects in terms of professional burnout,

and neither did job seniority, school and its geographical location, despite slightly higher values in male teachers.

Perception of self-efficacy as a personality variable is a significant factor preventing professional burnout in general education teachers ($p < 0.001$, $\chi^2 = 40.230$, $df = 3$). This correlation is statistically significant in teachers of humanities and physical education ($p < 0.05$, $\chi^2 = 11.143$ and $\chi^2 = 9.464$ respectively, $df = 3$). A strong correlation can also be noted in teachers of sciences ($p < 0.01$,

$\chi^2 = 15.796$, $df = 3$). According to Bandura, the stronger one's conviction of possibilities to face challenges and meet standards is, the higher the resistance to failures. Disappointment with the discrepancy between the level of performance and adopted standards can also motivate one to intensify his or her efforts [2].

Table 4 presents the mean indices of general self-efficacy in the groups of non-burned out, partially burned out and burned out teachers. The correlation between perception of self-efficacy and different components of the three-dimensional burnout syndrome was assessed with the Pearson correlation coefficient (Tab. 5).

A high level of general self-efficacy most effectively prevents the loss of sense of personal accomplishment (PA) in the teachers under study (Tab. 5). Perception of self-efficacy also determines to a great extent the level of tolerated stress during intentional acts [12, 13 after 2]. It protects teachers against inevitable disorganization of actions and growing emotional exhaustion (EE), and prevents – mostly male teachers – from deterioration of interpersonal skills (Tab. 5). Depersonalization of students (DP) in conditions of intense professional stress is a defense mechanism.

The teachers of different subjects perceive differently the preventive role of self-efficacy. Generally, self-efficacy perception protects teachers against the loss of professional interests and satisfaction. The exceptions are teachers of foreign languages, especially women, in whom perception of self-efficacy is decreased considerably by emotional exhaustion ($p < 0.05$) (Tab. 3, 5).

Professional burnout proceeds much slower in teachers of sciences (Tab. 3), in whom the preventive role of self-efficacy is highly significant ($p < 0.01$). The first reaction of teachers to professional stress is profound disillusionment with work at school (the highest percentage in Cluster I). Conviction of self-efficacy protects teachers (mostly women) against reduction of work satisfaction and progressive burnout (Tab. 3, 5).

Perceived self-efficacy in teachers of humanities determines two components of the burnout syndrome. In this group of subjects the burnout is initiated by emotional exhaustion (Tab. 3). The sense of self-efficacy protects the teachers (male teachers, in particular) against the loss of personal accomplishment (PA) and reduces stress at work in school (EE) (Tab. 5).

The analysis of professional burnout syndrome in PE teachers shows a high percentage of both non-burned out and burned out teachers. Perception of self-efficacy

of PE teachers determines all the three components of the syndrome (Tab. 5).

The obtained results point to the necessity of development of teachers' sense of self-efficacy during their university studies and in-service training. This way the protection against the professional burnout syndrome will be ensured. A high level of perception of self-efficacy enhances effective stress management and coping with professional duties; it also facilitates changes in the working environment and prevention of the burnout causes [5]. The development of self-efficacy as a means of multidimensional resistance to the burnout syndrome should be of particular concern for PE teachers. Following Tucholska [6] it is the professional group of PE teachers, that displays the highest level of dissatisfaction with the effects of their professional activities.

Conclusions

1. General perception of self-efficacy protects school teachers against the professional burnout syndrome manifested by low professional satisfaction, growing emotional exhaustion and a tendency to depersonalize their students.

2. Among teachers of different subjects the preventive role of perception of general self-efficacy concerns the following burnout syndrome components:

- emotional exhaustion, loss of personal accomplishment and depersonalization in physical education teachers;
- emotional exhaustion and loss of personal accomplishment in teachers of humanities;
- loss of personal accomplishment in teachers of sciences and natural sciences;
- emotional exhaustion in teachers of foreign languages.

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Address for correspondence

Maria Brudnik
Katedra Teorii i Metodyki Wychowania Fizycznego
Akademia Wychowania Fizycznego
al. Jana Pawła II 78
31-571 Kraków, Poland
e-mail: majabru@interia.pl



INFLUENCE OF CULTURE ON SPORTS ACHIEVEMENTS: THE CASE OF SPRINT RELAY TEAMS FROM JAPAN, BRAZIL, THE USA AND GREAT BRITAIN

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Piotr Sorokowski

Institute of Psychology, University of Wrocław, Wrocław, Poland

ABSTRACT

Purpose. Research outside sport psychology indicates that collectivist cultures positively influence group achievements. Because of this results of sports teams from collectivist cultures should be better than those of their counterparts from individualist cultures. This hypothesis was examined in two studies. **Basic procedures.** (1) In study I, 15 coaches, using the IC Interpersonal Assessment Inventory (ICIAI), enumerated characteristics that a perfect team member should possess. (2) In study II, individual results (achieved between 2001 and 2008) of four top Japanese and Brazilian athletes (collectivist cultures) and American and British (individualist cultures) were compared against the best 4 × 100 m relay results from these countries. **Main findings.** (1) In the coaches' opinion players of team sports should definitely be more collectivist than individualist in relation to the values professed. (2) In the context of athlete's potential, the Japanese and Brazilian relay teams achieved generally better results than their American and British counterparts. **Conclusions.** The obtained results show that collectivist cultures not only facilitate and favor the development of sports teams, but also enhance their performance.

Key words: sport, collectivism, individualism, track and field, 4 × 100 m relay

Introduction

The Individualism-Collectivism dimension (IC) is one of the most important theoretical constructs used for classification of cultures. Since Hofstede's first reports [1], revealing differences in the approach to collectivist and individualist values among IBM employees in several countries, the IC has become an object of extensive analysis and research [2]. According to Triandis et al. [3], cross-cultural differences on the Individualism-Collectivism Interpersonal Assessment Inventory (ICIAI) are linked with the distinctness of relationships between "I", "my own group" and "the strangers." Collectivist cultures rely to a large degree on the effective functioning of groups, and individuals from these cultures try to maintain enduring relationships within their own group and feel emotionally tied with other group members. On the other hand, individuals from individualist cultures feature a high level of independence and strong feelings of autonomy within the group [3].

Results of different studies show the extreme usefulness of the IC as a measure explaining cross-cultural differences. The IC research has become one of the most interesting fields of modern intercultural psychology [2].

The review of studies below presents merely some issues of IC research.

A number of analyses showed that the IC dimension affected people's behavior towards others. Yi and Park [4] revealed that subjects from collectivist cultures (Korea, Japan, China) are more disposed towards cooperation than their counterparts from the United States or Canada. According to Hamilton et al. [5], Americans, more than the Japanese, pay close attention to the effort of individual group members rather than to the whole group itself.

Another factor which could be affected by culture is emotional expression. Matsumoto et al. [6] revealed that, unlike people from individualist countries, representatives of collectivist cultures accepted that one should not display negative emotions within one's own group, but it was perfectly acceptable to express them towards strangers. On the other hand, Wallbott and Scherer [7] demonstrated that in a collectivist culture shame was felt for a shorter period of time and perceived less immoral than in individualist societies.

The IC construct can also have an impact on the ways of communication. Representatives of collectivist cultures are more sensitive to messages from other members of their own group [8].

Many studies have also concerned the impact of IC on human health. Triandis et al. [3] noted that people from the most individualistic societies were particularly vulnerable to cardiac diseases, which could be related to the fact that social relationships are a buffer zone protecting individuals from stress and nervous tension. This observation was also confirmed by Matsumoto and Fletcher [9], who showed that a high level of individualism was related to an increasing risk of death from cancer and heart disease, while a high level of collectivism ensues the risk of death from diseases of the vaso-cerebral system and respiratory system (since their research results relied on the study of GDP in different countries, the obtained results were not linked in any way to, for example, the accessibility and quality of public health services). Moreover, more suicide cases have been recorded in individualist than collectivist cultures [10].

The broadest research area related to the IC is concerned with the functioning of people in teams and organizations [11]. According to Hofstede [11], collectivist cultural values are more conducive to effective teamwork, enhance compliance with the rules within a group and preserve conformism in behaviors within the group. Moreover, in collectivist cultures harmony and conformity in work teams are valued more than in individualist cultures.

Very few works have been devoted to the influence of IC on the functioning of athletes. McCutcheon and Ashe [12] examined the relationship between athletes' IC dimension and their level of satisfaction from participation in team sports. Kernan and Greenfield [13] proved that the level of IC and other indices of cultural distinctiveness among members of female basketball teams affected the quality of cooperation and the number of conflicts within a sports team. This is most likely associated with the fact that players of different origin evaluate and interpret developments in a sport team differently due to different IC values accepted by them [13]. Hartenian [14] wanted to know whether team skills could be linked to the IC values accepted by employees, and whether these skills were affected by the employees' earlier sports careers. Her results confirmed the significant role of IC in the development of teamwork skills; however, they failed to reveal any correlations between these skills and an earlier sports career. The study did not specify, however, the subjects' sports level and whether they had been former individual or team athletes.

There have been no studies providing data on the influence of IC on athletes' sports results. In the light of presented studies it may seem that due to their specificity collectivist cultures are conducive to creation of more valuable sports teams to a greater extent than individualist cultures. Therefore, sports results achieved by sports teams from collectivist cultures should be better than the results of their counterparts from individualist cultures (in the context of the team's specific capabilities).

Material and methods

Study I

Study I used the IC Interpersonal Assessment Inventory (ICIAI) translated into Polish. The ICIAI developed by Matsumoto et al. [15] enables evaluation of the individualism vs. collectivism levels as well as subjects' perception of IC values. The ICIAI has been applied in different intercultural [6, 16] and intra-group studies [17]. The original ICIAI questionnaire includes items related to interacting with people in four different types of relationships: family, close friends, colleagues and strangers [15]. In the present study the scope of the inventory was limited to the values accepted by subjects in their relationship with colleagues only.

The study sample consisted of fifteen coaches of different team sports (volleyball, soccer, basketball) at different sports levels (junior, youth, collegiate and professional leagues). The coaches were asked to rate the ICIAI questionnaire items to create a psychological profile of the ideal team player (in their respective sports). The control group included forty students (20 males and 20 females) of various majors, mostly from the University of Wrocław, who were asked to carry out their self-assessment using the inventory.

Results

Study I

The obtained results are the means of rating answers (from 0 – Not at all important to 6 – Very important) to all ICIAI items. The “ideal team player” profile created by the coaches featured a higher result ($M = 4.84$, $SD = 0.45$) than the profile of an average student ($M = 3.39$, $SD = 1.22$); $p < 0.0001$, Student's t-test for independent variables. Thus the “ideal team player” in the coaches' opinion displayed a significantly higher level of collectivism than an average student.

Table 1. Comparison of results of top four sprinters from the USA, Great Britain (GBR), Brazil (BRA) and Japan (JPN) with the best results of 4×100 m relay teams from these countries in the years 2001–2008

Year	Country	Runner 1 time (s)	Runner 2 time (s)	Runner 3 time (s)	Runner 4 time (s)	Total of the runners' times (s)	Relay team time (s)	Time difference (s)
2001	USA	9.84	9.94	9.97	9.99	39.74	38.35	1.39
	GBR	9.87	10.09	10.13	10.30	40.39	38.72	1.67
	BRA	10.17	10.20	10.26	10.35	40.98	38.44	2.54
	JPN	10.02	10.31	10.35	10.47	41.15	38.67	2.48
2002	USA	9.78	9.89	9.95	9.95	39.56	37.95	1.61
	GBR	9.87	10.04	10.11	10.13	40.15	38.19	1.96
	BRA	10.19	10.20	10.28	10.31	40.98	38.58	2.40
	JPN	10.05	10.05	10.13	10.24	40.47	38.90	1.57
2003	USA	9.94	9.97	9.97	9.99	39.87	37.77	2.10
	GBR	10.03	10.07	10.08	10.17	40.35	38.60	1.75
	BRA	10.20	10.21	10.23	10.25	40.89	38.26	2.63
	JPN	10.03	10.22	10.23	10.23	40.71	38.77	1.94
2004	USA	9.85	9.87	9.88	9.95	39.55	37.92	1.63
	GBR	10.12	10.12	10.21	10.26	40.71	38.07	2.64
	BRA	10.13	10.15	10.18	10.21	40.67	38.62	2.05
	JPN	10.09	10.10	10.21	10.29	40.69	38.35	2.34
2005	USA	9.88	9.94	9.99	10.01	39.28	38.48	1.34
	GBR	10.08	10.13	10.13	10.22	40.56	38.27	2.29
	BRA	10.17	10.25	10.27	10.29	40.98	38.92	2.06
	JPN	10.15	10.27	10.29	10.29	41.00	38.46	2.54
2006	USA	9.77	9.84	9.91	9.94	39.46	37.59	1.87
	GBR	10.07	10.16	10.16	10.19	40.58	38.77	1.81
	BRA	10.22	10.23	10.30	10.45	41.20	39.03	2.17
	JPN	10.25	10.26	10.28	10.31	41.10	38.87	2.23
2007	USA	9.84	9.93	9.96	10.01	39.74	37.78	1.96
	GBR	10.06	10.10	10.13	10.14	40.43	37.90	2.53
	BRA	10.14	10.28	10.31	10.34	41.07	37.99	3.08
	JPN	10.14	10.15	10.23	10.39	40.91	38.03	2.88
2008	USA	9.96	10.05	10.05	10.06	40.12	38.72	1.40
	GBR	10.11	10.18	10.20	10.31	40.80	39.46	1.34
	BRA	10.19	10.22	10.26	10.28	40.94	38.94	2.00
	JPN	10.17	10.29	10.50	10.58	41.74	38.94	2.60

Material and methods

Study II

Study II compared the total time of four top 4×100 m relay sprinters from Japan, Brazil, the USA and Great Britain with the best results of sprint relay teams from these countries in the years 2001–2008 (Tab. 1). The analysis of results was made separately for each year. The individual and relay team results were taken from

international top lists from the IAAF webpage. Some results were taken from respective national lists. The 2008 results came from the track and field championships from May 20, 2008.

The selected players' countries of origin had to satisfy the following criteria: (1) availability of research data determining a given country as a collectivist or individualist culture; (2) the level of sprint races in a given country (to ensure the inclusion of a few sprinters on the official IAAF top lists); (3) exclusion of African runners resident in the USA or Europe (whose partici-

pation in the study could have profoundly affected the questionnaire answers [13], making it impossible to establish their IC level). In consideration of the above restrictions, teams from four countries were selected for the study: Japan and Brazil (collectivist cultures) and the USA and Great Britain (individualist cultures). It should also be noted that in researchers' opinion the Japanese culture is more collectivist than Brazilian culture; whereas the American culture is more individualist than British culture [11].

Four top individual 100 m results of sprinters from the selected countries were taken for analysis. They were always four different runners, however, not necessarily members of a relay team under study. Like in the official IAAF lists, the running times recorded in the conditions of heavy wind were rejected. In the case of American teams also the results of collegiate relay teams and USA B or USA Red/Blue/White were taken into consideration (providing all the team members were U.S. citizens). In the case of the other countries the top results were always achieved by the respective national relay teams.

Results

Study II

The differences between the best results of relay teams from the USA, Great Britain, Brazil and Japan were compared with the potential capabilities of runners from a given country, according to the formula: Runner 1 time + Runner 2 time + Runner 3 time + Runner 4 time – the time of the best relay team (Tab. 1). The differences (mean values for the years 2001–2008) were: USA ($M = 1.66$, $SD = 0.29$), Great Britain ($M = 2.0$, $SD = 0.45$), Brazil ($M = 2.37$, $SD = 0.37$) and Japan ($M = 2.34$, $SD = 0.44$).

The analysis of the above mean values revealed statistically significant differences between the results of U.S. and Brazil relay teams ($p < 0.001$), and the U.S. and Japan relay teams ($p < 0.01$). No statistically significant differences were noted between the results of the British and Brazilian ($p = 0.09$) and Japanese relay teams ($p = 0.14$). The total times of the Japanese and Brazilian relay teams ($M = 2.35$, $SD = 0.39$) turned out to be significantly better than the times of the U.S. and British teams ($M = 1.83$, $SD = 0.4$, $p < 0.001$).

Discussion

The studies were aimed to show that a given type of culture (collectivist or individualist) can have an impact on the sports results of athletes from this culture. The results presented indicate that, due to their specificity, collectivist cultures, to a greater extent than individualist cultures, are more conducive to the development of valuable sports teams. According to sports team coaches an ideal team player should hold onto collectivist values. Moreover, the analyzed 4×100 m relay results show that the times attained by relay teams from collectivist cultures are relatively better than by teams from individualist cultures. The results of the British relay teams were not significantly worse than the results of the Brazilian and Japanese teams. However, it should be remembered that the amount of analysed data (mean eight times from the years 2001–2008) makes it difficult to achieve statistically significant differences (there are no earlier data in the IAAF statistical database).

The question of why the runners from collectivist cultures can achieve better results in relay races than their counterparts from individualist cultures (in the context of specific abilities of a team, whose result depends on the individual predispositions of all the team members) is still an open one. One of the hypotheses assumes that athletes from individualist cultures may value their personal achievements above the overall team success, which can be reflected in their negligence of elements of relay training, for instance, exchanging the baton, etc.

The above study took into account four top results of runners during a given season. They were not necessarily the results attained by the members of the relay teams under study. In the author's opinion, this should not be regarded as a drawback. Non-participation of the top runners in their national relay team can be related to the aforementioned IC dimension of a given culture. Runners can decline their membership in a relay team as they can consider it to be less important than their individual achievements. They might also be excluded by the national relay coach due to their specific psychological traits which may be a hindrance to the overall team effort. A factor which can also exclude the top athletes from running as members of a relay team can be sports injuries. This, however, should not affect the general pattern of achieved results. In individualist cultures (USA, Britain) an injury sustained by a member of a re-

lay team is not a factor which lowers its quality, since he or she can be easily replaced by an equally well-qualified substitute runner.

There are many factors affecting the results of particular relay teams. The relatively good results of Polish teams confirm the general assumption of this study that other important factors, for instance traditions of a given sport in a particular country, can also have an effect on the sports achievements of the country's athletes. On the other hand, it is commonly assumed that the Polish society is more collectivist than individualist [18]. Thus the relatively good results of the Polish relay teams can also confirm the aforementioned hypothesis.

The research on the IC dimension has also produced a number of IC analytical tools. At present these tools enable not only the measurement of intercultural differences but also assessment of the IC level in individuals. Oyserman et al. [19] made a review of several studies which involved different IC scales at the individual level. Therefore a number of instruments exist which allow evaluation of individual IC levels. These tools can be potentially applied in the process of selection of athletes with desired collectivist profiles for sports teams. Such an application could be very interesting from the cognitive standpoint. The top players fulfilling different functions in a sports team might possess different characteristics on the IC scale. One can speculate whether, for instance, a defensive midfielder on a soccer team should be a collectivist, while a forward should possess individualist traits. Further research in this area may bring some interesting results.

The studies presented have certain limitations. The general assumption that Asian cultures feature a higher level of collectivism, while the Western cultures are more individualist is somewhat problematic. There have been a few reliable studies whose results seem to contradict the ones presented above [20], or whose interpretation is not uniform [21]. Moreover, the results of the present study concern one sport only, and the study sample was relatively small (on the other hand, the analyzed results were achieved by the runners over the period of eight years). These limitations should be taken into account in any discussion of the results presented.

Conclusions

The obtained results show that a collectivist culture is more conducive to the development of sports teams

and achievement of team success. Due to the prototypicality of the above research as well as relatively small amount of data for analysis the suggested hypothesis still requires further examination.

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Address for correspondence

Piotr Sorokowski

ul Wyspiańskiego 4

48-300 Nysa, Poland

email: sorokowskipiotr@yahoo.co.uk



WOMEN'S FREE TIME VERSUS PROFESSIONAL WORK AND FAMILY AND HOUSEHOLD DUTIES

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Maria Nowak^{1*}, Mariola Radzińska², Tadeusz Rynkiewicz³

¹ Chair of Theory and Methodology of Sports, Branch Faculty of Physical Culture, Gorzów Wielkopolski, Poland

² Chair of the Humanities, Branch Faculty of Physical Culture, Gorzów Wielkopolski, Poland

³ Chair of Theory and Methodology of Physical Culture, Branch Faculty of Physical Culture, Gorzów Wielkopolski, Poland

ABSTRACT

Purpose. The aim of the study was to determine correlations between ways of spending free time and work-related and family-household duties among women taking part in physical recreation activities for many years. **Basic procedures.** The study included 1,104 women, aged 20 to 75, exercising in organized groups in cities of western Poland. The length of the respondents' physical activity history was defined by the number of years of doing exercise. The study used the diagnostic poll method and complementary survey techniques verified in a pilot study. The research results were analyzed qualitatively and statistically (χ^2 test of independence, Kruskal–Wallis H test, Mann–Whitney U test, and multiple comparisons z-test). **Main findings.** The shortest length of physical activity (one year) was characteristic of women-mothers with children at the pre-school or school age, burdened with household chores and working jobs. At the same time, respondents with a shorter length of physical activity (under four years) spent more of their free time watching television both on weekdays and weekends. **Conclusions.** A comparison between the weekly volume of time of women's participation in physical exercise and the amount of time devoted to watching television proves that apart from the existence of objective barriers connected with the real work-related and family-household responsibilities, involvement in physical activity remains more of a question of the subjects' personal preferences and choices rather than having free time. Long-lasting physical activity is the decisive factor influencing the choice of active forms of spending free time.

Key words: free time, physical activity, watching television, working woman, mother

Introduction

Leisure is a product of civilization, urbanization and industrialization. In any gender analysis of the use of leisure time it is important to distinguish between the concept of leisure and its content [1–4]. A study conducted by the Polish Central Statistical Office showed that on average Polish women spent 4 hours 50 min for household chores a day, i.e. 2 hours and 14 min more than men [5]. A U.S. study based on reports on different types of activities revealed that American women spent at least 2 hours a day on household chores and family duties, while American men merely 30 min [6]. Regardless of the cultural diversity of societies, in modern times the amount of women's leisure time is significantly restricted in comparison with men's.

The physical recreation theory distinguishes at least three meanings of the concept of recreation: (1) a set of behavior patterns in one's free time, (2) rest after work,

(3) a dynamic socio-cultural phenomenon [7]. Having leisure time conditions participation in different forms of physical activity, which according to numerous studies, depend on age, sex, marital status, number of children and their age, level of education and financial conditions [8–14].

The problem of unequal distribution of free time with regard to gender was discussed in the context of obstacles to undertaking physical activity [15] and social barriers (learning, psychological, cultural, ideological) [16]. Psychological and cultural barriers turned out to be more significant in women. Deficit of leisure, so characteristic of modern times, was classified as a cause of physical passivity by women who had once undertaken physical activity. For subjects who had been physically passive earlier the main barrier to undertake physical activity was lack of interest [17].

The choice of ways of spending leisure time takes place in situations in which alternative patterns of behavior are possible [18], e.g. physical activity, watching television, etc. Most adult Poles spend their free time

* Corresponding author.

(more than 18 hours a week) passively (watching television for many hours) [19]. Undertaking physical activity requires making a choice, defining the objective and making an effort, all of which enforce changes in one's daily life. Only 5% of 20-year-old Polish women participate intensively in physical exercises [19]. What is interesting is the way women who fulfill different social roles find time to participate in physical recreation.

Studies on physical activity so far have dealt with the question of whether recreational physical activity is a permanent behavior manifesting itself systematically in the long term. There has been no research on women who undertake physical exercises for many years, or at least for one year. This kind of study poses certain limitations of the sample selection but it also opens new possibilities for analysis.

Following the physical recreation theory the observed increase in the amount of free time makes leisure an important socio-cultural phenomenon. The socially accepted model of a woman who combines her household chores with professional duties facilitates the social differentiation of men and women not only in terms of household chores and professional duties, but also in terms of their leisure time [20]. This limits women's possibilities of self-fulfillment and participation in different forms of physical activity. With the existing inequalities it is important to present the participation of women in physical recreation in the context of social roles traditionally assigned to the gentle sex.

In consideration of the social significance of the problem of low level of physical activity of Polish women a research study was undertaken to determine relations between ways of spending free time and professional, household and family duties of women who had participated in physical recreation for many years. On the basis of professional literature the following two research hypotheses were formulated:

1. Participation of women in physical recreation for many years is determined by their fewer and less burdensome professional duties and household chores.
2. The main determinant of choice of particular forms of active leisure by women is undertaking physical activities for many years.

Material and methods

The study sample consisted of 1,104 women taking part in physical recreation classes in cities of western Poland (Gorzów Wielkopolski, Poznań, Szczecin, Wrocław,

Zielona Góra). The classes (paid) were held in sports clubs, community and fitness clubs, school gyms and at swimming pools. The respondents' history of participation in physical activities was given in years. On the basis of data obtained from each respondent the lower quartile, median and upper quartile were calculated. Four groups of subjects were distinguished: Group 1 (G I) included 322 women who had exercised for one year; Group 2 (G II) consisted of 307 women doing exercises for more than one year but less than four years; Group 3 (G III) consisted of 210 women exercising from 4 to 7 years. Group 4 (G IV) included 265 women who were exercising for at least seven years: 30.2% between 7 and 10 years; 47.9% between 11 and 20 years; 12.8% between 21 and 30 years; 9.1% between 31 and 40 years. The age range of all respondents was 20–75 years. Almost 90% of them assessed their financial situation as good and very good, only 10% as satisfactory. The women under study had usually one or two children (30.4%, or 37.9%, respectively). Respondents with three children were merely 5.8% of the total sample, and 25.9% of subjects had no children.

A diagnostic survey method was used in the study. To characterize the lifestyle of physically active women with reference to their professional situation, family and household duties and age, different research techniques were applied in the study: questionnaires, interviews, scale of pro-health attitudes.

The applied complementary questionnaire survey techniques ("I – my health – sport" questionnaire designed in the Chair of the Humanities of the University School of Physical Education in Warsaw, and "Woman – physical activity – lifestyle" questionnaire designed by the authors themselves) were verified in pilot studies [21]. Each respondent filled both questionnaires anonymously. The results were subject to qualitative and statistical analysis (χ^2 test-independence, Kruskal–Wallis H test, Mann–Whitney U test and multiple comparisons z-test).

Results

The differences in the physical activity of women were affected by demographic and social factors (Tab. 1). There was a statistically significant correlation between the subjects' age and participation in physical activity in years ($p = 0.0000$ for the χ^2 test of independence). The largest group of subjects were women aged between 30

Table 1. Correlations between women's age, number of children, age of children, education, professional work and participation in physical activities in years (χ^2 test of independence)

	Participation in physical activities (years)				Total		p for χ^2 test
	G I	G II	G III	G IV	n	%	
Women's age							
20–29 years	22.4	12.7	15.7	12.1	176	15.9	$p = 0.0000$
30–39 years	27.6	30.9	20.0	13.6	262	23.7	
40–49 years	23.6	30.6	30.0	27.2	305	27.6	
50–59 years	12.7	13.4	15.7	18.1	163	14.8	
60–75 years	13.7	12.4	18.6	29.0	198	17.9	
Number and age of children							
No children	30.1	23.2	28.2	22.2	286	25.9	$p = 0.0000$
Under 7 years	14.9	8.1	6.7	11.7	118	10.7	
[7–16) years	21.1	32.9	23.5	15.9	260	23.6	
[16–26) years	17.4	17.9	18.2	19.6	201	18.2	
≥ 26 years	16.5	17.9	23.4	30.6	238	21.6	
Education							
Primary	4.5	5.3	3.6	3.3	58	4.3	$p = 0.0009$
Secondary	41.3	35.8	27.9	28.3	464	34.1	
Post-secondary	54.2	60.0	68.5	68.4	838	61.6	
Professional work							
Working	68.1	68.1	65.2	57.7	718	65.0	$p = 0.0089$
Permanently not working	22.0	21.8	27.6	34.7	288	26.1	
Temporarily working	9.9	10.1	7.2	7.6	98	8.9	

Table 2. Analysis of rank values for the amount of time the subjects devoted to selected activities on working days and free days and participation in physical activities (Kruskal–Wallis H test)

Activities	Groups of subjects	Working days			Free days			H statistics
		n	Median	Min.–Max.	n	Median	Min.–Max.	
Daily household duties	G I	285	2	0.5–12	263	3	0.5–12	$H_2 (3, 908) = 11.09$ $p = 0.0112$
	G II	279	2	0.5–12	261	3	1–12	
	G III	186	2	0.5–8	176	3	0.5–8	
	G IV	229	2	0.5–12	208	3	0.5–12	
	Total	979	2	0.5–12	908	3	0.5–12	
Physical activity	G I	322	0.4	0.67–5.8	40	1	0–5	$H_1 (3, 1104) = 66.52$ $p = 0.0000$
	G II	307	0.4	0.75–7	35	1	0–3	
	G III	210	0.4	0.5–6	36	1	0.25–4	
	G IV	265	0.5	0.5–7	59	1	0.2–8	
	Total	1104	0.4	0.5–7	170	1	0–8	
Watching TV	G I	268	2	0–10	265	3	0.5–12	$H_1 (3, 896) = 9.12$ $p = 0.0278$; $H_2 (3, 914) = 20.77$ $p = 0.0001$
	G II	253	2	0.5–5	258	3	0.5–6	
	G III	168	2	0.5–7	179	2	1–20	
	G IV	206	2	0.5–7	212	2	0.5–12	
	Total	895	2	0–10	914	3	0.5–20	
Looking after children	G I	125	3	0–12	122	4	0–12	$H_2 (3, 389) = 8.14$ $p = 0.0433$
	G II	133	2	0.5–12	127	3	0.5–15	
	G III	61	3	0.5–12	64	3	0.5–12	
	G IV	78	3	0.5–12	76	4	1–12	
	Total	397	3	0–12	389	4	0–15	

H1 – statistically significant differences for working days, H2 – statistically significant differences for free days

and 49 years (51.3%). A numerous group of physically active women were subjects over 60 years of age (17.9%). This can be indicative of the increased amount of free time of women at the retirement age. Women who had been active for less than seven years (G I, G II, G III) were mostly over 50 years of age, while the group of subjects exercising for more than seven years (G IV) consisted of the similar number of subjects before and after 50 years of age.

Women from G I had children at the pre-school and school age more often than women from other groups, while the children of women from G IV were at the professional training stage (16–26 years) and over 26 years of age ($p = 0.0000$ for the χ^2 test of independence).

Most women under study had a post-secondary education (63.6%): secondary and lower in women from G I and II, and post-secondary in women from G III and IV ($p = 0.0009$ for the χ^2 test). The respondents were mostly professionally active (65%); however, the number of professionally active women was smaller (57.7%) in G IV, which included the largest number of professionally passive (retired) subjects (34.7%) ($p = 0.0089$ for the χ^2 test of independence).

There were also statistically significant differences (Kruskal–Wallis H test) in the amount of leisure time during free days devoted by the women under study to daily household chores, looking after children and watching television ($p = 0.0112$, $p = 0.0433$, $p = 0.0001$, respectively). In terms of leisure time during working days, statistically significant differences were noted in the amount of time devoted to physical activity and watching television ($p = 0.0000$, $p = 0.0001$, respectively) (Tab. 2).

Differences in the amount of time devoted to selected activities by the particular groups of subjects are shown in Table 3. Statistically significant differences between the amount of time devoted to household chores on free days were noted between: G I and G III (U test), G II and G III (z-test, U test), and G II and G IV (U test). The subjects from G I and G II needed more time for daily household chores; in the case of the other groups the amounts of time devoted to household chores did not differ significantly.

Statistically significant differences were noted in the amount of time devoted to watching television on working days between G I and G II, G II and G III, and G II and IV (U test). Women from G II spent more of their leisure time watching television than the other groups. On free days, watching television was more time-consuming for subjects from G I as compared

with G III and G IV (z-test, U test), and for subjects from G II in comparison with G III (z-test, U test) and G IV (U test).

The analysis of the amount of time devoted to looking after children revealed significant differences between G I and G II and G I and G III (U test). Women from G I spent more time looking after their children than women from G II and G III.

All activities performed by the subjects during their free days took them more time than activities during weekdays (Tab. 4). Women from G I and G II worked for 8 hours a day more often than their counterparts from G III and G IV ($p = 0.0213$ for the χ^2 test of independence).

Over 80% of the respondents declared watching television on weekdays and weekends; however; women who had participated in physical activity for a longer time, spent less time watching television ($p = 0.0022$ for the χ^2 test of independence). In G III the smallest number of women watched TV for 3 hours (6.5%), and in G IV only 2.9% of women watched TV for more than 4 hours. On weekends, women from G I and G II watched television significantly more often (5 hours and more) than their counterparts from G III and G IV ($p = 0.0000$ for the χ^2 test of independence).

Looking after children on weekdays and weekends was an activity declared by more than 35% of subjects at different ages. The respondents from G I (41.2%) spent comparatively the greatest amount of their free time looking after children (4 hours and more) ($p = 0.0077$ for the χ^2 test of independence), whereas the women from G III and G IV cared for children for about 3 hours a day (36% and 29.5%, respectively). Women from G II spent the least time caring for children. In G I (61.5%) and G IV (59.2%) the subjects spent 4 hours and more with their children on weekends ($p = 0.0288$ for the χ^2 test of independence); whereas in G II the largest group were women spending with their children 3 hours a day.

The amount of time devoted to activities analysed in Tables 2–4 is given in hours. However, participation in physical activity, due to the comparatively shorter time devoted to physical exercises, is expressed in minutes (Tab. 5). Most women spent from 61 to 120 min a week, the largest number in G I and G II. 25.3% of subjects from G III and almost 40% of subjects from G IV spent more than 180 minutes a week doing physical exercises. In groups of women who had participated in physical activity for more years a tendency to devote more time to physical exercises per week was noted.

Table 3. Analysis of rank values for the amount of time the subjects devoted to selected activities on working and free days and participation in physical activities

Activities	Grups	Groups				Mean rank values for z-test
		G I	G II	G III	G IV	
		<i>p</i> for z-test*				
Household duties on free days H (3, 908) = 11.09 <i>p</i> = 0.0112	G I					473.55
	G II			0.0385		483.03
	G III	0.0171	0.0051			413.31
	G IV		0.0246			429.47
Watching TV on working days H (3, 896) = 9.12 <i>p</i> = 0.0278	G I					435.71
	G II	0.0201				487.73
	G III		0.0097			424.57
	G IV		0.024			436.59
Watching TV on free days H (3, 914) = 20.77 <i>p</i> = 0.0001	G I			0.0011	0.0164	497.38
	G II			0.0099		482.42
	G III	0.0001	0.0014			401.64
	G IV	0.0020	0.0140			424.49
Looking after children on free days H (3, 389) = 8.14 <i>p</i> = 0.0433	G I					217.93
	G II	0.0126				182.99
	G III	0.0243				178.33
	G IV					192.3

* Statistical significance for z test in bold face, for U Mann–Whitney test in Roman face

Table 4. Correlations between selected activities on working days and free days and participation in physical activities in years (χ^2 test of independence)

Activities	Participation in physical activity in years				Total		<i>p</i> for χ^2 test
	G I	G II	G III	G IV	<i>n</i>	%	
	%						
Professional work, studying (working days)							
4 hours	10.5	16.0	14.6	18.1	116	14.6	<i>p</i> = 0.0213
5–7 hours	26.0	22.7	31.1	32.2	219	27.5	
8 hours	43.3	43.6	34.4	27.3	303	38.0	
more than 8 hours	20.2	17.7	19.9	22.4	159	19.9	
Watching TV (working days)							
1 hour	44.4	34.4	42.6	42.7	365	40.8	<i>p</i> = 0.0022
2 hours	34.7	39.1	42.6	37.4	341	38.1	
3 hours	11.6	18.6	6.5	17.0	124	13.8	
4 hours and more	9.3	7.9	8.3	2.9	65	7.3	
Watching TV (free days)							
2 hours	42.3	44.2	59.2	52.8	444	48.6	<i>p</i> = 0.0000
3 hours	26.4	24.0	24.0	28.3	235	25.7	
4 hours	14.0	14.7	12.9	12.3	124	13.6	
5 hours and more	17.3	17.1	3.9	6.6	111	12.1	
Looking after children (working days)							
1 hour	17.6	20.9	23.0	16.6	77	19.4	<i>p</i> = 0.0077
2 hours	24.0	34.3	23.0	23.1	108	27.1	
3 hours	16.8	19.4	36.0	29.5	92	23.1	
4 hours and more	41.6	25.4	18.0	30.8	121	30.4	
Looking after children (free days)							
2 hours	28.7	35.4	42.2	35.5	134	34.4	<i>p</i> = 0.0288
3 hours	9.8	18.1	7.8	5.3	44	11.3	
4 hours and more	61.5	46.5	50.0	59.2	211	54.2	

Table 5. Differences in the weekly amount of time spent on physical exercises in groups under study (χ^2 test of independence, $p = 0.0000$)

Groups	Weekly amount of time for physical exercises				Total <i>n</i>
	< 60 min	61–120 min	121–180 min	> 181 min	
G I	13.4	58.4	15.2	13.0	322
G II	10.8	59.0	12.4	17.8	307
G III	10.0	49.5	15.2	25.3	210
G IV	6.4	36.6	18.1	38.9	265
Total (<i>n</i>)	114	570	167	253	1104
%	10.0	51.6	15.1	23.3	100.0

Table 6. Analysis of rank values for weekly time the subjects devoted to physical exercises and participation in physical activities in years ($H(3, 1104) = 66.52, p = 0.0000$)

Groups	Groups				Mean rank values
	G I	G II	G III	G IV	
	<i>p</i> for z-test*				
G I			0.0010	0.0000	476.76
G II			0.0430	0.0000	506.34
G III	0.0001	0.0052		0.0125	583.11
G IV	0.0000	0.0000	0.0013		673.75

* Statistical significance for z test in bold face, for U Mann–Whitney test in Roman face

To determine the differences in the amount of time per week devoted to physical exercises mean rank values were compared (Tab. 6). The subjects from G I and G II spent on the average less of their weekly free time on exercises than women from G III and G IV (z-test, U test). The women from G IV differed significantly from their counterparts from the three other groups as they devoted most time to exercises (z-test, U test). The subjects from G I and G II did not differ significantly in terms of the total weekly time spent on exercises (z-test, u test), but differed in terms of years of participation in physical activity.

Discussion

The predictions of sociologists thirty years ago, which confined women's duties to household chores, looking after children and family duties, have not been confirmed [22]. This model is strongly opposed by women seeking professional self-fulfillment, despite numerous hardships related to reconciling different social roles and lack of free time [1, 2]. There are women who choose to spend their leisure time actively and have been doing exercises for years. Research studies have confirmed the relationship between physical activity

and the level of education, having a job, financial situation and children's age [11, 14, 17]; which is particularly visible among women involved in physical recreation for many years.

Having children requires women to focus on child-care and daily household duties. Women from G I more often had children at the pre-school age and below 16 years of age, and devoted most of their time to children on all weekdays. On weekends they spent more time on the household chores (from 2 hours to 3 hours). The women from G I and G II with younger children spent more time on the domestic chores than women from G III and G IV. It can be thus observed that the smaller children the women had, the less time they spent on physical exercises [13, 23].

Professional work, looking after children and household duties seriously limit women's leisure time [4, 24–27]. Finding free time for physical exercise on weekdays (particularly by women from G I) is possible by performing a few activities at the same time and good time organization. This skill is referred to in literature as “time extension” [20] and is demonstrated by a number of Poles [28]. Women participating in physical activities for the longest time (7 years and more), devoted much time to caring for their children both on weekdays and week-

ends. They included almost the same number (about 50%) of women before and after 50 years of age. It can be concluded that both mothers and grandmothers were involved in childcare. The involvement of grandparents in the upbringing and organizing daily activities of their grandchildren is fairly common in the Polish society, which is often facilitated by living together or close to the parents [29–30]. The grandparents' help in childcare has become even more necessary in recent years, which is related to the difficulties of young mothers with children to get good jobs. Professional duties (particularly of women from G I and G II), looking after children (G I and G IV) and household chores (G I and G II) limit the subjects' participation in physical activities. In all likelihood, shorter involvement in physical activities (in years) results from heavy demands of professional and family duties. This seems to confirm the postulated hypothesis that participation of women in physical recreation for many years is determined by fewer and less burdensome professional duties and household chores.

At the same time the conducted analysis of the use of free time by women determines the place of active leisure among their other activities. Women from G I and G II (especially from G II) spent much time watching television on weekdays, whereas most women from G III and G IV devoted 1–2 hours to watching TV, and subjects from G IV watched TV longer than 4 hours very rarely. Similarly, women from G I and G II spent significantly more time (more than 5 hours) watching television than women from G III and G IV (mostly 2 hours).

Doing physical exercises for about 2 hours a week, in comparison with the amount of time spent on watching television every day (1–2 hours during weekdays, 2–3 hours during weekends), leads to a conclusion that women's participation in physical activities for many years is not related to the amount of free time at their disposal. These women find time to participate in physical recreation because they choose to. This confirms the second hypothesis that the main determinant of choice of particular forms of active leisure by women is undertaking physical activities for many years.

The improving socio-economic conditions of women along with more intensive propagation of pro-sport lifestyle standards on television (with the observed growing ratings of various TV programmes) is a chance for physical activation of the Polish society, and Polish women in particular.

Conclusions

1. Professional work, looking after children and household duties limit the leisure time of women and their systematic participation in physical recreation. This limitation is also affected by women's age which interferes with their performance of respective social roles.

2. Women who were involved in physical activities for the shortest time were professionally active mothers with children at the pre-school and school age, who were heavily loaded with the their household duties. At the same time, they spent more leisure time watching television on weekdays and weekends.

3. The comparison of the subjects' weekly amount of time spent on physical exercises and on watching television shows that, despite external barriers, participation in physical activities is more of a matter of the subjects' personal preferences and choices than having free time at their disposal.

4. The main determinant of choice of particular forms of active leisure by women is undertaking physical activities for many years.

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Address for correspondence

Maria Nowak
Zamiejscowy Wydział Kultury Fizycznej
ul. Estkowskiego 13
66-400 Gorzów Wielkopolski, Poland
e-mail: maria-nowak@wp.pl

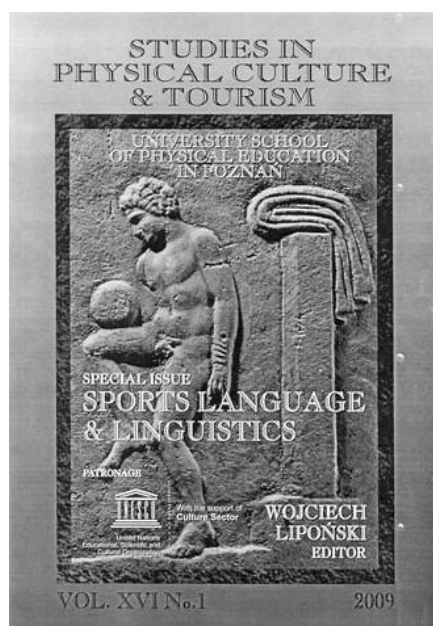


JOURNAL REVIEWS

STUDIES IN PHYSICAL CULTURE AND TOURISM SPECIAL ISSUE: SPORTS LANGUAGE & LINGUISTICS

The study of sport constitutes a research field which borders on all other possible branches of the humanities and sciences. The interdisciplinary character of sport reveals its fascinating relations to biology, physics, culture, society, media, politics and finally linguistics. As far as the last correlation is concerned sport must be viewed a highly renewable source of language (or languages) with its specific terminology, jargons, dialects, grammatical and syntactical features and social and cultural contexts. At the same time various aspects of sport language are becoming subject to rapid changes.

The reviewed special issue of journal *Studies in Physical Culture and Tourism* (Vol. XVI No. 1) devoted to sports language and linguistics is a unique volume, which can serve as a cornerstone of a new branch of sport science – sport linguistics. The SPCT is an English-language journal published by the University School of Physical Education in Poznań, which since its foundation in 1990 has always tackled the interdisciplinary character of sport sciences. Its editor Professor Wojciech Lipoński is a personification of an interdisciplinary scholar. The author of the monumental *Encyclopedia of World Sports* (2003) published in several languages under UNESCO auspices, renowned Anglicist, historian of Olympism, sport and culture Wojciech Lipoński reveals the academic potential of language of sport. Contributors to the volume include prominent sport and physical culture scholars and scientists, sports historians, philosophers, philologists, linguists and journalists from Poland, Greece, Germany, France and the United Kingdom. All of them also happen to be sports lovers and active sports practitioners.



The opening article by Thomas Yiannakis and Soteria Yiannaki focuses on the Greek language as the foundation of the language of global sport. Modern terminology of the Olympic Games and numerous sports has drawn extensively from ancient Greek words and phrases, and the linguistic legacy of ancient Greek sports is still visible in almost all track and field disciplines.

Wojciech Lipoński in his comprehensive study on the distinctiveness of the language of sport places the sport language in a wider linguistic context. He focuses on such areas of linguistics as etymology, lexicology, dialectology, slang and ethnolinguistics as well as on the dominance of particular languages in individual sports. The subsequent sections of the paper concentrate on the oldest sport vocabulary in Polish, the impact of English terminology on global sports, and the sports language in the media with all its grammatical, syntactic and pragmatic intricacies. The article ends with a highly valuable review of the history of lexicography of sport. Lipoński expresses his criticism of the rather superficial interest of general linguists in the area of sport language, revealing at the same time its tremendous albeit fairly neglected potential.

Heiiner Gillmeister's study on the origin and diffusion of European ball games applies methodology of historical linguistics and dialectology to show the cultural developments of various ball games, and refutes some popular stereotypes, e.g. the apparent historical preeminence of British sport in the European context. His thorough analysis of lexical cognates and literary sources presents solid evidence of the complex cultural expansion of different sports in the European past.

The next paper by Jan Ożdżyński discusses the cognitive framework of sports utterances in the media. Ap-

plying the principles of periphrasis derivation, interactive grammar and discourse analysis in the study of sports commentaries the author comes up with very interesting outcomes. Ożdżyński's thorough analysis of both professional and colloquial sports utterances clearly discloses the nature of sport language as a vivid manifestation of feelings and values.

Henryk Benisz raises the discussion of language of sport to a philosophical level. His analysis concerns differences between perception and creation of physical culture set against language theories of Wittgenstein, Chomsky, Bernstein and Lyons. Physical culture is treated by Benisz as a coherent philosophical entity, and language of sport as a way of its perception and creation.

Language of sport in the context of communication and culture is the topic of the article by Jadwiga Kowalikowa. It focuses on the concept of sport jargon with its specific vocabulary, internationalisms, discourse and phonology. Kowalikowa points to the fact that a great number of sport vocabulary items are closely related to the military and warfare. The paper concludes with a thought provoking question whether the characteristic military discourse of sport language is a reflection of re-militarization and brutalization of modern sport.

Two papers consider the issue of language policy with reference to sport vocabulary in Germany and France, where the native sport lexicons have been subject to different mechanisms of change, in particular, language borrowing. Jürgen Buschmann and Mathias Bellinghausen present a review of lexical transformations in present-day German, in particular, the huge impact of anglicisms and hispanisms on the language of football. George-Ray Jabalot presents the official language policy of standardization of new sports terminology by the French government and the French Academy. The author recalls the special status of French as an official language of the IOC, and justifies the seemingly controversial practice of language standardization by stressing the proportional responses of the French government to the social and cultural impact of different world sports on French culture and society.

Agnieszka Borzęcka's article presents a detailed discussion of narration of television sport commentary. Using numerous examples of sports commentaries and utterances on TVP and Eurosport, the author scrutinizes the multidimensional structure of TV sports discourses.

The last four papers included in the volume are devoted to the terminology of particular sports disciplines. In fact, they can be treated as concise, practical glossaries of specialized terms of four sports, with highly informative commentaries reflecting their social and cultural aspects. Fanch Peru discusses the immensely rich terminology of traditional Breton games. His presentation of technical terms and expressions and even spectators' commentaries reflect the wealth of old beliefs, traditions, lifestyle and sense of humor of the native population of Brittany. Ewa Polak in her article on the use of international terminology of various gymnastic sports points to the problem of terminology standardization. She discusses the present-day typology of gymnastics sports, in consideration of their historical origins and then conducts a critical, lexicographic and semantic analysis of a substantial corpus of gymnastic terms. Ewa Polak is the author of the first Polish-English dictionary of gymnastic terms and concepts, a review of which is also included in the volume.

The language of golf is the subject of the paper by John Bromhead from the British Society of Sports History. With great eloquence, sense of humor and loads of famous golf quotations he explains the genuine terms related to golf technique, equipment and course. Bromhead's article can serve as a most useful golf manual to a total layman. Finally, Patrycja Sedlaczek discusses the history, cultural context and terminology of windsurfing. She stresses the English language background of windsurfing terms and their proliferation worldwide.

Sports Language and Linguistics is in many ways a breakthrough publication promoting the diversity of the linguistic dimension of sport, under the official patronage of UNESCO Culture Sector. The value of this work is best illustrated by the words of Wataru Iwamoto, Director of the UNESCO Division of Social Sciences, Research and Policy: "Previously, linguists, with some minor exceptions, have overlooked sport in their research, while sports specialists have not sufficiently appreciated language as an important tool of communication requiring a philological approach. Although this publication cannot exhaust all aspects of the topic, it instigates a vital academic dialogue which will feed into the preservation and promotion of these regional sports dialects as part of human heritage in the future."

Dr Tomasz Skirecki

School of English

Adam Mickiewicz University in Poznań



CONFERENCE REPORTS

THE INTERNATIONAL SCIENTIFIC CONFERENCE “PHYSICAL EDUCATION AND SPORT IN RESEARCH” AND “AGING AND PHYSICAL ACTIVITY”, RYDZYNA, POLAND, September 10–12, 2009

RESOLUTION

The Scientific Conference, which was organized on 10–12 September in Rydzyna, Poland, was attended by over 140 participants from 18 countries. The participants of the Conference adopt this resolution with deep conviction that physical education and sport are an important part of the tradition and cultural heritage of every country. The needs related to promoting and creating conditions for undertaking physical activity by the elderly and people of advanced age constitute medical, economic and social challenges of recent years and foreseeable future. Not only do people want to live longer, but they also want to maintain independence and high quality of life.

Despite the fact that many years ago (1978) UNESCO identified physical education as one of the basic human rights, in some countries physical education is under challenge. It is sometimes suggested by authorities to reduce or even eliminate physical education classes in order to realize cost savings or to focus on other subjects considered to be more “academic”. In many countries, physical education teachers are afforded low status within society. Furthermore, there is often a lack of sports equipment and facilities. The awareness of the significance of physical education for the physical, emotional, social and cognitive development of children and teenagers is very low, not only in Poland, but also worldwide. In contrast, numerous scientific studies have repeatedly found that participating in physical activity is strongly correlated with other numerous elements of healthy lifestyle among children and teenagers.

Alarming phenomena can also be observed in the functioning of professional sport. Sport, in its humanis-

tic doctrine, is based on noble values – equality, justice and fairness in competition, respect for human rights, peaceful cooperation between the people of different races, religions, and countries. Nowadays, it is very common in sport to break traditional moral values, arrange wins and defeats, and use illegal substances. Prejudice and poor sportsmanship by both spectators and competitors with little respect for ethics and sporting values too often characterizes modern sporting events. Participants in the 2009 Rydzyna Congress believe that sport can and should cultivate the highest moral values and be a role model of good customs and respect for others.

In recent decades we have observed a dramatic worldwide increase in the impact of diseases which are directly caused by sedentary lifestyles. Many scientific studies have demonstrated the role that physical activity plays in the prevention of chronic diseases and preservation of functional independence. There is now strong evidence that regular physical activity can help to increase life expectancy. In addition, physical inactivity and sedentary behavior is implicated in the alarming increase in overweight and obesity throughout the world. Physical activity has been shown to be associated with a reduction in cardiovascular diseases, obesity, hypertension, diabetes, osteoporosis, depression, falls, and various injuries. Physical activity also improves muscular strength and endurance which is especially important for older persons who face limitations in their ability to perform activities of daily living due to declines in fitness. In addition, physical activity impacts a number of variables related to overall quality of life, including cognitive and emotional function, life satisfaction and feelings of well-being, sexual function, social function, recreation and economic status.

Significant societal benefits are likely to be realized by increasing physical activity among older persons. Older persons have much to contribute to society. Physically active lifestyles help them to maintain their independence and optimize the degree to which they are capable of participating in work and social events. Promoting healthy and active lifestyles will enable the society to benefit from the wealth of experiences and wisdom possessed by seniors in a better way.

Conclusions and recommendations

1. Physical education is a basic human right. It should be conducted while taking into account the needs and interests of all children. Physical education should focus on both preparing for physical activity and healthy living, as well as for developing motor skills and literacy. These benefits apply not only to children but also to adults and the elderly.

2. The quality of physical education depends mainly on the level of qualifications and the knowledge, skills, and abilities of physical education teachers. Special attention should be paid to the preparation of teachers charged with carrying out physical education classes in kindergarten and primary schools.

3. It is necessary to guarantee a proper place for physical education in school curricula and provide children and teenagers with wider access to sports equipment and facilities outside school. In this way, governments and local communities can demonstrate their understanding for the need for physical education and health and emphasise the educational role of frequent participation in physical activity in and outside the school setting.

4. The development of contemporary professional sport, intensive training and increasing financial and other pressures require the application of state-of-the-art advances in social, psychological, biological, and medical sciences in order to safeguard the health and well-being of athletes.

5. The popularity of sport provides us with an opportunity to shape the patterns of social behaviour and demonstrate real authority and moral values. The greatest efforts should be undertaken to eliminating the use of illegal substances, and towards implementing rules of fair play for all. We should re-emphasize the integrative, aesthetic and spiritual value of sporting events. Without these factors sport is dehumanized, it loses its moral and social value.

6. Governments and local authorities should support policies and programs which provide opportunities for physical activity participation for persons of all ages. These opportunities should include regular physical education classes for children, as well as increased programs and facilities for middle-aged and older adults.

7. Universities and colleges should place greater emphasis on educating students about the importance of physical activity for persons of all ages and abilities. Particular attention should be paid to preparing future generations of researchers and health professionals to help meet the needs of all citizens.

REPORT

On 10–12 September 2009, in Rydzyna near Leszno, the International Scientific Conference „Physical Education and Sport in Research” and „Aging and Physical Activity” was held. The Chairman of the Organising Committee was prof. dr hab. Wiesław Osiński and the Conference Secretary was dr hab. prof. nadz. Robert Szeklicki. The organisers of this international event were the Jan Amos Komeński State School of Higher Vocational Education in Leszno, the Eugeniusz Piasecki University School of Physical Education in Poznań, the University School of Physical Education in Wrocław and the International Association of Sport Kinetics.

140 participants from Iraq, Japan, South Korea, the USA and 13 European countries took part in the Conference. Among special guest lecturers were the most outstanding international scholars. The language of the Conference was English.

The scientific programme of the Conference included 3 plenary sessions with 6 speakers, 9 sessions with 52 talks and 2 poster sessions with 114 presentations. The following lectures were presented during plenary sessions: (1) Robert M. Malina (USA) “Physical activity in childhood and adolescence: implications for adult health outcomes”, (2) Josef Wiemeyer (Germany) “Serious games in prevention and rehabilitation”, (3) Włodzimierz Starosta (Poland) “Muscle relaxation ability in physical education and sport”, (4) Peter O'Donoghue (Great Britain) “Relative age in elite junior tennis”, (5) Anita Hökelmann, Peter Blaser, Andre Müller (Germany) “Senior fitness through music and dance – a study about cognitive and balance abilities”, (6) Wojtek Chodzko-Zajko, Andiana Schwingel (USA) “International strategies for the promotion of physical activity and high quality of life in older adults”.

The participants also had the possibility to visit the Rydzyna Castle and take part in a traditional sports show. Numerous meetings made it possible to establish scientific contacts.

The Conference resulted in adopting a Resolution which presents the most important problems faced by local communities and the governments of different countries, related to contemporary physical education, sport, recreation and supporting physical activity in older age. The Resolution is available in Polish and English at “<http://www.rydzyna2009.pwsz.edu.pl/>”.

Adam Kantanista
University School of Physical Education in Poznań



COMPETITION

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

Submission requirements:

- Only papers published in the year prior to the date of competition may be submitted
- Papers (offprints) must be sent before the end of March of each year to the Organizers' address:

Akademia Wychowania Fizycznego
Katedra Dydaktyki Wychowania Fizycznego
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tel. 0 (prefix) 71 347-31-69, fax 348-25-27
www.awf.wroc.pl/czabanski
e-mail: olepio@awf.wroc.pl

- Independent academics must not take part in the competition
- Former award winners must not take part in the competition
- A research paper can be a team work effort, but the team of authors must not include an independent academic

Evaluation criteria:

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

Jury:

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

- Prorector for Research
- Head of Chair of Physical Education Didactics
- Head of Chair of Swimming

The jury convenes annually on **April 24**. The jury's final decision will be made available to all participants. Only one paper is awarded with the prize (diploma of merit and 1.000 PLN).

The award is presented each year during the inauguration ceremony of the academic year at the University School of Physical Education in Wrocław, Poland.



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Redakcja półrocznika *Human Movement* przyjmuje do publikacji oryginalne prace empiryczne oraz przeglądowe dotyczące ruchu człowieka z różnych dziedzin nauki (m.in. medycyny sportu, fizjologii wysiłku fizycznego, biomechaniki, antropomotoryki, socjologii, psychologii, pedagogiki) w zakresie wychowania fizycznego, zdrowotnego, rekreacji i turystyki, rehabilitacji, fizjoterapii. Przyjmowane są również listy do Redakcji, sprawozdania z konferencji naukowych i recenzje książek. Prace mogą być napisane w języku polskim lub angielskim. Teksty polskie po uzyskaniu pozytywnej recenzji są tłumaczone na język angielski przez Redakcję. Autorzy nie otrzymują honorarium.

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Tekst prac empirycznych wraz ze streszczeniem, rycinami i tabelami nie powinien przekraczać 20 stron, a prac przeglądowych – 30 stron znormalizowanych formatu A4 (ok. 1800 znaków na stronie, złożonych 12-punktowym pismem Times New Roman z zachowaniem 1,5 interlinii). Redakcja przyjmuje teksty przygotowane wyłącznie w edytorze tekstu Microsoft Word. Strony powinny być ponumerowane.

The *Human Movement* journal, issued semi-annually, accepts for publication original papers and review papers in various aspects of human movement (e.g., sociology, psychology, pedagogy, exercise physiology, biomechanics, motor control, sport medicine) in a broad sense of the term: physical education, recreation, physiotherapy, health and fitness, and sport science. Authors are not paid for their articles. Letters to the Editor, reports from scientific meetings and book reviews are also welcome. Articles written in Polish and English will be accepted. After acceptance, articles in Polish will be translated into English by the Editorial Office.

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Na stronie tytułowej należy podać:

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Przed tekstem głównym należy umieścić streszczenie w języku angielskim, zawierające około 250 wyrazów i 3–6 słów kluczowych (ze słownika i w stylu MeSH). Powinno się ono składać z następujących części: Purpose, Basic procedures, Main findings, Conclusions.

TEKST GŁÓWNY

Tekst główny pracy empirycznej powinien zawierać następujące części: wstęp, materiał i metody, wyniki, dyskusja (omówienie wyników), wnioski, podziękowania (jeżeli potrzebne), przypisy (jeżeli występują), piśmiennictwo (zawarte tylko w bazach danych, np. SPORTDiscus, Medline). W pracach innego typu należy zachować logiczną ciągłość tekstu, a tytuły poszczególnych jego części powinny odzwierciedlać omawiane w nich zagadnienia.

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Material and methods. Clearly describe selection of the experimental subjects. Identify their age, sex, and other important characteristics. Identify the methods, apparatus (give the manufacturer's name and address in parentheses), and procedures in sufficient detail to allow other workers to reproduce the results. Give references to established methods, including statistical methods (see below); provide references and brief descriptions for methods that have been published but are not well known; describe new or substantially modified methods, give reasons for using them, and evaluate their limitations. When reporting experiments on human subjects, indicate whether the procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional or regional). The Editors reserve the right to

Wnioski. Przedstawiając wnioski, należy pamiętać o celu pracy oraz postawionych hipotezach, a także unikać stwierdzeń ogólnikowych i niepopartych wynikami własnych badań. Stawiając nowe hipotezy, trzeba to wyraźnie zaznaczyć.

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Results. Present results in a logical sequence in the text, tables, and figures. Do not repeat in the text all the data presented in the tables or illustrations; emphasize or summarize only important observations.

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Acknowledgments. List all contributors who do not meet the criteria for authorship (e.g., a person who provided purely technical help or writing assistance). Financial and material support should also be acknowledged.

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