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Contents

A NOVEL METHOD FOR CALCULATION OF KNEE DEFORMATION ANGLES IN CLINICAL AND SPORT BIOMECHANICS

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Abstract. Biomechanical analyses seek to improve understanding of the mechanisms of knee injury and to find ways to reduce knee injury incidence. Many clinical biomechanics researchers use a standard kinematic adopted from Newington Children's Hospital. Biomechanical studies include the knee joint configurations, where joint architecture immutably constrains and guides movement outcomes. Investigators will default to reporting resultant joint deformation without considering the influence of joint architectural configurations on kinematic responses. The purpose of this study was to develop a new joint angular kinematic method that accounts for influence of dynamic joint architectural configuration on deformation values. Twenty subjects performed unloaded dynamic flexion/extension and 45° cutting maneuver. The knee deformation angles obtained with the new method proposed were compared with the values that obtained using the standard method. One way repeated measurement ANOVA's was used to compare knee deformation angles values from the standard method that uses a static trial and the new method that uses a dynamic trial. The proposed method distinguishes between dynamic joint architectural configuration and joint deformation. Loaded standard abduction/adduction (β) and rotation (γ) angles were 3.4 ±1.8° and 11.2 ±3.8°, respectively. Using the new method, the β and γ angles decrease to 1.5 ±1.4° (<0.05) and 7.1 ±1.8° (<0.05) during cutting. The new method accounted for dynamic joint architectural configuration produced loaded β and γ angles that had smaller magnitudes than the standard method, suggesting that previous studies may have overestimated β and γ angles. Injury management strategies could be influenced by a consideration for dynamic joint architectural configuration. Such a consideration could influence ligament repair strategies. Future studies should account for dynamic configuration when establishing the influence of joint deformation on graft design and appropriate isometry values during reconstruction.

Key words: Knee Deformation, Joint Architecture, Knee Injuries, Kinematic, Orthopaedic Surgery, Cutting Maneuver

Introduction

Knee injuries are common in daily and exercise activities and amount to between 12% and 19% of all injuries (Arendt, Dick, 1995; Swenson et al., 2013). Anterior cruciate ligament (ACL) injuries create substantial financial impact with costs related to orthopaedic care and rehabilitation in the United States reaching approximately $850 million each year. (Di Stasi, Myer, Hewett, 2013; Griffin, Agel, Albohm, 2000) Additional evidence suggests that when the knee is flexed less than 40° represents the most unprotected range for ACL tears as consistently

reported in cadaveric (Kanamori, Woo, Ma, 2000; Markolf, O'Neil, Jackson, 2004), in vivo (Heijne, Fleming, Renstrom, 2004; Pedowitz, O'Connor, Akeson, 2003) and computer simulation (Pandy, Shelburne, 1997; Pflum, Shelburne, & Torry, 2004) studies of ACL strain or force. Biomechanical analyses seek to improve understanding of the mechanisms of knee injury and to find ways to reduce knee injury incidence (Di Stasi et al., 2013; Haddas, James, Hooper, 2015; Haddas, Yang, Sizer, 2015; Jung et al., 2013; Liu-Barba, Hull, Howell, 2007; Patzkowski et al., 2012). These biomechanical studies usually include analysis of knee joint deformation, where joint architecture immutably constrains and guides movement outcomes (Liu-Barba et al., 2007; Wilson, Feikes, Zavatsky, O'Connor, 2000). Second, they attempt to assess resultant knee joint torques that could produce joint deformation, or changes in the architecture that could change the movement outcomes (Besier, Lloyd, Ackland, Cochrane, 2001; Liu-Barba et al., 2007; Uygur, Richards, Jaric, Freitas, Barlow, 2009).

Deformation defines as segment change in orientation as a result of the application of external stress to it, which cause increase/decrease in angular movement (Schafer, 1987). Unfortunately, investigators will default to reporting resultant joint deformation without considering the influence of joint architectural configurations caused by bone structure, articular cartilage, muscles and ligaments on kinematic responses (Chow, Hemleben, Stokic, 2009; Ferber, Davis, Williams, 2003; MacLean, Davis, Hamill, 2006; Malinzak, Colby, Kirkendall, Yu, Garrett, 2001; Pollard, Davis, Jamill, 2004; Uygur et al., 2009). This shortfall could lead to error in estimating joint kinematic responses that relate to performance and injury.

Cadaveric research supports in-vivo consideration for joint configuration changes during joint kinematic measures (Liu-Barba et al., 2007; Wilson et al., 2000). Several investigators have reported configuration changes in the directions of varus/valgus and internal/external rotation when measuring flexion/extension movements in cadaveric knees (Blankevoort, Huiskes, de Lange, 1988; Liu-Barba et al., 2007; Wilson, Feikes, O'Connor, 1998; Wilson et al., 2000).

Many clinical biomechanics researchers use a standard kinematic method proposed by Davis et al. and Kadaba et al., adopted from Newington Children's and Helen Hayes Hospitals, which serves to define joint kinematic and kinetic responses during human movement (Davis, Ounpuu, Tyburski, Gage, 1991; Kadaba, Ramakrishnan, Wootten, 1990). These investigators adopted a standard method for calculating knee joint angular positions and motions necessary for assessing injury risk. As a preliminary step before collecting any trial in this method, the investigators attempt to collect a standing static trial in order to "zero" the joints angles during subject analyses. This defines the starting place for subsequent movement measurement (Davis et al., 1991; Kadaba et al., 1990).

Using a static trial in order to calculate the resultant joint deformation angle at the knee as determined by the standard method is commonly troubled by an important methodological problem. The standard static trial does not account for lax ligament, cartilage deficiencies, bony abnormalities, and tightness of structures surrounding the joint during dynamic configuration. While traditional method may account for the influence of static joint architectural configuration on deformation angles, they do not account for the influence of dynamic configuration on those same angles. This could lead to error in kinematic calculations involved in basic and science, as well as clinical assessment and management strategy choices in the orthopaedic population.

The knee is a triplanar joint with kinematic coupling between flexion/extension, varus/valgus, and internal/external rotation (Andriacchi, Koo, Scanlan, 2009). As a consequence of joint architectural configuration, the obliquity of the actual anatomical knee flexion/extension axis relative to the long axes of the thigh and shank produce knee varus/valgus and internal/external rotation angular displacement (Liu-Barba et al., 2007; Wilson et al.,

1998). Additional external loading, which potentially create a torque or stress, during an activity may potentially produce additional varus/valgus and internal/external rotation angular displacement depending on the magnitude of the external loading and the geometry and integrity of the knee joint. In other words, the dynamic knee motion (without any additional external load) may already exhibit varus/valgus and internal/external rotation angles. Thus, any measures of joint architectural configuration and any use of those measures when determining deformation angles must account for the changes in joint axis obliquity through the range of motion that influence a dynamic joint architectural configuration outcome.

Kinematic measurement accuracy is essential when assessing kinematic and kinetic calculations (i.e. joint angular accelerations, joint powers etc.). Small errors in these calculations could lead to larger errors in further calculations germane to biomechanical assessment of the entire lower quarter. Practically, similar errors may change perspectives on ligament graft isometry, design and use of dynamic joint bracing, joint replacement and limb prosthetics (Fitzpatrick, Clary, Laz, Rullkoetter, 2012; Jung et al., 2013; Kent & Franklyn-Miller, 2011; Patzkowski et al., 2012).

There is a reasonable solution to the problems associated with discounting the influence of dynamic joint architectural configuration on deformation values. Accurate deformation values could be calculated by subtracting the angles of the relatively unloaded dynamic trial from those of the loaded condition. However, the issue is more complex, since the varus/valgus (β Cardan angle) and internal/external rotations (γ Cardan angle) of the knee in the dynamic trial condition should be expected to vary throughout the range of knee flexion/extension, as witnessed in the previously described cadaveric studies (Liu-Barba et al., 2007; Wilson et al., 1998; Wilson et al., 2000). To account for this complexity, a dynamic trial that assesses architectural configuration throughout the entire range of knee motion can be used to establish the dependence of the β and γ Cardan angles upon the simple knee flexion angle (α). Subsequently, these β and γ angles can be subtracted from those of loaded trials to calculate the β and γ deformations of the knee that were only due to the external load and not due to the external load and joint architectural configuration.

The purpose of this study was to develop a new joint angular kinematic method that distinguishes between dynamic joint architectural configuration and joint deformation. The proposed method is innovative and unique, in that it is the first to consider the influence of dynamic architectural configuration trial values on calculating knee deformation angles.

Methods

Twenty subjects (ten male (1.87 ±0.11 m, 90 ±14 kg) and ten female (1.67 ±0.11 m, 69 ±19 kg) participated in the investigation. All the subjects were healthy varsity basketball players. All participants read and signed an informed consent form approved by the affiliated university's Institutional Review Board for the protection of human subjects. The subjects performed six slow dynamic trial knee flexion/extension of the right shank on the femur while sitting in open kinetic chain from proximally 90° to 180° (full extension). The subjects performed three cutting maneuver which they ran forward 8 meters at a moderate target speed of 5.5–6.5 m/s, stepped on the force platform with the right leg, and executed a 45º angle cutting maneuver to the left. All trials, the dynamic and the cutting maneuver were averaged. Six Vicon cameras (Oxford Metrics, Ltd., Oxford, United Kingdom) captured the motions of spherical reflective markers attached to the subjects' skin, at a sampling rate of 100 Hz and calculated 3D coordinates for the markers. The instants of right foot landing and takeoff in the cutting maneuver were determined

using an AMTI Model OR6-7-1000 force platform embedded in the floor (Advanced Mechanical Technology, Inc., Watertown, MA) synchronized with the Vicon and gathering data at a sampling rate of 1000 Hz. Ten spherical reflective markers were attached to the subjects' skin in the following locations: left and right anterior superior iliac spines (ASIS); left and right posterior superior iliac spines (PSIS); medial and lateral of the femoral epicondyles of the right leg; medial and lateral malleoli of the right leg.

The positions of the ASIS bony landmarks were estimated from the positions of the ASIS marker centers, the distance from each marker center to the corresponding ASIS bony landmark, and a convergence angle in the transverse plane of the pelvis. The distance from the ASIS marker center to the ASIS bony landmark was the sum of the 15.7 mm distance from the marker center to the skin and 8 mm of estimated tissue thickness (Bush & Gutowski, 2003). The right hip joint was estimated to be located at distances of 36%, 22% and 30% of pelvic width laterally, posteriorly and caudally, relative to the midpoint between the ASIS bony landmarks (Bell, Brand, Pedersen, 1989; Seidel, Marchinda, Dijkers, Soutas-Little, 1995). The right knee was calculated as the midpoint between the medial and lateral knee markers, and the right ankle as the midpoint between the medial and lateral ankle markers. Quintic spline functions were fit to the time-dependent coordinates of each body landmark with a smoothing factor equivalent to a 15 Hz digital filter (Woltring, 1986).

Two non-inertial right-handed orthogonal reference frames were defined for the thigh (R_T), and shank **(**R_S**)** of the right lower extremity. The 3D orientations of the three axes of R_T and R_S were calculated for all times of the dynamic trials. The knee configuration was calculated for every normalized time-point of the dynamic trial. This was expressed in terms of the three Cardan angles (α, β and γ) that would be needed to rotate R_S into an orientation identical to that of R_T in α-β-γ order of rotations.

The α, β and γ angles of the shank relative to the thigh were calculated for the loaded cutting conditions. The predicted β and γ angles of the dynamic trial were then subtracted from the β and γ angles of the loaded condition to calculate, respectively, the deformations of the knee joint in the directions of varus/valgus (β) and internal/external rotation (γ) during the loaded trial. The average knee deformation angles between landing to take off obtained with the new kinematic method proposed using a dynamic trial were compared with the average values that would have been obtained using the standard kinematic method with a static trial for each subject. One way repeated measurement ANOVA's were used to compare knee deformation angles values from the standard method that using a static trial and the new method that using a dynamic trial.

Results

The proposed joint angular kinematic method, using a dynamic trial instead of static trial, distinguishes between dynamic joint architectural configuration and joint deformation. The polynomials of the β and γ versus simple knee angle (knee flexion) relationships was plotted in the all dynamic trials (Figures 1 and 2). The dynamic trial β values showed little intra-subject variability, but γ values were more variable as supported by the literature (Table 1) (Blankevoort et al., 1988; Liu-Barba et al., 2007; Wilson et al., 1998; Wilson et al., 2000).

Analysis of the dynamic maneuver with the new kinematic method proposed produces smaller deformation values compared to the standard kinematic method (Table 1, Figure 3). The mean and standard deviation (SD) of static trial abduction/adduction (β) and internal/external rotation (γ) angles were 0.9 $\pm$0.7° and 2.1 $\pm$2.0°, respectively. The mean and SD of dynamic trial abduction/adduction (β) and internal/external rotation (γ) angles were 3.3 $\pm$1.9° and 4.9 $\pm$3.2°, respectively. The relationships of β and γ with simple knee angle (knee flexion) was plotted with all

Table 1. Descriptive (mean ± SD) results for mean knee joint angles using the standard method (using static trial) and the suggested method (using dynamic trial) during a cutting maneuver for all subjects (n = 16)

	Beta		Gamma	
Static Trial	0.9 ±0.7		2.1 ±2.0°	
Dynamic Trial	3.3 ±1.9		4.9 ±3.2°	
	Beta-Static	Beta-Dynamic	Gamma-Static	Gamma-Dynamic
Cutting Maneuver	3.4 ±1.8°	1.5 ±1.4°*	11.2 ±3.8°	7.1 ±1.8°*

* P ≤ 0.05, significant difference between methods.

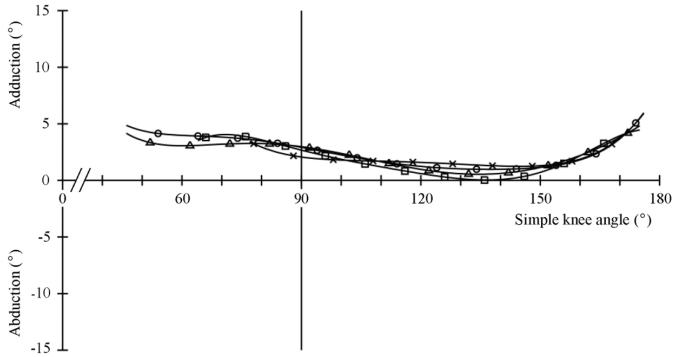

Figure 1. Polynomials of the β versus simple knee angle (180 degrees represent full extension) in the relatively unload dynamic trials of a representative subject

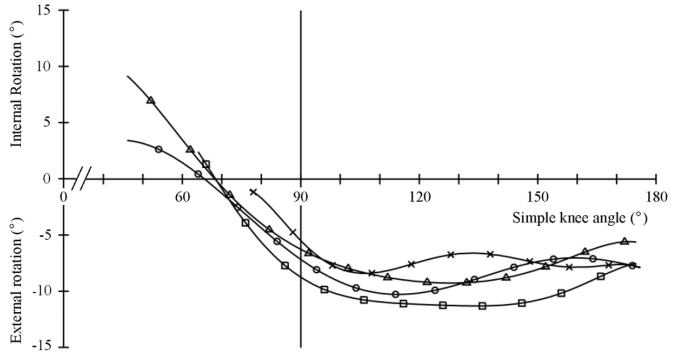

Figure 2. Polynomials of the γ versus simple knee angle (180 degrees represent full extension) in the relatively unload dynamic trials of a representative subject

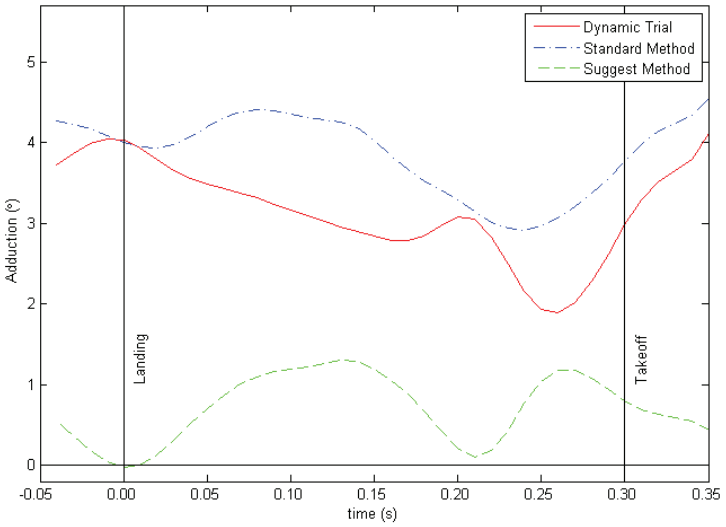

Figure 3. Knee architecture and knee deformation (β) using the standard method versus the suggested method during cutting maneuver

available dynamic trials, and the 6th degree polynomials fitted to the β and γ angles. Using the standard kinematic method when taking to account the static trial only, loaded standard β and γ angles were 3.4 ±1.8° and 11.2 ±3.8°. Using the new method when taking to account the dynamic trial, the β and γ angles were 1.5 ±1.4° ($P < 0.05$) and 7.1 ±1.8° ($P < 0.05$) during cutting (Table 1).

Discussion

The purpose of this study was to develop a new joint angular kinematic method that accounts for the influence of dynamic joint architectural configuration on deformation values using a dynamic trial instead of dynamic one. The new method accounted for dynamic joint architectural configuration produced loaded β and γ angles that had smaller magnitudes than the standard method. The results of the current analyses suggest that previous studies overestimate β and γ angles by using the standard kinematic method based on static trials (Chow et al., 2009; Davis et al., 1991; Ferber et al., 2003; Kadaba et al., 1990; MacLean et al., 2006; Pollard et al., 2004; Uygur et al., 2009). By using the standard kinematic method, results reported by previous studies may have failed to exclude dynamic joint architectural configuration when reporting joint deformation values, thus distorting their outcomes.

Our findings support previous cadaveric studies that exhibited a distinction between knee joint architecture and knee deformation angles and reflected structural differences between different knee specimens (Blankevoort et al., 1988; Liu-Barba et al., 2007; Wilson et al., 1998; Wilson et al., 2000). The results of the current study support that dynamic joint architectural configuration in the knee already create varus/valgus and internal/external rotation structural angles (Figures 1 and 2). The β and γ values, when using a static trial, represent the knee architectural configuration and joint deformation as knee deformation, whereas using a dynamic trial for dynamic joint architectural configuration reduces knee deformation angle outcomes (Figure 3, Table 1). The β and γ angles

of the dynamic trial motions demonstrated a moderate tendency to follow patterns similar to those of the loaded activities. Therefore, the β and γ angles using the new proposed method generally reached less extreme values versus using the standard method.

While considerable attention has been given to the influence of joint deformation on human performance, (Besier et al., 2001; Ferber et al., 2003; MacLean et al., 2006; Malinzak et al., 2001; Pollard et al., 2004) a consideration for dynamic joint architectural configuration on that performance is wanting. The influence of such configurations on joint kinematics and kinetics during high performance and duress must be examined. Any conclusions could fine tune training strategies based on dynamics changes in loading throughout the joint range.

Along to our findings, the new method has several limitations: (1) different dynamic trial position should be considered; (2) we acknowledge limitations associated using the marker set including skin movement, anthropometric model, system tracking error and data smoothing procedure error; and (3) this method should be examined on people with knee pathology.

Conclusion

The findings from this new kinematic method could potentially improve the understanding of the mechanisms that produce injury. Any overestimation when reporting joint deformation may result in overlooking other underlying factors that influence injury.

Injury management strategies could be influenced by a consideration for dynamic joint architectural configuration. Such a consideration could influence ligament repair strategies. Future studies should account for dynamic configuration when establishing the influence of joint deformation on graft design and appropriate isometry values during reconstruction. To date, investigators have not accounted for dynamic joint architectural configuration in the design and use of dynamic joint bracing and limb prosthetics. Such a consideration could influence the dynamics of the brace or prosthetic articular mechanism, thus influencing design and production. Finally, dynamic joint configuration should be considered when addressing the challenges joint prosthetic design, production and implantation using the proposed new kinematic method for calculating dynamic knee configuration angles.

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SHORT COMMUNICATION: THE ROLE OF DIFFERENT BODY-RELATED VISUAL CUES IN SYNCHRONIZED TRAMPOLINING

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Abstract. Visual information is thought to be a dominant information source when performing whole-body movements in gymnastics. Visual information can furthermore facilitate performance when being engaged in situations of interpersonal coordination that may occur in sports such as synchronized trampolining. The question arises, which body-related visual cues are most important in the emergence of behavioral synchronization between two gymnasts in synchronized trampolining? To address this question, advanced gymnasts were asked to synchronize their performance to video-sequences of a model gymnast, while body-related visual cues of the model gymnast were systematically manipulated. Results revealed, first that biological motion cues are more important than non-biological motion cues, and second that the perceived motion of the arms seems to drive synchronicity in synchronized trampolining. It is stated, that biological visual information of the arms is a dominant visual information source when performing leaps in synchronized trampolining.

Key words: visual perception, trampoline gymnastics

Introduction

Perception and action are tightly coupled in the performance of complex skills in sports (Raab, de Oliveira, Heinen, 2009; Warren, 2006). When a gymnast performs leaps on the trampoline, the perception of the trampoline bed in relation to the position of the gymnast when airborne supports the estimation of landing on the trampoline bed, and thus can help to prepare the subsequent leap (Hondzinski, Darling, 2001; Luis, Tremblay, 2008). Perceptual information can furthermore facilitate athlete's performance when being engaged in situations of interpersonal coordination that may occur in sports such as synchronized trampolining (Heinen, Koschnick, Schmidt-Maaß, Vinken, 2014; Schmidt, Fitzpatrick, Caron, Mergeche, 2010). However, the question arises which body-related perceptual cues are most important in the emergence of synchronicity between two gymnasts in synchronized trampolining?

Behavioral synchronization occurs in rather simple interpersonal coordination tasks (Schmidt, Turvey, 1994), more complex everyday tasks (Richardson, Marsh, Isenhower, Goodman, Schmidt, 2007; Schmidt et al., 2010), as well as in more complex sport-specific tasks (Vesper, van der Wel, Knoblich, Sebanz, 2013). From a theoretical point of view, it is argued that the emergence of interpersonal coordination strongly relies on shared internal representations between action perception, action planning, and action execution (Blake, Shiffrar, 2007; Prinz, 1997; Sebanz, Knoblich, 2009). Thus, in synchronized trampolining, behavioral synchronization may occur when both gymnasts are connected on an informational level. Each gymnast utilizes his/her internal representations of the task at hand to predict the movements of the other actor with the aim of achieving a high degree of behavioral synchronization (Sebanz, Knoblich, 2009).

Visual information is thought to be a dominant source of information when performing skills such as leaps or somersaults (Heinen, 2011; Raab et al., 2009). It is thought that human's visual system is most sensitive to biological motion thereby utilizing different visual cues depending on aspects such as level of expertise as well as on the skill to be performed when performing complex tasks in sport (Blake, Shiffrar, 2007; Mann, Williams, Ward, Janelle, 2007). In synchronized trampolining, two trampolines are placed side by side and two gymnasts perform the same routine at the same time (Kelly, 2014). Both gymnasts could (peripherally) see each other's body movements during performance, and both gymnasts could also hear each other's sounds when being in contact with the trampoline bed during a leap. Given the task constraints in synchronized trampolining, gymnasts are coupled on an informational level and may use this information directly in order to coordinate their own movements with the movements of the gymnast on the other trampoline (Schmidt et al., 2010; Withagen, Michaels, 2005).

In synchronized trampolining, visual information content is first and foremost composed of body-related visual cues of the gymnast on the second trampoline, as well as his/her body movements, and his/her current state of motion. Nevertheless, it is questionable, *which* body-related visual cues are most important in the emergence behavioral synchronization between two gymnasts in synchronized trampolining? In order to address this question, body-related visual cues of the gymnast on the second trampoline were systematically manipulated by utilizing an occlusion paradigm (Magill, 2007). Gymnasts were asked to synchronize their performance to a model gymnast. It was hypothesized that full visual information should lead to the best degree of behavioral synchronization when performing straight leaps. Systematically occluding body-related visual cues should hamper synchronicity. There was no assumption on which visual cue/s may be most important in the emergence of behavioral synchronization but we sought to explore the role of different body-related visual cues in behavioral synchronization. It was additionally expected that visual information containing biological information should enhance synchronicity as compared to visual information containing no biological information.

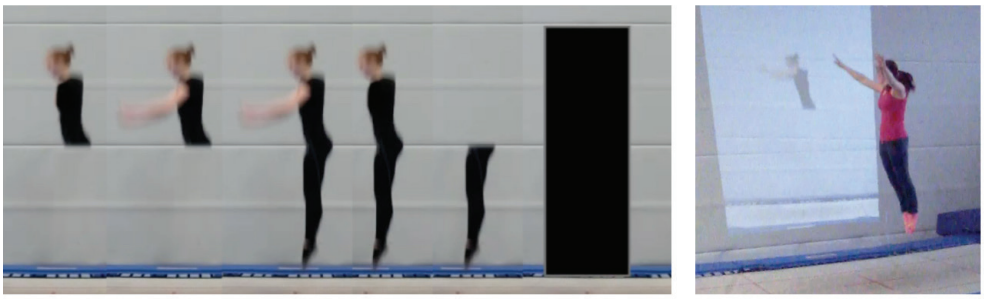
Material and Methods

Participants

N = 17 trampoline gymnasts participated in this study. Gymnasts were active gymnasts with at least seven years of experience in training and competition (age: 17 ±2 years). It was decided to recruit advanced gymnasts to assure that they were already attuned to the relevant visual cues that guide their action (Vickers, 2007). Gymnasts were informed about the general purpose and the procedures of the study. They had normal or corrected-to-normal vision and gave their written consent prior to the study. The study was carried out according to the local universities' ethical guidelines.

Task and Measures

Movement Task. The movement task was to perform straight leaps on a trampoline in six experimental conditions. The trampoline was arranged, as it would have been in an international competition in synchronized trampolining, with elevated safety mats in front and behind the trampoline as well as along both sides of the trampoline. The trampoline was placed next to a curtain that was let down from the ceiling of the gymnasium. A data projector was placed behind the trampoline in a way that a full-size video sequence of a gymnast performing straight leaps on a trampoline could be projected on the curtain, thereby reflecting the perspective the gymnast would have had when performing synchronized leaps together with a second gymnast (see Figure 1).



a) b)

Figure 1. a) Screenshot of the six experimental conditions in this study (from left to right): 1 – occlusion of legs and arms, 2 – occlusion of legs, 3 – full visual information, 4 – occlusion of arms, 5 – occlusion of head, trunk, and arms, 6 – black rectangle. b) Photograph of the procedure of the study: The video sequence of the model was projected to a silver screen on the right side of the gymnast, mimicking the perspective when performing leaps with a partner in synchronized trampolining

A video sequence of a model gymnast was played back on the curtain in each of the six experimental conditions. The task of the gymnast was to adapt his/her leaps to the leaps performed by the model gymnast. He/she was asked to verbally indicate as soon as he/she subjectively felt to perform synchronously with the video sequence of the model gymnast. After that, he/she should perform another 15 leaps on the trampoline, which were used for later data analysis (see below).

Manipulating Visual Cues. The first experimental condition reflected gymnasts' natural situation in synchronized trampolining. In another four experimental conditions body-related visual cues were systematically occluded. This resulted in the following five conditions: 1 – occlusion of legs and arms, 2 – occlusion of legs, 3 – full visual information, 4 – occlusion of arms, 5 – occlusion of head, trunk and arms. An additional experimental condition comprised a black rectangle. The rectangle contained no body-related visual cues but only reflected the temporal coordination of the leaps.

Temporal Analysis. Gymnasts' temporal coordination was assessed by means of a digital video camera that was placed 15 m away from the trampoline at an angle of approximately 45° towards the middle of the trampoline bed (sampling rate: 240 Hz). The camera was arranged in a way that it was able to picture the feet of the gymnast when being in contact with trampoline bed together with the model video sequence projected on the curtain.

From the 15 leaps that were defined by the gymnast as being performed synchronously (see above), another ten leaps were used for further analysis. The absolute values for touchdown times of gymnasts' feet as well as model's feet on the trampoline bed during ten leaps were analyzed. Each touchdown was defined as the first visible contact of gymnasts' and models' feet with the trampoline bed. The mean absolute temporal error between gymnasts' and models' touchdown times was calculated as an indicator of synchronicity (Magill, 2007). An absolute temporal error of 0 would have reflected perfect synchronicity between the gymnast and the model, whereas the larger the temporal error value, the less synchronous the leaps between gymnast and model were.

Procedure

In the first phase of the study, each individually tested gymnast arrived at the gymnasium, was informed about the general purpose and procedure of the study, and completed the informed consent form. The gymnast was given a 20-minute warm-up phase during which he/she was allowed practice trials of straight leaps on the trampoline (Enoka, 2002). In the second phase the gymnast was asked to adapt his/her leaps to the leaps performed by the model gymnast projected as a video sequence on the silver screen (see Temporal Analysis). The full visual information condition was always presented at first to the gymnast. The other five experimental conditions were presented in a randomized order. Gymnasts were allowed to take breaks as requested. The third phase of the study took place after a gymnast completed all experimental conditions. The gymnast was debriefed and received a small gift for participation.

Data Analysis

A significance criterion of $\alpha = 5\%$ was defined for all reported results. In order to test the main hypothesis, an analysis of variance with repeated measures was calculated including the mean absolute temporal error between gymnasts' and models' touchdown times as dependent variable. Experimental condition (1 – no legs and no arms, 2 – no legs, 3 – full visual information, 4 – no arms, 5 – no head, no trunk and no arms, 6 – black rectangle) was treated as independent variable. Cohen's *f* was calculated as an effect size (Cohen, 1988).

Results

It was hypothesized that full visual information should lead to the best synchronicity when performing straight leaps in synchronized trampolining. Systematically occluding visual cues should hamper synchronicity. There was no assumption on which visual cue/s may be most important in the emergence of behavioral synchronization but we sought to explore the role of different body-related visual cues in behavioral synchronization. It was additionally expected that visual information containing biological information should enhance synchronicity.

Results revealed a significant main effect of Experimental Condition on mean absolute temporal error, $F(5, 80) = 2.36$, $p < 0.05$, Cohen's $f = 0.38$ (see Figure 2).

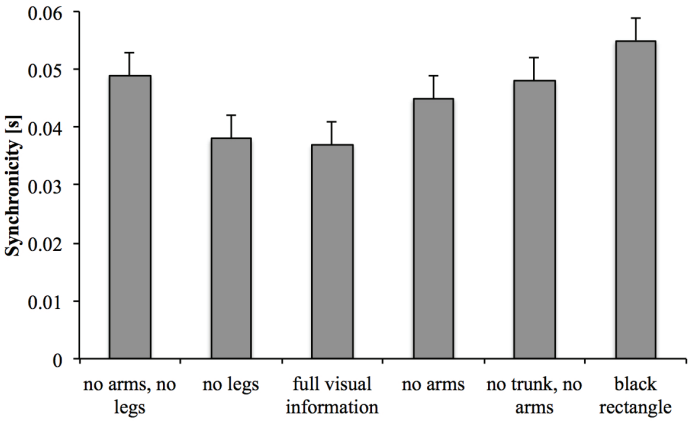


Figure 2. Mean absolute temporal errors reflecting synchronicity (±SE) between gymnast and model in the experimental conditions. The lower the values, the more synchronously the leaps between gymnasts and model were

Gymnasts exhibited best synchronicity in both, the full visual information condition and in the condition where the legs were occluded but the arms were visible. Conditions in which the arms were occluded comprised worse synchronicity, and the black rectangle condition comprised worst synchronicity.

Discussion

In this study, the role of different body-related visual cues in the emergence of synchronicity in synchronized trampolining was assessed. Gymnasts were asked to synchronize their performance to video-sequences of a model gymnast, while body-related visual cues of the model gymnast were systematically manipulated. Taking the results of the current study together it becomes apparent, first that biological motion cues are more important than non-biological motion cues in synchronized trampolining. Gymnasts exhibited the worst degree of behavioral synchronization when they adapted their leaps to a black rectangle that only reflected the model gymnast's temporal coordination of the leaps but comprised no further body-related visual information. Second, the perceived motion of the arms seems to drive behavioral synchronization in synchronized trampolining. Gymnasts exhibited the best degree of synchronicity in experimental conditions where the arms of the model were visible.

The visual system of humans is highly sensitive to the perception of biological information implying a tight coupling between observation and performance of the same action, which might relate to some common representation of observation (perception) and action, and thus enhance the use of the corresponding information (Blake, Shiffrar, 2007). In synchronized trampolining, behavioral synchronization may benefit from the perceived biological motion of each gymnast thereby utilizing his/her internal representations of the task at hand to predict to movement of the other gymnast (Sebanz, Knoblich, 2009). When referring to the different body-related visual cues of the gymnast on the other trampoline, particularly the perceived motion of the arms seems to drive behavioral synchronization in synchronized trampolining. The arms are thought to be at least partly responsible for a fine-tuning of vertical impulse when performing leaps (Enoka, 2002). Perceiving the dynamics of the arms in relationship with other visual cues could thus lead to a better estimation of the flight phase, which may help one gymnast to

adapt his/her leaps to the other gymnast. Additionally, the movement of the arms of the gymnast on the second trampoline may be more salient to the gymnast on the first trampoline due to their greater spatio-temporal dynamics as compared to the movement of the legs or the trunk.

There are several practical implications of this study and one should be highlighted. Achieving a high degree of behavioral synchronization is a key element in synchronized trampolining because it is an important judging criterion, and therefore directly related to successful performance (Freeman, 2007). As a consequence, beginning trampoline gymnast's attention should be directed towards the arms as a relevant informational cue in the emergence of behavioral synchronization in synchronized trampolining. This could be achieved by integrating different forms of perceptual training into skill acquisition processes (Abernethy, Wann, Parks, 1998). Either highlighting (e.g., by using point-lights) or occluding (e.g., by using background-colored clothing) could be fruitful approaches to direct and/or focus learner's attention to different visual cues in synchronized trampolining.

Taken the results of the current study together, it is stated, that biological visual information of the arms is a dominant information cue in the emergence of behavioral synchronization in synchronized trampolining.

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CALORIC RESTRICTION DIET (CR DIET) OR MEDITERRANEAN DIET (MD) – WHICH IS THE BEST CHOICE FOR FORMER ATHLETES?

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Abstract. Overweight or obesity which often develop in athletes who end their careers is one of the most important issues of the world of sport. During aging, an increase in the amount of intra-abdominal fat is observed; this fat increases the risk of such metabolic disease as diabetes or hypertension.

The participants of the study were 94 males. The people were randomly assigned to one of 2 groups: group 1 – people using the diet based on calorie restriction CRON (n = 32), and group 2 – those who followed the recommendations of the Mediterranean diet (n = 34). The patients who at the check-up declared not following any diet were assigned to the control group (n = 28).

A change in parameters was observed in each of the sub-groups after the intervention. The most significant changes were observed in the sub-group which lost >2.6 kg.

Both the diet based on mild calorie restriction and the Mediterranean diet had positive effect on the change of the former athlete's body parameters after the 6-week long dietary intervention. Both diets which were being tested changed the body composition of the athletes who ended their careers in a similar way.

Key words: caloric restriction, CRON diet, Mediterranean diet

Introduction

Overweight or obesity which often develop in athletes who end their careers are important issues of the world of sport. A typical problem is the decrease in the muscle mass accompanied by an increase in the proportion and a change in the localization of fat tissue (Jaskólski, Jaskólska, 2006).

During aging, an increase in the amount of intra-abdominal fat is observed; this fat increases the risk of such metabolic disease as diabetes, hypertension or circulatory diseases (O'Kane, Teitz, Fontana, Lind, 2002). It seems

that majority of athletes start gaining weight within 15–30 years after the conclusion of sporting careers (Pihl, Jürimäe, 2001). The average increase in the BMI (Body Mass Index) among footballers was 2.4 kg/m^2 since the end of their career. In the tested group, 78% of those surveyed were found to be overweight, whereas 4% – obese (Arliani et al., 2014). In other studies it was demonstrated that the percentage of overweight athletes was as high as 35% and with obesity – 3% (Marquet et al., 2013). The increase in the body weight of former athletes is related to the increase in the risk of circulatory diseases (Pihl, Jürimäe, 2001).

Despite those findings, it seems that the former athletes face a risk of diet-related diseases which is still lower than for the rest of the population (Kerr, DeFreese, Marshall, 2014). Lower incidence of these diseases may be related to their lifestyle (Batista, Soares, 2013). Also the results of Polish studies are similar to the ones described above. After examining 90 obese former athletes, it was found that they suffered from diabetes less often and had smaller waist lines than their obese peers. Additionally, in the group of the most obese former athletes (BMI > 40 kg/m^2) hypertension was less frequent and the period of obesity was shorter (Szczawińska, Ponikowska, Chojnowski, Grabowska, 2006).

Scientists think that the caloric restriction (CR) diets, also known as CRON diets (*Calorie Restriction with Optimal Nutrition*), which mean consuming a lower amount of calories than the body's demand may be one of the methods of extending lifespan Until now, only a few studies have been made which examined the influence of caloric restriction on humans (Heilbronn, Ravussin, 2003).

The Mediterranean diet is characterized by inclusion of vegetables and little participation of processed products. The main source of fats in this diet is olive oil. A characteristic feature of this diet is the daily consumption of small or moderate amounts of dairy and red wine. An inseparable element of this diet is also daily, moderate physical activity (Przysławski, 2007).

Purpose

The problem of the increasing body weight of former athletes still has not been solved. The aim of this study is to compare the impact of the CRON diet and the Mediterranean diet on the body composition of persons who have ended their sporting careers. The object of the study is the comparison of the body weight parameter changes in patients before the introduction of the diet and after completion thereof. The research challenge is to answer the question whether a diet based on mild caloric restrictions has a better influence on the improvement of the body composition in the group of former athletes using the diet for 6 weeks as compared to the Mediterranean diet. Establishing which diet has a better impact will allow for creation of algorithms of behaviour for people after ending their sporting careers. Achieving this aim will allow them to reduce overweight and obesity in this group and to improve their health.

Methods

The participants of the study were 94 males of the Caucasian race, aged 20–57, who volunteered to take part in the project "CRON diet as an alternative for athletes ending their sporting career" which was carried out in the Department of Biochemistry and Human Nutrition of the Pomeranian Medical University in Szczecin. All persons belonged to the group of different sport disciplines former athletes and the period which elapsed since the end of their sporting careers until accession to the study did not exceed 5 years. Each participant expressed in writing their consent to take part in the project.

The people who participated in the study were randomly assigned to one of 2 groups: group 1 – people using the diet based on calorie restriction CRON (n = 32), and group 2 – those who followed the recommendations of the Mediterranean diet (n = 34). The patients who at the check-up declared not following any diet were assigned to the control group (n = 28).

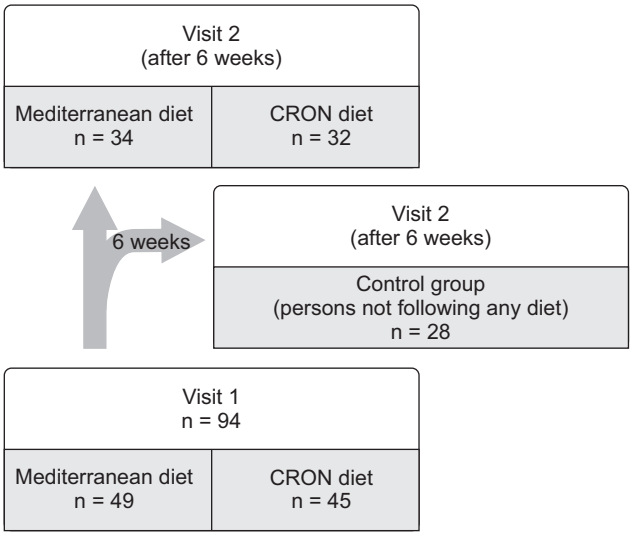

Figure 2. Scheme of the study

The criteria which excluded participants from the study were the following: high level of physical activity, hypercholesterolaemia (cholesterol concentration >0.8 mM or treated dyslipidaemia), diabetes (glucose concentration >126 mg/dl or treated diabetes), arterial hypertension (systolic pressure >140 mm Hg or diastolic >90 mm Hg or treated hypertension), co-occurrence of food allergies, celiac disease or other bowel diseases, vegetarianism or conditions requiring special diets, alcoholism or drug addiction.

Anthropometric measurements

During every check-up, the patient underwent several anthropometric measurements: body weight and height, waist line, hip circumference, left arm circumference, skinfold thickness measurement below the lower tip of the left shoulder blade and above the iliac crest, and also the skinfold thickness measurement over the triceps and biceps on the left arm.

To measure the body weight RADWAG scales was used (model WPT 100/200 OW) which also had a height measuring mechanism; the result of the measurement of the body weight was in kilograms (0.1 kg precision) while the height in cm (0.5 cm precision). The circumferences of the waist, hips and arm were measured with an non-expandable anthropometric measuring tape (0.1 cm precision). The waist circumference was measured halfway between the lower extent of the ribs and the upper tip of the iliac bone, while the hip measurement was taken

where it was the largest. Each measurement was performed twice and the results were averaged. The thickness of skinfolds was measured with a Saehan caliper. Measurements were made three times and the results were averaged.

The patients also underwent measurements of BMR (*basal metabolic rate*) and their body composition was measured with the BIA (Bioelectrical Impedance Analysis), Cosmed device.

Estimate of calorie demand

Total metabolic rate (TMR) was calculated on the basis of BMR and a physical activity co-efficient. The level of physical activity was established using long version of International Physical Activity Questionnaire (*IPAQ*). On the basis of results participants were assigned to one of 3 categories:

- "High – to this category belong athletes who meet one of the criteria:
  - 3 or more days of intensive physical activity, a total of at least 1,500 MET-min/week,
  - 7 or more days of any combination of activity (walking, moderate or intensive activity) exceeding 3,000 MET-min/week.
- Moderate – includes athletes who meet 1 of 3 criteria:
  - 3 or more days of intensive physical activity, at least 20 minutes per day,
  - 5 or more days of moderate activity, at least 30 minutes per day,
  - 5 or more days of any combination of activity (walking, moderate or intensive activity) exceeding 600 MET-min/week.
- Insufficient – includes athletes who did not do any physical activity or did not meet the criteria for a level moderate or high" (Sławecki, 2012).

Diet introduction

The study used 2 types of diets: CRON and Mediterranean diet. Their characteristics are presented below (Table 1).

Table 1. CRON diet and Mediterranean diet characteristics

	CRON diet	Mediterranean diet
Total calorie content of the diet	Standard calorie intake or reduction by 500 kcal compared to TMR	Reduced by 30% in relation to BMR (on average reduced by 806 kcal)
Proteins	1 g/kg of body weight	1 g/kg of body weight
Fats, including	<20% of TMR demand	30–35% of TMR demand
SFA	<7%	<10%
MUFA	>20%	>60%
PUFA	>30%	>20%
Cholesterol	200 mg/day	200–300 mg/day
Carbohydrates	50–60% of TMR demand	50–60% of TMR demand
Amount of fish per week	2 times	3 times
Afternoon snacks	Fruit and natural yoghurts	Fruit and nuts

Nutrition diary

In order to verify whether patients adhered to the recommendation, they ran a nutrition diary, in which they noted what, in what amounts, at what time they ate and drank during the two days before the control visits. All diaries were checked by a dietician and the weight of the products was adjusted on the basis of *photo album of products and dishes*, published by the Food and Nutrition Institute, 2000.

Statistical analysis

All statistical analyses were performed using the statistical R package (version 3.0.1,16 May 2013). Since the obtained results corresponded with normal distribution, the T-student test was used in statistical analysis. The level of relevance was accepted as $p < 0.05$.

Results

In the CRON group, 31 participants had moderate level of physical activity (1 participant had insufficient level of physical activity) and in Mediterranean diet 34 participants had moderate level of physical activity.

The characteristics of both groups at the time of accession to the study are presented in Tables 2 and 3.

Table 2. Characteristics of the CRON group before the dietary intervention

Variable	Arithmetic average	Standard Deviation	Median	Min.	Max.
Body weight [kg]	89.80	12.98	86.70	69.00	118.80
Thickness of the skinfold over the triceps [mm]	13.40	5.45	11.50	5.00	29.00
Thickness of the skinfold over the biceps [mm]	10.10	5.21	8.80	2.00	23.00
Thickness of the skinfold under the shoulder blade [mm]	20.10	6.74	19.00	10.00	38.70
Thickness of the skinfold over the hip [mm]	19.50	7.12	19.00	7.50	38.70
Upper arm circumference [cm]	33.80	3.17	34.40	25.50	41.00
Waist circumference [cm]	94.00	13.75	102.00	23.80	117.00
Hip circumference [cm]	100.30	13.75	102.00	23.80	117.00
BMI [kg/m^2]	28.00	4.05	27.30	21.80	39.20
Fat tissue [kg]	27.00	9.02	26.40	10.80	46.60
Fat tissue [%]	28.94	6.52	30.20	5.00	39.30
Lean body mass [kg]	62.50	6.85	61.00	50.80	76.10
Muscle mass [kg]	44.00	5.52	43.10	34.30	60.2
BCM [kg]	36.48	4.95	36.10	29.80	50.70
Total water in the body [kg]	46.61	4.95	45.20	38.20	55.70
Extracellular water [kg]	19.74	2.75	19.30	14.20	24.80
Intracellular water [kg]	26.87	3.38	26.40	22.70	36.30

In the CRON diet group a higher body weight was observed (88.80 ± 12.98 kg VS 87.80 ± 13.73 kg), larger waist circumference (94.00 ±13.75 cm vs 91.70 ±14.67 cm) and higher content of fat tissue (27.00 ±9.02 vs 25.30 ±10.18). In comparison with the Mediterranean group, the patients from the CRON diet group also manifested a higher muscle mass (44.00 ±5.52 kg vs 42.40 ±6.21 kg) and higher body cell mass BCM (36.48 ±4.95 vs 35.19 ±4.26).

Table 3. Characteristics of the Mediterranean diet group before the dietary intervention

Variable	Arithmetic average	Standard deviation	Median	Min.	Max.
Body weight [kg]	87.80	13.73	86.90	60.50	122.10
Thickness of the skinfold over the triceps [mm]	13.60	5.58	13.00	5.00	29.80
Thickness of the skinfold over the biceps [mm]	10.40	5.22	9.30	2.00	24.70
Thickness of the skinfold under the shoulder blade [mm]	19.10	6.78	19.00	4.00	35.00
Thickness of the skinfold over the hip [mm]	20.80	7.45	20.00	8.00	39.00
Upper arm circumference [cm]	33.30	6.30	32.50	17.50	62.30
Waist circumference [cm]	91.70	14.67	92.80	16.00	115.50
Hip circumference [cm]	99.50	8.56	101.50	56.50	110.50
BMI [kg/m^2]	27.40	4.00	26.80	19.20	38.40
Fat tissue mass [kg]	25.30	10.18	26.10	3.20	42.90
Fat tissue mass [%]	28.13	8.75	29.20	3.40	40.90
Lean body mass [kg]	61.10	7.76	61.00	43.30	79.20
Muscle mass [kg]	42.40	6.21	42.30	29.20	56.30
BCM [kg]	35.19	4.26	35.50	24.80	44.10
Total water in the body [kg]	45.24	4.73	45.50	34.60	56.60
Extracellular water [kg]	19.16	2.72	19.00	14.70	24.40
Intracellular water [kg]	25.64	3.52	26.10	15.20	32.40

In neither of the groups a BMI > 40 kg/m^2 was observed. 25% of patients from group Mediterranean diet group had proper body weight, and 22% of the people in the CRON diet group. In both groups most people had BMI indicating overweight (57% vs 56%).

Results of the patients from both groups were further divided into 3 sub-groups: a sub-group of patients who reduced their body weight by up to 1.4 kg (n = 15 in CRON group, and n = 15 in Mediterranean group); a sub-group of patients who lost between 1.5–2.4 kg (n = 10 in CRON group and n = 11 in Mediterranean group); and a sub-group of persons, who during the dietary intervention lost more than 2.4 kg (n = 7 in CRON group and n = 8 in Mediterranean group). The results of each of the subgroups are shown in the Table 4.

Table 4. Changes in patients from both groups, those who lost up to 1.4 kg

Intervention	CRON		Mediterranean	
	Average ± SD	P	Average ± SD	P
1	2	3	4	5
BMI	28.5 ±1.3		28.8 ±8.5	
BMI after 6 weeks	27.0 ±17.8	p < 0.05	28.2 ±14.2	P < 0.004
Thickness of the skinfold over the triceps	15.4 ±5.3		13.0 ±6.1	
Thickness of the skinfold over triceps after 6 weeks	14.0 ±7.0	NS	13.1 ±5.1	NS
Thickness of the skinfold over biceps	14.3 ±6.3		12.0 ±4.3	
Thickness of the skinfold over biceps after 6 weeks	14.8 ±6.2	NS	12.0 ±5.7	NS
Thickness of the skinfold below the shoulder blade	24.9 ±5.7		22.7 ±9.1	
Thickness of the skinfold below shoulder blade after 6 weeks	22.8 ±6.2	NS	20.4 ±7.4	NS
Thickness of the skinfold over the hip	22.8 ±8.4		23.7 ±7.2	
Thickness of the skinfold over hip after 6 weeks	21.5 ±5.6	NS	19.8 ±5.0	P < 0.05

1	2	3	4	5
Upper arm circumference	34.6 ±2.9		35.2 ±4.3	
Upper arm circumference after 6 weeks	34.7 ±1.8	NS	34.7 ±4.1	NS
Waist circumference	99.7 ±8.0		98.8 ±9.0	
Waist circumference after 6 weeks	97.8 ±7.4	NS	95.3 ±0.8	P < 0.015
Hip circumference	100.0 ±24.5		103.7 ±4.9	
Hip circumference after 6 weeks	105.2 ±3.7	NS	98.2 ±12.4	NS
Fat mass kg	31.4 ±8.9		33.3 ±6.4	
Fat mass kg after 6 weeks	31.7 ±6.2	NS	29.9 ±9.1	NS
Fat mass %	32.1 ±7.1		34.0 ±3.1	
Fat mass % after 6 weeks	33.9 ±4.4	NS	31.4 ±5.7	NS
Lean body mass kg	65.6 ±7.7		64.3 ±8.1	
Lean body mass after 6 weeks	61.6 ±7.4	NS	63.7 ±5.8	NS
BCM kg	37.6 ±5.8		37.1 ±5.2	
BCM kg after 6 weeks	35.2 ±4.3	NS	38.5 ±5.8	NS
Muscle mass kg	45.9 ±6.6		45.1 ±6.1	NS
Muscle mass kg after 6 weeks	42.9 ±5.1	NS	46.6 ±6.5	
Total body water TBW kg	48.7 ±4.8		47.4 ±5.7	
Total body water TBW kg after 6 weeks	45.7 ±4.9	NS	47.0 ±4.0	NS
Extracellular water EW kg	20.7 ±3.1		20.0 ±2.7	
Extracellular water EW kg after 6 weeks	19.6 ±3.0	P < 0,025	18.7 ±1.8	NS
Intracellular water IW kg	28.0 ±3.7		27.4 ±3.5	
Intracellular water IW kg after 6 weeks	26.2 ±2.8	NS	28.3 ±3.8	NS

In patients who followed the CRON diet for the period of 6 weeks, a statistically significant decrease of extracellular water was observed. The participants who used the Mediterranean diet, a statistically significant reduction was the one regarding the thickness of the skinfold over the iliac crest and the reduction of waist line. In both groups the reduction of BMI was statistically significant, with this reduction being larger in the CRON diet (–1.5 vs –0,6).

Table 5. Changes in patients from both groups, those who lost between 1.4–2.4 kg

Intervention	CRON		Mediterranean	
	Average ± SD	P	Average ± SD	P
1	2	3	4	5
BMI	30.0 ±4.2		30.7 ±4.3	
BMI after 6 weeks	28.3 ±3.9	p < 0.015	29.7 ±4.0	P < 0.05
Thickness of the skinfold over the triceps	16.0 ±5.9		13.4 ±7.5	
Thickness of the skinfold over triceps after 6 weeks	13.9 ±7.7	NS	13.5 ±6.0	NS
Thickness of the skinfold over biceps	15.4 ±6.3		12.1 ±4.9	
Thickness of the skinfold over biceps after 6 weeks	15.9 ±5.4	NS	14.7 ±5.1	NS
Thickness of the skinfold below the shoulder blade	25.4 ±6.5		24.9 ±8.2	
Thickness of the skinfold below shoulder blade after 6 weeks	24.0 ±6.5	NS	23.1 ±7.5	NS
Thickness of the skinfold over the hip	23.9 ±8.5		24.1 ±7.8	
Thickness of the skinfold over hip after 6 weeks	21.9 ±5.7	NS	20.4 ±5.4	NS
Upper arm circumference	35.1 ±2.4		37.0 ±4.1	
Upper arm circumference after 6 weeks	34.7 ±1.8	NS	36.1 ±4.2	NS

1	2	3	4	5
Waist circumference	101.3 ±8.6		100.8 ±10.6	
Waist circumference after 6 weeks	98.9 ±8.2	NS	96.7 ±10.0	P < 0.05
Hip circumference	98.0 ±28.4		103.7 ±6.0	
Hip circumference after 6 weeks	105.2 ±4.4	P < 0.05	95.7 ±14.7	NS
Fat mass kg	31.9 ±10.2		35.8 ±6.5	
Fat mass kg after 6 weeks	32.9 ±6.7	NS	33.0 ±9.5	NS
Fat mass %	31.6 ±8.1		34.9 ±3.2	
Fat mass % after 6 weeks	34.2 ±5.0	NS	33.3 ±5.7	NS
Lean body mass kg	67.6 ±7.3		66.4 ±9.1	
Lean body mass after 6 weeks	63.0 ±7.9	P < 0.04	64.7 ±7.0	NS
BCM kg	38.3 ±6.5		37.9 ±6.0	
BCM kg after 6 weeks	35.7 ±4.9	NS	39.6 ±6.8	NS
Muscle mass kg	46.8 ±7.3		46.2 ±7.1	
Muscle mass kg after 6 weeks	43.6 ±5.7	NS	47.8 ±7.8	NS
Total body water TBW kg	50.3 ±4.2		49.1 ±6.2	
Total body water TBW kg after 6 weeks	47.0 ±4.9	P < 0.03	47.9 ±4.7	NS
Extracellular water EW kg	21.7 ±2.5		20.9 ±2.8	
Extracellular water EW kg after 6 weeks	20.3 ±3.0	P < 0.025	18.8 ±1.9	P < 0,025
Intracellular water IW kg	28.6 ±4.0		28.1 ±4.0	
Intracellular water IW kg after 6 weeks	26.7 ±3.0	NS	29.1 ±4.3	NS

Among the patients from the CRON group, a statistically significant observation was that regarding an increase of the hip circumference, as well as a decrease of body's lean mass, total body water content and extracellular water. Among those who followed Mediterranean diet, statistically significant were: the reduction of fat mass, reduction of waist circumference and of extracellular water. In both groups, a reduction of BMI was statistically significant (reduction by 1.7 kg/m^2 vs 1.0 kg/m^2).

Table 6. Changes in patients from both groups, those who lost over 2.4 kg

Intervention	CRON		Mediterranean	
	Average ± SD	P	Average ± SD	P
1	2	3	4	5
BMI	32.0 ±5.0		30.0 ±4.2	
BMI after 6 weeks	31.0 ±5.0	p < 0.02	28.3 ±3.9	P < 0.015
Thickness of the skinfold over the triceps	16.2 ±6.5		13.5 ±8.1	
Thickness of the skinfold over triceps after 6 weeks	16.0 ±6.6	NS	13.9 ±6.3	NS
Thickness of the skinfold over biceps	16.0 ±5.6		11.9 ±5.3	
Thickness of the skinfold over biceps after 6 weeks	16.0 ±6.1	NS	15.1 ±5.4	NS
Thickness of the skinfold below the shoulder blade	26.5 ±6.8		26.5 ±7.3	
Thickness of the skinfold below shoulder blade after 6 weeks	25.4 ±6.4	NS	24.4 ±7.2	NS
Thickness of the skinfold over the hip	25.2 ±9.4		25.6 ±7.2	
Thickness of the skinfold over hip after 6 weeks	21.7 ±6.5	P < 0.03	21.6 ±4.4	NS
Upper arm circumference	36.0 ±1.9		37.7 ±3.9	
Upper arm circumference after 6 weeks	35.1 ±1.9	NS	36.8 ±4.1	NS
Waist circumference	103.1 ±9.0		102.0 ±11.0	
Waist circumference after 6 weeks	100.3 ±8.2	P < 0.03	97.7 ±10.3	NS

1	2	3	4	5
Hip circumference	96.5 ±32.6		103.9 ±6.4	
Hip circumference after 6 weeks	105.6 ±4.8	P < 0.015	95.1 ±15.8	NS
Fat mass kg	35.7 ±7.2		35.9 ±7.0	
Fat mass kg after 6 weeks	34.6 ±6.5	NS	33.3 ±10.2	P < 0.03
Fat mass %	34.4 ±5.4		34.5 ±3.2	
Fat mass % after 6 weeks	34.7 ±5.4	NS	33.1 ±6.1	NS
Lean body mass kg	67.9 ±7.5		67.7 ±9.0	
Lean body mass after 6 weeks	65.0 ±7.8	P < 0.02	65.7 ±6.9	NS
BCM kg	37.1 ±5.2		39.2 ±5.2	
BCM kg after 6 weeks	36.1 ±5.4	NS	40.9 ±6.1	NS
Muscle mass kg	45.6 ±6.0		47.6 ±6.3	
Muscle mass kg after 6 weeks	44.3 ±6.2	NS	49.2 ±7.0	NS
Total body water TBW kg	50.8 ±3.8		49.6 ±6.6	
Total body water TBW kg after 6 weeks	48.7 ±4.1	P < 0.02	48.1 ±5.0	NS
Extracellular water EW kg	22.8 ±1.4		20.8 ±3.0	
Extracellular water EW kg after 6 weeks	21.5 ±2.1	P < 0.05	18.4 ±1.7	P < 0.03
Intracellular water IW kg	28.0 ±3.0		28.8 ±3.8	
Intracellular water IW kg after 6 weeks	27.2 ±3.1	NS	29.7 ±4.2	NS

In the sub-group of participants who lost >2.4 kg of body weight, the highest number of statistical significances was observed. In the CRON group, a statistically significant reduction of the thickness of skinfold over the iliac crest was observed, as well as the reduction of waist line, and an increase of hip circumference, and a decrease of the lean body mass. There was also a statistically significant reduction of total body water content and of extracellular water. In the Mediterranean group, a statistically significant change was the reduction of fat mass and of extracellular water. In both groups, a reduction of BMI was statistically significant (reduction by 1.0 kg/m^2 vs 1.7 kg/m^2).

Table 7. Changes in control group

Intervention	Control group	
	Average ± SD	P
1	2	3
Thickness of the skinfold over the triceps	10.6 ±4.3	
Thickness of the skinfold over triceps after 6 weeks	11.7 ±5.3	NS
Thickness of the skinfold over biceps	6.6 ±2.2	
Thickness of the skinfold over biceps after 6 weeks	7.4 ±4.8	NS
Thickness of the skinfold below the shoulder blade	15.3±4.6	
Thickness of the skinfold below shoulder blade after 6 weeks	15.5 ±4.7	NS
Thickness of the skinfold over the hip	12.5 ±2.3	
Thickness of the skinfold over hip after 6 weeks	17.2 ±7.3	NS
Upper arm circumference	32.5 ±1.5	
Upper arm circumference after 6 weeks	32.3 ±2.8	NS
Waist circumference	87.3 ±7.2	
Waist circumference after 6 weeks	87.6 ±7.4	P < 0.03
Hip circumference	90.1 ±20.0	
Hip circumference after 6 weeks	94.9 ±4.0	P < 0.015

1	2	3
Fat mass kg	20.8 ±5.4	
Fat mass kg after 6 weeks	23.1 ±7.9	NS
Fat mass %	26.0±4.3	NS
Fat mass % after 6 weeks	28.5 ±7.2	
Lean body mass kg	58.6 ±5.0	
Lean body mass after 6 weeks	56.7 ±4.6	P < 0.02
BCM kg	34.0 ±3.4	
BCM kg after 6 weeks	34.0 ±4.6	NS
Muscle mass kg	41.4±4.0	
Muscle mass kg after 6 weeks	41.2 ±5.2	NS
Total body water TBW kg	42.9 ±3.6	
Total body water TBW kg after 6 weeks	41.5 ±3.4	P < 0.02
Extracellular water EW kg	17.9 ±1.5	
Extracellular water EW kg after 6 weeks	16.6 ±1.0	P < 0.05
Intracellular water IW kg	25.9±2.2	
Intracellular water IW kg after 6 weeks	24.9±3.1	NS

Among the members of the control group (n = 28) after 6 weeks of unregulated consumption there were increases of thickness of skinfolds, increase of waist and hip circumference, and fat tissue content. The decrease in lean body mass was observed, the same for water content. Statistical significance was not established for any of these changes.

Discussion

According to A. Tsigos studies (2009), 10–25% of Europeans are obese, while the number of overweight and obese people has grown over the last 10 years by 10–40%. This data corresponds with the results obtained from the present study. The largest percentage of men taking part in the study had BMI indicating obesity (57% and 56%), and only 25% and 22% had their BMI in the normal range (20.0–24,99 kg/m^2). This proves that in the group of former athletes, the problem of being overweight and obese is widespread. Admittedly, none of the participants of the study had obesity III°, however, 4% had obesity II°, which significantly increases the risk of diet-related diseases. Similar results were obtained by Arliani et al. (2014), who established overweight in 78% and obesity in 4% of footballers. Similar results were also presented by Marquet et al. (2013), who observed that 35% of examined athletes were overweight, while 3% – obese.

Visceral obesity is the most dangerous distribution of fat tissue in the body. One of the simplest and quickest ways to estimate the amount of visceral fat is to measure waist circumference. The average waist circumference of the men examined was 94.0 cm in the CRON diet group and 91.7 cm in the Mediterranean diet group. If recommendations of the *International Diabetes Federation* are considered, according to which abdominal obesity in men starts as early as at the waist line of 94 cm, it can be observed that the CRON diet patients had a border-line value for waist circumference. Adding to that the percentage amounts of fat tissue which were 28.91% and 28.13%, it can be stated that the average content of fat tissue in both groups indicated obesity (Pi-Sunyer, 2000). These results confirm the observation that an athlete ending his sporting career often does not differ from his peer who did not actively pursue sport in his earlier life.

Despite having done sport in the past and having led a healthy lifestyle, after the end of their career, the occurrence of excessive weight and obesity is similar for the former athletes as for their peers who never actively pursued sport. It is common knowledge that the occurrence of excessive weight, obesity and increased proportion of fat tissue in the body are all related to the increased risks of developing diet-related diseases. It is estimated that for men up to the age of 65 whose BMI is 25.0–28.9 kg/m^2, the risk of ischemic heart disease increases by 72% (Szymocha, Bryła, Maniecka-Bryła, 2009). It is, therefore, important to take care of the athletes health not only during their career, but also after its completion. Usually, it is after the end of their career that, in combination with the aging process, undesirable changes in the body appear.

A change in parameters was observed in each of the sub-groups after the intervention. In the subgroup, which reduced their body weight by up to 1.4 kg, there were more statistically significant changes observed in the Mediterranean group. In the CRON group, there were significant changes in the reduction of BMI and the proportion of extracellular water. In the group of the Mediterranean diet, more parameters were observed which proved changes in the fat tissue: BMI reduction, hip skinfold reduction, and smaller waist line. This attests to the fact that in this group, the Mediterranean diet had larger impact on the reduction of fat tissue.

In the sub-group which lost 1.5–2.4 kg similar effects of both diets were observed. Both the Mediterranean diet and the CRON diet resulted in BMI reduction. In the Mediterranean diet group, an additional observation was made regarding the reduction of fat mass and of waist circumference. The CRON diet resulted in the reduction of lean body mass, but this change was brought about by the reduction of water.

The most significant changes were observed in the sub-group which lost >2.4 kg. From the nutritional point of view, the most important change was the reduction of BMI which was observed both in the CRON group and the Mediterranean group. The CRON diet also caused a reduction of the skinfold over the hip and a decrease of waist circumference, whereas the Mediterranean diet – a reduction of fat mass. The only undesirable change was the reduction of lean body mass. If, however, the reduction of water is taken into account, it can be stated that the reduction of lean body mass was caused by these changes.

The existing literature lacks in the studies comparing the impacts of the CRON diet and the Mediterranean diet on the body composition. However, in few, similar research studies, similar results have been produced. The study by Racette et al. (2006) demonstrated that the people following a 20% caloric restriction of the period of one year were observed to lose the fat tissue located around waist (body weight reduction by 8.0 ±0.9 kg and the reduction of fat tissue by 6.2 ±1.2). Similarly, Redman et al. (2008) demonstrated that men following a 25% caloric restriction regimen for the period of 6 months were observed to reduce fat tissue by 5.8 ±1.3 kg and to reduce visceral fat tissue by 1.4 ±0.2 kg. That diet, however, had more desirable effect when combined with physical activity. A positive impact of the Mediterranean diet was, in turn, demonstrated by Shai et al. (2008), who compared the Mediterranean diet, low fat diet and low carbohydrate diet, and found that men who followed the Mediterranean diet for 24 months lost 4 kg of body weight and their BMI dropped by 1.5 ±2.2 and the waist circumference by 3.5 ±5.1 cm. In this study, the largest impact was from the low carbohydrate diet.

In summary, it can be stated that both diets followed for the period of 6 weeks brought about similar, desirable changes to the body composition of former athletes. They primarily caused a reduction of BMI and a decrease of waist circumference – important indicators of risks of diet-related diseases. This observation is important, because according to the WHO (World Health Organization), body weight of an average human will continue rising over the coming 10 years (Szymocha et al., 2009). Therefore, it is of such great importance to find ways of preventing the

risks of excessive weight and obesity for middle-aged persons. One of such ways is the application of a diet based on mild caloric restriction or a Mediterranean diet.

Conclusions

Both the diet based on mild caloric restriction and the Mediterranean diet had positive effect on the change of the former athlete's body parameters after the 6-week long dietary intervention.

Both diets which were being tested changed the body composition of the athletes who ended their careers in a similar way.

Mild caloric restriction diet and Mediterranean diet may both be recommended for people after ending sporting careers.

It seems that by implementing the diets as an algorithm after the end of a sporting career, it will be possible to reduce the occurrence of excessive weight or obesity in the group of athletes, which will affect their health in a positive way.

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MOTIVES FOR COMMENCING STUDIES AND EXPECTATIONS CONCERNING PROFESSIONAL COMPETENCE IN STUDENTS WHO PRACTICE, USED TO PRACTICE OR HAVE NEVER PRACTICED SPORTS

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Abstract. Aim: Economic development, connected with the concept of a society engaged in lifelong learning, demands that education produce optimal professional competences. The aim of this study was to determine the motives for the choice of physical education studies, and ascertain expectations concerning professional competences, as well as self-evaluation of competences acquired, in current and former athletes and non-athletes.

Methods. 226 people were examined, all studying physical education at the Faculty of Physical Culture in Gorzow Wielkopolski, a branch of the University School of Physical Education in Poznan. Purposive sampling was used (Radzińska, Nowak, L., Nowak, M., 2013). The study included current (22.6%) and former athletes (31.8%) as well as non-athletes (45.6%). A diagnostic survey was employed, with the use of the techniques of auditorium questionnaire, interview and document analysis. In order to draw statistical conclusions, the trait frequency and the independence χ^2 test were used.

Results. Former athletes more often reported having been motivated to choose the studies by their interest in employment with institutions of physical culture while non-athletes by their wish to obtain jobs in schools ($p \leq 0.05$). Expectations of competence in physical education methodology were indicated by all respondents, slightly more often by former athletes and non-athletes ($p \leq 0.05$). For current athletes, competence in physical fitness was important. Psycho-pedagogical competence in motivating schoolchildren to work was expected by most students (84.5%), slightly more often by former athletes and non-athletes ($p \leq 0.05$). Respondents rated their preparation for employment with regard to foreign languages and preparation for scientific work as average and fair, and their self-education ability and computer skills as good.

Key words: physical education students, current athletes, former athletes, non-athletes, motives, competence, expectations, self-evaluation

Introduction

In the lifelong process of education (Ferenz, 2010) there is a clear differentiation of the particular stages in the context of objectives and ways to achieve them. According to the concept of psychosocial development (Erikson, 2004), each stage in the life of man has its tasks. The development task of the study stage involves gaining and improving knowledge, crystallization of professional competences, shaping of identity, determining career plans. In the Lisbon Declaration, professional competences, including social competence, were considered crucial for citizens of European Union Member States. They represent a specific combination of humanistic knowledge, engaging in relationships and community activities, capacity for free choice and critical judgment (Salmela-Aro, Tolvanen, Nurmi, 2009).

The purpose of modern education, which is based on the humanistic training model, is the creation of a student's personality in accordance with the adopted education outcomes and societal demand. In this context, the process of checking the quality of education should be consistent with the learning outcomes set out in the National Qualification Framework (hereinafter referred to as NQF) and the descriptors of the Bologna process (Kraśniewski, 2004; Cieśliński, 2009). In a study summarizing the implementation of the NQF in higher education institutions, the resulting benefits were clearly exposed, e.g. programs targeted on the achievement of learning outcomes, changes in curricula, changes in the content of programs and their adaptation to the learning outcomes, changes in the organization of curricula (expanding the offer of subjects to choose), changes in the way classes are conducted (increase in the number of classes focused on acquiring skills, conducted in active forms) (Kraśniewski, Próchnicka, 2013).

The portrait of a graduate in physical education specifies that they receive basic knowledge and skills in the area of social sciences, natural sciences and physical education, enabling them to competently influence man's personality and organism in order to meet their needs with respect to physical and motor development, as well as those related to participation in physical culture (www.bip.gov.pl, 10.11.2015). Participation in culture is believed to play a significant role (Kotarska, Wunsch, Raszeja-Wyszomirska, Kempińska-Podhorecka, Wójcicki, Milkiewicz, 2015). Finnish research has repeatedly confirmed that people who had been physically active in the past, i.e. former athletes, are much more likely to take up physical activity in adulthood than non-athletes (Telama, Laakso, Yang, 1994; Telama, Xiaolin, Laakso, Viikari, 1997). Such a division was adopted in this work (current athletes, former athletes, non-athletes).

In accordance with the present core curriculum, there are four hours of physical education, including two hours realized on facultative basis (www.reformaprogramowa.men.gov.pl; 5.12.2015). A school physical education program structured in this way allows students to develop their interests, as it covers variously profiled activities related to recreation and health, dance, tourism or sports. Diversification of the educational offer in this area obliges a future teacher to acquire specific competence. A young person's decision to commence studies in a given field should be matched with training oriented toward entering a particular profession, and meeting, at least in part, expectations of the student as far as the knowledge and skills acquired are concerned (Buchta, 2009; Radzińska et al., 2013).

Dynamic economic development is associated with the concept of a society engaged in lifelong learning. These connections pose challenges for the educational system and the modern labor market (Eider, 2009; Buchta, 2012; Czerepaniak-Walczak, 2013). Meeting these challenges makes it imperative to discover and train those skills which

will most effectively facilitate running a successful career. Cooperation with a schoolchild and preparing them for self-reliant work on their fitness and health in the future, requires specific competence. This competence is related to substantive knowledge of the subject taught, and psycho-pedagogical, methodological and communication skills (Kwiatkowska, 2008; Jagusz, 2011).

The aim of this study was to determine the motives for the choice of physical education studies, and ascertain expectations concerning professional competences, as well as self-evaluation of competences acquired, in current and former athletes and non-athletes.

The following hypotheses were formulated:

1. For current athletes the main motive for the choice of physical education studies was the desire to work in institutions of physical culture, and for non-athletes it was employment in schools.
2. Expectations of specialist competence in knowledge and skills related to physical education methodology were more often indicated by non-athletes.
3. Psycho-pedagogical competence in motivating schoolchildren to work was expected by all students.
4. Respondents most often rated their preparation for employment as average and fair.

Research material and methods

Research into the quality of teaching in particular institutions of higher education stems from the guidelines of the Bologna process. The results of this study are part of the evaluation of education quality carried out by students of the Faculty of Physical Culture of the Poznan University School of Physical Education. The study included 226 people (48.7% women and 51.3% men), second and third-year undergraduate students and first-year postgraduate students in the field of physical education. Purposive sampling was used. A detailed description of the research was presented in the previous work (Radzińska et al., 2013). Three groups within each year-group were studied (male, female and mixed). The respondents lived mainly in urban areas (71.9%) and reported a very good or average material situation (54.1% and 36.2% respectively). Of the 226 people surveyed, 123 had practiced sports at competitive level before commencing their studies. Currently 51 students continued training (22.6%), 72 people had stopped training (31.8%), and 103 people declared not having trained at all (45.6%).

In the research, a diagnostic survey was employed, with the use of the techniques of auditorium questionnaire, uncategorized interview, and document analysis. In the design of the questionnaire the concept of the triple dimension of teachers' professional competence was used (Hamer, 1994). The first dimension embraces knowledge and skills related to the subject taught (specialist competences), the second and third ones concern the pedagogical and psychological skills, which are combined into psycho-pedagogical skills. The empirical material was statistically analyzed according to the number and characteristics of the variables (Van Buurren, de Leuve, 1992). In order to draw statistical conclusions, the trait frequency and the independence χ^2 test were used. For the calculations the Statistica 10.0 software package was used (StatSoft, Inc., USA).

Research results

Motives for the choice of the studies

For greater clarity of the results presented, the respondents were divided into three groups, and the following abbreviations were used in the tables: CA – students who currently practiced sports at competitive level – current

athletes (n = 51), FA – students who used to practice sports at competitive level in the past – former athletes (n = 72), NA – students who had never practiced sports at competitive level – non-athletes (n = 103).

Most people's reasons for the choice of physical education studies were: having athletic predispositions, the prospect of an interesting job, being interested in physical recreation, possibilities for self-realization and development of an athletic career. These choices had no connection with belonging to the above mentioned groups (Table 1).

Table 1. Motives for the choice of physical education studies among current and former athletes and non-athletes

Motives for the choice of physical education studies	Student categories			Total (n = 226)	
	CA (n = 51)	FA (n = 72)	NA (n = 103)		
		%		n	%
Having athletic predispositions	26.0	30.0	44.0	100	44.2
Prospect of an interesting job in sport	30.1	32.5	37.3	83	36.7
Being interested in physical recreation	26.9	23.1	50.0	78	34.5
Need for self-realization	20.0	32.9	47.1	70	30.1
Possibilities for development of an athletic career	31.2	32.8	35.9	64	28.3
Desire to work in other institutions of physical culture*	29.5	43.1	27.2	44	19.4
Conviction of the necessity to gain qualifications	12.2	34.1	53.6	41	18.4
Necessity to gain a higher education	23.6	28.9	47.3	38	16.8
Desire to work in school*	35.1	16.2	48.6	37	16.3
Conviction of the attractiveness of the studies*	21.6	48.6	29.7	37	16.3
Conviction of a high social prestige of the teaching profession	22.8	34.2	42.8	35	15.4
Desire to follow one's physical education teacher's example	16.6	33.4	50.0	18	7.9
Friends and acquaintances' persuasion	0.0	33.3	66.6	15	6.6

Note: Value of p for the χ^2 test was marked as follows: *$p \leq 0.05$.

Statistically significant correlations were found concerning the desire to work in school, in institutions of physical culture (in sports clubs, sports associations, administration, private fitness clubs) and the conviction of the attractiveness of the studies, among current and former athletes, as well as non-athletes (in each case the value of $p \leq 0.05$ for the χ^2 test). The desire to work in school was declared to be an important motive for commencing the studies mostly by non-athletes (48.6%). Being interested in employment in other institutions of physical culture was most often indicated by former athletes (43.1%). For former athletes the conviction of the attractiveness of the studies was also a significant motive (48.6%). It can be also observed that only 16.3% of the total of the subjects associated their choice of the studies with the desire to work in school, and 19.4% in institutions of physical culture.

The desire to follow the example of respondents' physical education teachers and their friends and acquaintances' persuasion were least often mentioned as motives for the choice of physical education studies.

Students' expectations of specialist and psycho-pedagogical competences

The studying period involves acquiring knowledge, skills and attitudes, in other words specific competences. Students' expectations in that respect concern specialist competences connected with their field of studies (Table 2) and psycho-pedagogical competences (Table 3). Statistically significant correlations were found with respect to expectations of knowledge and skills related to physical education methodology among current and former athletes

and non-athletes (value of $p \leq 0.05$ for the χ^2 test). These competences were more often indicated by those who had practiced sport at competitive level in the past (86.1%) and those who had never practiced sport (86.4%). For all respondents significant were also skills in conducting recreational activities and activities in chosen sports disciplines. Students also expected to acquire skills related to planning and realization of physical education classes, as well as facultative activities. The fewest indications concerned competences connected with theoretical knowledge of physical culture and a high level of physical fitness. Current athletes, who displayed the highest level of physical fitness, expected its improvement.

Table 2. Expectations of specialist competences among current and former athletes and non-athletes

Specialist competences	Student categories			Total (n = 226)	
	CA (n =51)	FA (n = 72)	NA (n = 103)	n	%
	%				
Knowledge and skills related to physical education methodology*	70.5	86.1	86.4	187	82.7
Skills in conducting recreational activities	62.7	63.8	66.9	147	65.0
Skills in conducting activities in a chosen sports discipline	68.6	63.8	61.7	144	63.7
Skills in planning and realization of physical education classes and facultative activities	62.7	59.7	60.1	137	60.6
A high level of physical fitness	62.7	43.0	48.5	113	50.0
Theoretical knowledge of physical culture	50.9	56.9	51.4	90	39.8

Note: Value of p for the χ^2 test was marked as follows: * $p \leq 0.05$.

Statistically significant differences were found in the expectations of current and former athletes and non-athletes with regard to motivating schoolchildren to work (value of $p \leq 0.05$ for the χ^2 test). The majority of former athletes and non-athletes indicated this psycho-pedagogical competence as the most important (86.1% and 86.4% respectively). Regarding the other competences indicated, no differences were observed with: shaping schoolchildren's self-evaluation of physical fitness and health, interpersonal communication techniques, activating techniques and methods, schoolchildren team management, shaping schoolchildren's sport-oriented attitudes, clarifying objectives that should be achieved by the teacher. In each case they were chosen by more than 50% (Table 3).

Table 3. Expectations of psycho-pedagogical competences among current and former athletes and non-athletes

Psycho-pedagogical competences	Student categories			Total (n = 226)	
	CA (n = 51)	FA (n = 72)	NA (n = 103)	n	%
	%				
Motivating schoolchildren to work*	76.4	86.1	87.3	191	84.5
Shaping schoolchildren's self-evaluation of physical fitness and health	74.5	66.6	56.3	144	63.7
Using interpersonal communication techniques	66.6	31.4	44.2	140	61.9
Schoolchildren team management ability	56.8	59.7	59.2	133	58.8
Using activating techniques and methods	62.7	58.3	56.3	132	58.4
Shaping schoolchildren's sport-oriented attitudes	60.7	58.3	48.5	123	54.4
Clarifying objectives that should be achieved by the teacher	62.7	50.0	48.5	118	52.1

Note: Value of p for the χ^2 test was marked as follows: *$p \leq 0.05$.

General self-evaluation of specialist and psycho-pedagogical competences

Respondents rated their own specialist competences as good, average and very good (68%, 22.9% and 9.1% respectively). No correlations were observed concerning the self-evaluation of specialist competences of current and former athletes and non-athletes.

Statistically significant differences were found concerning the self-evaluation of psycho-pedagogical competences of current and former athletes and non-athletes (value of $p \leq 0.001$ for the χ^2 test) (Figure 1). Among non-athletes, most people were characterized by a good and average evaluation of their own psycho-pedagogical competences (50.5% and 43.4% respectively). Current athletes mostly rated these competences as good and very good (64.7% and 14.8% respectively). Former athletes' proportions of average and good self-evaluations were similar (37.1% and 42.8%). At the same time, this group had the greatest number of respondents with the highest self-evaluation (20.1%).

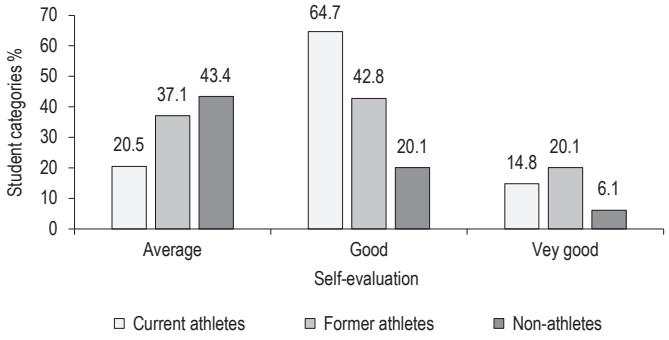

Figure 1. Self-evaluation of psycho-pedagogical competences among current and former athletes and non-athletes ($p \leq 0.001$ for the χ^2 test)

Self-evaluation of the preparation for employment with respect to chosen competences indicated by the students

Statistically significant differences were found concerning the self-evaluation of competences with respect to development of an athletic career (value of $p \leq 0.001$ for the χ^2 test), knowledge of foreign languages (value of $p \leq 0.01$ for the χ^2 test), preparation for scientific work, self-education ability and computer skills (value of $p \leq 0.05$ for the χ^2 test in each case) among current and former athletes and non-athletes (Table 4).

The lowest self-evaluation of competences related to planning and development of an athletic career while studying was reported by non-athletes (fair by 41%). A good and very good levels of these competences were indicated by current and former athletes (58.4% and 51.5% respectively).

Most respondents rated their own preparation for scientific work as average (55.8%). This preparation was most often rated as fair by non-athletes, and as good by current athletes (26.7% and 37.5% respectively).

Table 4. Self-evaluation of the quality of the preparation for employment among current and former athletes and non-athletes

Self-evaluation of preparation for employment		Student categories			Total (n = 215)	
Self-evaluation elements	Scale 1–5	CA (%)	FA (%)	NA (%)	n	%
Development of an athletic career***	Fair	14.5	16.6	41.0	59	27.5
	Average	27.1	31.9	36.0	70	32.7
	Good	39.5	37.9	20.0	64	29.9
	Very good	18.9	13.6	3.0	21	9.9
Preparation for scientific work*	Fair	14.6	13.6	26.7	43	43
	Average	47.9	65.1	53.4	120	55.8
	Good	37.5	21.3	19.9	52	24.1
Self-education ability*	Fair	8.3	1.7	7.9	13	6.0
	Average	15.1	18.1	12.5	54	25.1
	Good	62.5	57.5	63.0	117	54.4
	Very good	14.1	22.7	16.6	31	14.4
Knowledge of foreign languages**	Fair	39.5	24.2	53.4	60	27.9
	Average	23.0	19.7	14.5	59	27.4
	Good	23.0	40.9	25.2	72	33.5
	Very good	14.5	15.2	6.9	24	11.2
Computer skills*	Fair	11.7	12.3	2.1	18	8.5
	Average	18.9	16.6	25.2	47	22.1
	Good	41.3	43.9	40.4	88	41.3
	Very good	28.1	27.2	32.3	60	28.1

Note: Value of p for the χ^2 test was marked as follows: * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$. A Likert scale was used 1–5, where 1 stands for 'insufficient' and 5 for 'very good'. The lowest evaluations were not reported.

More than half of the students examined rated their self-education ability as good (54.4%). Among current athletes and non-athletes there were more instances of rating self-education ability as fair (8.3% and 7.9% respectively).

Knowledge of foreign languages was rated as fair and average by most of current athletes and non-athletes (62.5% and 67.9% respectively). Good and very good evaluation of knowledge of foreign languages was more often reported by former athletes (56.1%).

Competence related to computer skills was rated as good by 41.3% of all the students. A very good evaluation of this competence was more often indicated by non-athletes (32.3%), among whom there were at the same time fewer people who rated it as fair (2.1%).

Discussion and conclusions

In a study of students of a physical education university, it was found that while making the choice of their field of study the respondents were driven mainly by the group of sport-related motives (athletic predispositions, practicing sports at competitive level). To a lesser extent they considered employment-related motives (the prospect of working as a physical education teacher, working with youth, having a job connected with physical culture) (Brojek, Zajkowska-Magier, 2004). In a study by other authors, the main motives for the choice of the field of study cited by respondents concerned the desire to go into one of the following professions: physical education teacher,

health promotor, coach, sports manager. At the same time they expressed the conviction that studying in this field was attractive (Kumala, 2011; Radzińska et al., 2013).

It was found that having athletic predispositions, the prospect of an interesting job (including work in school or institutions of physical culture), and being interested in physical recreation were the most important motives for the choice of the studies. Choosing the field of physical education, students expected an interesting job, but only 16.3% thought of working in school and 19.4% of working in the institutions of physical culture. Thus the hypothesis was confirmed partially. An important motive for the choice of the studies was the conviction of their attractiveness. Results corresponding to the present ones have been produced in research by other authors (Buchta, 2012). The conviction of a high prestige of the teaching profession, the desire to follow one's physical education teacher's example, and friends and acquaintances' persuasion, were least often mentioned motives (Zowczak, 2009; Gliński, 2014).

The complicated socio-demographical situation in Poland, as well as constant changes in the educational system and the system of training teachers do not make employment in schools attractive (Day, 2004). The fourth hour of physical education, implemented in accordance with the Core Curriculum (http://www.reformaprogramowa.men.gov.pl; 15.10.2015), should, on the one hand, foster creation of new jobs; on the other hand, however, the current demographic decline makes it difficult to find a job in school, and diminishes the prospect of positive change in the future. The situation is also unclear concerning the announcements of changes in Polish people's pension entitlement, and another educational system reform involving elimination of junior high schools and changes in the core curriculum at all stages of education (sejm.gov.pl/2015.pdf; 18.12.2015).

In Wroclaw research, 15% of female and 20% of male students declared that they would not work as physical education teachers; others (46%) consider this possibility only if they did not find another, more attractive job (Lewandowski, Starościak, Guła-Kubiszewska, 2011). In many European countries the problem of a declining social standing of teachers is observed. The results of the Teaching and Learning International Survey (TALIS 2013), indicate a complicated professional and social status of teachers. Out of 172 thousand teachers included in the survey, only 18% declared that their profession is respected. The same survey also reveals factors affecting the decline in the prestige of the profession, which include social changes, lack of public awareness of the specifics of teachers' work, low pay, a negative influence of the media, a poor quality of teachers' training, parents' negative perception of teachers' work (http://eduentuzjasci.pl/badanie/599-talis; 4.12.2015). The present study confirmed a low standing of the profession of a physical education teacher.

Determining the full set of professional competences looked for in a physical education teacher is not simple, although defining them could be helpful in the modernization of the training process of students in this field (Paczyńska-Jędrycka, Łubkowska, 2013; Łubkowska, 2015). Today's requirements concerning employment, make it necessary that in addition to professional skills related to the job profile, candidates also have social skills, including collaboration, communication and negotiation capabilities. In the above study, the ability to use basic elements of the teacher's expertise was considered the most important.

Students included in the study considered methodological knowledge and skills related to physical education, recreation and chosen sports disciplines to be the most important specialist competences. These results confirm the hypothesis. Competences concerning a high level of physical fitness and theoretical knowledge of physical culture, on the other hand, were of lesser significance. A study of praxeological competence in pedagogical and methodological knowledge concerning effective teacher's performance produced similar results (Skibniewski,

2011). In the present study it was found that competence in physical fitness was of greater importance for subjects who currently practiced sports at a competitive level.

In the opinion of surveyed elementary school teachers, the most important specialist professional competences of a teacher are methodological skills and knowledge in the field of broadly understood physical culture; significant psycho-pedagogical competences, in turn, are a positive attitude toward schoolchildren, communication skills and motivating schoolchildren to work creatively (Radzińska, Fiedor, 2007; Zalech, 2011; Kyrgyrdis, Derri, 2006). In the present study, only the hypothesis concerning competence in motivating schoolchildren to work was confirmed. The greatest importance was attached to this competence by non-athletes and former athletes.

Self-evaluation can concern different aspects of man's actions, knowledge, abilities, attitudes, competences. Apart from students' expecting specific competences, which they considered important, they were aware of certain areas of their own incompetence. They admitted their fair or average knowledge of foreign languages and preparation for scientific work (research). Undoubtedly, a positive accent could be seen in the self-evaluation of the self-education ability, which was considered well-mastered. It can be assumed that the surveyed students had the readiness for continuous professional development and complementing their competences achieved through University studies, which is also confirmed by other research (Buchta, 2009; Kijo, 2007).

The demands of the labor market and the competitiveness of the educational offers of different universities result in a growing interest in the issues of education quality and equipping students with the competences expected by external interested parties. The necessity for the above study to be cyclical stems, among others, from the provisions of the Bologna Declaration, one of the objectives of which is to create the European Higher Education Area, as well as from responsibility toward the academic community and the country.

The problem of students quitting their sports training on commencing studies at a physical education university is beyond the scope of this study. Despite student athletes' having individual studying schedules, practicing sports at a high level is not conducive to studying at universities of physical education. Finding the causes of this situation will be the subject of subsequent research.

Conclusions

1. Most people's reasons for the choice of physical education studies were: having athletic predispositions, the prospect of an interesting job, being interested in physical recreation, possibilities for self-realization and development of an athletic career. Former athletes more often reported having been motivated to choose this field of study by their interest in employment with institutions of physical culture. Non-athletes declared they had made the choice because of their wish to obtain jobs in schools.

2. Expectations of competence in knowledge and skills concerning physical education methodology were indicated by all respondents, but slightly more often by former athletes and non-athletes. For current athletes, who present a high level of performance in their disciplines, expectations of increasing their competence in physical fitness were more important than for other students.

3. Most respondents indicated motivating schoolchildren to work as the most important psycho-pedagogical competence they expected to gain during their studies. Its significance was stressed more often by former athletes and non-athletes.

4. Respondents rated their preparation for employment with regard to their self-education ability and computer skills as good. Competences concerning their knowledge of foreign languages and preparation for scientific work were rated as average and fair.

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EFFECTS OF TWO 12-WEEK STRENGTHENING PROGRAMMES ON FUNCTIONAL MOBILITY, STRENGTH AND BALANCE OF OLDER ADULTS: COMPARISON BETWEEN TRX SUSPENSION TRAINING VERSUS AN ELASTIC BAND RESISTANCE TRAINING

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Abstract. No study has compared sling exercise training with elastic band resistance training in healthy older adults. Therefore, the purpose of this study was to determine whether different effects on functional mobility, strength and balance ability were produced by using different devices (sling trainer and elastic bands). Twenty-four participants were assigned to two different training groups, INT (TRX-OldAge) and CON (elastic bands). Participants trained three times per week for 30 minutes for 12 weeks. The Multisurface Obstacle Test for Older Adults (MSOT) and the 1-repetition maximum test using the chest press and the leg press were performed to assess functional mobility and dynamic strength, respectively. To examine balance ability, data of body-worn sensors and a force plate measured during different standing positions have been investigated. A main time effect occurred for functional mobility ($p = 0.009$) with a significant improvement within INT ($p = 0.044$), and for the chest press ($p = 0.017$) with a significant improvement within INT ($p = 0.019$). However, there was no group-by-time interaction in any of the measured parameters. Compared to elastic band resistance training, TRX-OldAge induced similar effects on the functional mobility, strength and balance ability of healthy older adults.

Key words: sling exercise training, TRX suspension training, healthy older adults, intervention, core stability

Introduction

The aging process leads to a reduction in the number of motor units and the number and size of muscle fibres, frequently resulting in a loss of strength, balance and mobility (Vandervoort, 2002). However, several previous studies demonstrated positive effects of resistance training on these important resources of older adults (Barnett, Smith, Lord, Williams, Baumand, 2003; Clemson et al., 2012; Irez, Ozdemir, Evin, Irez, Korkusuz, 2011; Kaesler, Mellifont, Kelly, Taaffe, 2007; Krebs, Scarborough, McGibbon, 2007; Taylor et al., 2012). For fall prevention in particular,

guidelines recommend a combination of balance and resistance training (Sherrington, Tiedemann, Fairhall, Close, Lord, 2011). Following this approach, functional resistance training has gained increasing importance in recent years and shown an increase in the one repetition maximum and sit-to-stand power test performance and maximal walking speed (Henwood, Taaffe, 2006; Lohne-Seiler, Torstveit, Anderssen, 2013; Solberg et al., 2013).

An up-and-coming form of functional resistance training that improves functional mobility, strength and balance ability is sling exercise training. For younger adults, upper-body strength improvements (1 – repetition maximum [1 RM] test at chest press), ranging from 4% to 11%, were shown (Dannelly et al., 2011; Maté-Muñoz, Monroy, Jodra Jiménez, Garnacho-Castaño, 2014; Prokopy et al., 2008). Furthermore, leg strength (1 RM at leg press or back squat at a Smith machine) increased between 13% and 66% (Dannelly et al., 2011; Maté-Muñoz et al., 2014). With regard to balance ability, single-leg stance of young female softball players significantly increased by about 57% and 65% (Prokopy et al., 2008). In a study by Stray-Pedersen, Magnussen, Kuffel, Seiler, Katch (2006), single-leg stance on the non-dominant leg improved significantly by about 45%. On the other hand, the observed single-leg stance improvements of the dominant leg of elite soccer players of 18% were not significant (Stray-Pedersen et al., 2006). Younger low back pain patients enhanced static (normal stance) and dynamic (normal stance after an 180° rotation) balance by about 23% and 50% (measured as sway speed of the centre of pressure), respectively (Kim, Kim, Bae, Kim, 2013). In another study, patients with hemiplegia achieved a comparable improvement of 30% for the normal stance sway length of the centre of pressure after eight weeks of sling training (Park, Hwangbo, 2014) However, data have only been collected using younger subjects and patients. Studies targeting older adults have been predominantly conducted with older patients (Bae, Jung, Lee, Cho, 2014; Lee, Lee, 2014; Schroeder, Knauerhase, Kundt, Schober, 2012; Schroeder, Knauerhase, Kundt, Schober, 2014; Tsauo, Cheng, Yang, 2008), rather than healthy older adults. For older adults with total knee replacement, a six-week sling training led to significant quadriceps and hamstring strength improvements of 77% and 56%, respectively (Bae et al., 2014). Furthermore, functional mobility (Timed Up and Go test [TUG]) improved significantly by about 5% after four weeks of sling training for older hemiplegic patients (Lee, Lee, 2014). Older osteoporosis patients significantly enhanced TUG performance by around 25% after three-months of sling training (Schroeder et al., 2014).

However, because of different target groups, study designs and measures, results are not consistent. Beyond that, there is still a lack of knowledge about the effects of sling training in healthy older adults. Based on these constraints in literature, a new specific sling exercise training programme for a target group of healthy older adults was developed (TRX-OldAge by Gaedtke, Morat, 2015). Based on this, the purpose of this study was to analyse and compare the effects of TRX-OldAge and Thera-Band training on strength, functional mobility and balance ability of older adults. We hypothesized that a 12-week resistance training with three sessions per week induced significant greater functional mobility, strength and balance ability improvements for TRX-OldAge than occurred for elastic band resistance training.

Material and Methods

Study design

The present pilot study is based on a 12-week, single-blinded, randomized controlled trial with two training groups in a parallel design. An initial assessment (T1) was conducted prior to intervention and was repeated immediately after the training intervention (T2). In order to ensure a gender balance between the two treatment groups, a block randomization with a block size of 3 × 2 was separately made for men and women. The ethics

committee at the German Sport University Cologne granted ethical approval. The study design took into account the principles set out in the Declaration of Helsinki (2008). All participants completed consent forms. Participants were informed that all the data collected would be processed anonymously. The study was conducted in the City of Cologne, Germany.

Participants

The participants were community-dwelling healthy older adults aged 60 years and older. They had been recruited by advertisements placed on web pages, in local newspapers, posters, and flyers in Cologne and the surrounding area. Participants had to bring in a medical certificate from his or her physician to declare their good state of health. Exclusion criteria for participating in this study were hypertension not being regulated by a physician, acute and chronic heart diseases, herniated disc in the last six months, acute inflammation of the musculoskeletal system, post-polio syndrome, and osteoporosis.

Intervention

Participants were randomly assigned into the two different training groups. One group received the TRX-OldAge program (INT, see Gaedtke, Morat, 2015). The control group (CON) conducted an elastic band resistance training, which has also been shown to have positive effects on upper-body strength (Fahlman, McNevin, Boardley, Morgan, Topp, 2011), lower-body strength (Fahlman et al. 2011; Krebs et al., 2007; O'Shea, Taylor, Paratz, 2007), balance (measured as area of centre of gravity movement during normal stance), sit-to-stand performance (Choi, Kim, Hwang, 2011), Timed Up and Go Test time (Ribeiro, Teixeira, Brochado, Oliveira, 2009), gait velocity and step length of older adults (Fahlman et al., 2011). Beyond that, compared to sling training, with elastic bands we could generate similar exercises. The exercise programme for TRX-OldAge was published in a previous study (Gaedtke, Morat, 2015). For CON, seven exercises that train similar muscle groups as in TRX-OldAge were implemented.

Both groups (INT and CON) trained outdoors for 12 weeks (three times per week for 30 minutes) from June to August. An installed pavilion protected participants from rain and sun. The participants trained in pairs. For INT, two TRX Suspension Trainers (TRX; Fitness Anywhere LLC, San Francisco, California, USA) were attached to a TRX Suspension Frame (TRX; Fitness Anywhere LLC, San Francisco, California, USA), while CON trained with Thera--Bands of different thickness for variation in resistance (resistance at 100% extension: yellow = 1.3 kg, red = 1.8 kg, green = 2.3 kg, blue = 3.2 kg, black = 4.4 kg, silver = 6.0 kg, gold = 9.8 kg).

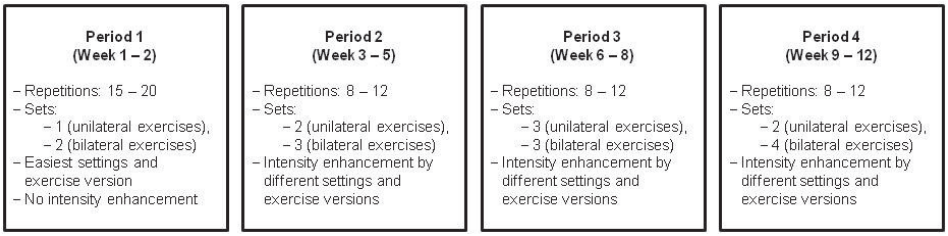

Figure 1. Training periods for both groups

Training was separated into four periods (see Figure 1) with different configurations of training control. A professional instructor supervised every training session. At the beginning of each session, a brief warm-up phase, which consisted of walking and mobility exercises (knee lift, heel-to-toe walk, shoulder rotation etc.), was implemented. In a cool-down phase at the end of a session participants executed stretching exercises. Subsequently to the warm-up phase, participants of INT followed the original prescription and order of the TRX--OldAge programme (Gaedtke, Morat, 2015). Between each set, they had a rest of 90 seconds. The intensity and number of repetitions were enhanced as soon as the participant reached two more repetitions in the last set of an exercise in two consecutive training sessions. Firstly, the number of repetitions was increased from eight to ten and from ten to twelve. After completing twelve repetitions, training intensity was raised. The progress in intensity was implemented by different exercise versions and settings (Gaedtke, Morat, 2015).

For CON, the load was defined by band colours and their depending resistance. Version A of an exercise means to train with the yellow and red elastic bands, version B was based on the green and blue bands, while version C included the black, silver and gold bands. Further settings for CON were realized as follows: band position on extremities or band folding (single-layer, twofold). During training, the participants were asked to rate their individual exertion after each set of an exercise on the OMNI-RES scale (Robertson et al., 2003). Exertion values of six to eight were classified as optimal. If the exertion was lower than the optimal range, intensity was increased in the next session.

Outcomes

The primary outcomes were the functional mobility, dynamic maximum lower-body strength, upper-body strength (1 RM) and balance ability. Physical activity and body weight were secondary outcomes.

Following a five-minute warm-up period of ergometer cycling with 1 watt per kg body weight, two researchers carried out the assessment.

Functional mobility was assessed using the Multisurface Obstacle Test (MSOT; Morat, Kroeger, Mechling, 2013). Within the MSOT, participants have to walk an 8-metre track with different obstacles and uneven surfaces. After three familiarization trials without the MSOT, participants had to complete three trials with their habitual gait speed (Morat et al., 2013). The best walking time (sec.) of these three trials on the MSOT was analysed.

One repetition maximum (1 RM) for the upper body and lower body was assessed by using the Ergo-Fit Chest Press 4000 and the Ergo-Fit Leg Press 4000 (Pirmasens, Germany), respectively. Both devices were adjusted for each participant. An 80-degree knee angle was defined as the initial position for the leg press. For the chest press, a 60-degree angle between trunk and abducted upper arm was used. After a familiarization set to the lowest possible intensity (lightest weight), 10–15 repetitions, and a following one-minute rest period, the researcher started the 1 RM testing procedure. In the first set, a load for three to five repetitions to fatigue was used. Subsequent to this, a two-minute rest period was conducted. For a maximum of four additional sets, a near-maximum load was estimated until 1 RM was achieved. If a single repetition failed, the load was reduced by 2.5% to 5% for the chest press and by 5% to 10% for the leg press. On the other hand, intensity was increased if the participant performed more than one repetition correctly (Spring, Franklin, de Jong, 2010). During the two-minute rest period between the sets, participants rated their individual exertion on the OMNI-RES scale (Robertson et al. 2003). If the 1 RM was not reached until the final set (after 1 familiarization set, 1 set of maximum 3–5 repetitions and a maximum of

4 additional sets of maximum 2–3 repetitions), participants should perform as many repetitions as possible. Based on this number of repetitions, the hypothetical 1 RM was estimated (Giessing, 2003). Both 1 RM upper-body and lower-body strength were measured in kilograms (kg).

Balance ability was measured on a Kistler force plate (type 9287B, Winterthur, Switzerland) with a frequency of 200 Hz with BioWare Software (version 4.0.x, type 2812A) and six APDM sensors (Portland, Oregon, USA). The six APDM movement sensors were attached to the followings positions: instep (left and right foot), tibia right above the ankles (left and right foot), lumbar spine and sternum (see Figure 2).

Figure 2. Movement sensor positions for balance ability measurement

Participants were instructed to stand as still as possible in the following standing positions on the force plate without (X) and with (A), an Airex Balance Pad: 1) closed-leg stance (CS); 2) tandem stance with the left foot forward (TS); 3) tandem stance with the right foot forward (TS); 4) single-leg stance on the dominant leg (SS_do); 5) single-leg stance on the not dominant leg (SS_ndo). One shoeless trial for each stance was executed with a maximum duration of 30 seconds (see Figure 3). If the maximum duration was reached or the participant lost their balance, time and data recording was stopped by the researcher. Analysis included root mean square (RMS) values of the lumbar spine sensor acceleration (ACC, measured in m/s^2) for medio-lateral (ML) and anterior-posterior (AP) direction, RMS values of the force plate force (FOR, measured in N) for ML and AP direction and centre of pressure (COP) velocity (COP_TRA, measured in mm/s). In respect of the tandem stance with the left and right foot forward, both standing positions were summarized together by generating a mean. Beyond that, the single-leg stance was discriminated between standing on the dominant (do) and not dominant leg (ndo). For balance ability, values were revised from analysis if the participant was not able to stand for at least ten seconds.

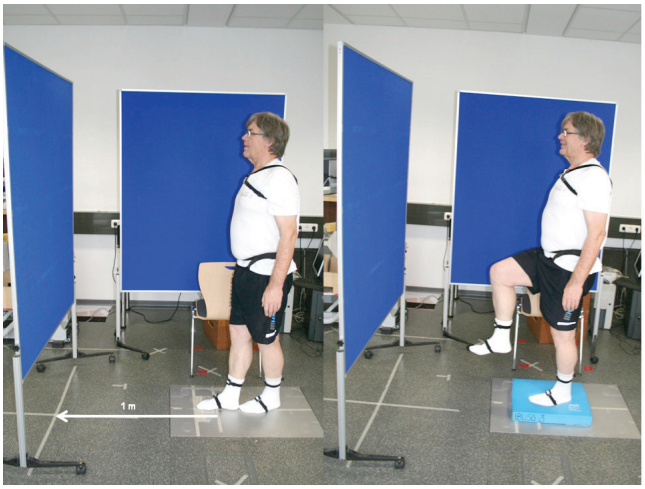

Figure 3. Exemplary standing positions during balance ability measurement

Physical activity was measured with the German-Physical Activity Questionnaire-50+ (German-PAQ-50+, Huy, Schneider, 2008). Its items investigate the time per week spent on different activities. By summing up the five categories (housework, gardening, leisure time, sports and profession) and multiplying the time spent with metabolic rate values (Ainsworth et al., 2000) a total energy consumption per week can be generated (measured in kcal per week). A further secondary outcome was body weight (measured in kg).

Statistical methods

Statistical analysis was conducted using IBM SPSS Statistics for Windows (version 22, IBM, Armonk, New York, USA). The level of significance was set at $\alpha = .05$. Boxplots of the different Δ-variables (T2-T1) indicated extreme outliers. If they were three times as large as the interquartile range, they were excluded from further analysis. A two-way repeated measures ANOVA (with the factors group and time) was executed. The Bonferroni post hoc test located specific differences afterwards. In the case of the preconditions of ANOVA not being fulfilled, the Friedman test or Kruskal-Wallis test were used instead.

G*Power software 3.1 (Faul, Erdfelder, Lang, Buchner, 2007) was used to calculate effect sizes and power for each test. For this, effect size was determined with partial η^2 values of the two-way repeated measures ANOVA for the relevant tests.

Results

A total of 22 healthy older adults, 17 males and 5 females completed the study (see Figure 4). The following diseases were present: hypertension adjusted by a physician (n = 11), type 2 diabetes (n = 4), rheumatoid arthritis (n = 1), scoliosis (n = 2), herniated disc more than 10 years ago (n = 3), elevated blood cholesterol level (n = 1), Bechterew's disease (n = 1), asthma (n = 1), tetraparesis (n = 1). Total training compliance was 81 ±11% with 85

±10% for INT and 77 ±11% for CON. Baseline data is shown in Table 1. There were no significant group differences at T1.

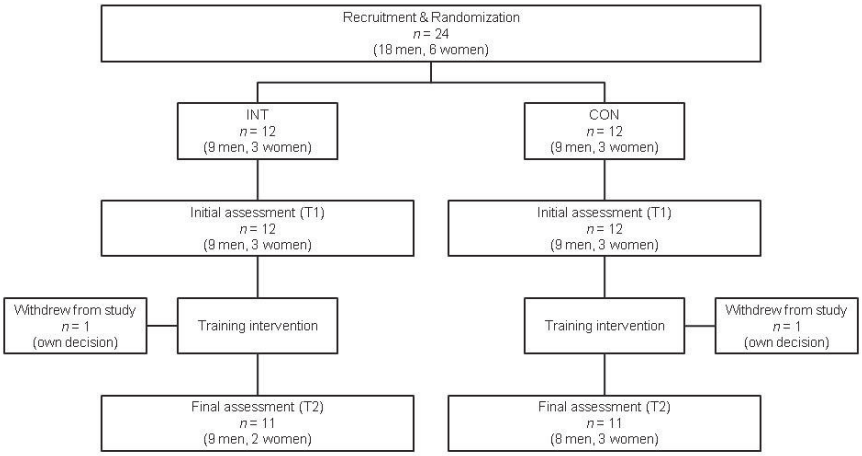

Figure 4. Process chart

Table 1. Baseline anthropometric data

	INT n = 11		CON n = 11		Total n = 22	
	M ± SD	95% CI	M±SD	95% CI	M±SD	95% CI
Age (in years)	66.3 ±4.2	63.4 to 69.1	67.3 ±4.2	64.5 to 70.1	66.8 ±4.1	64.9 to 68.6
Height (in m)	1.76 ±0.08	1.70 to 1.81	1.69 ±0.11	1.61 to 1.76	1.72 ±0.10	1.68 to 1.77
Body weight (in kg)	88.4 ±16.3	77.4 to 99.4	88.6 ±21.1	74.4 to 102.8	88.5 ±18.4	80.3 to 96.7

INT = intervention group (TRX-OldAge); CON = control group (elastic band resistance training); n = sample size; M = mean; SD = standard deviation; CI = confidence interval.

Body weight analysis revealed no group-by-time interaction ($F(1, 20) = 0.002$, $p = 0.969$, $\eta^2_{par} < 0.001$). No main time ($F(1, 20) = 1.316$, $p = 0.265$, $\eta^2_{par} = 0.062$) or group effects ($F(1, 20) = 0.001$, $p = 0.981$, $\eta^2_{par} < 0.001$) exist.

For physical activity, no group-by-time interaction ($F(1, 18) = 0.035$, $p = 0.854$, $\eta^2_{par} = 0.002$), main time ($F(1, 18) = 0.669$, $p = 0.424$, $\eta^2_{par} = 0.036$) or group effects ($F(1, 18) = 0.578$, $p = 0.457$, $\eta^2_{par} = 0.031$) are present.

The analysis of functional mobility showed no group-by-time interaction ($F(1, 19) = 0.007$, $p = 0.936$, $\eta^2_{par} < 0.001$). The main time effect ($F(1, 19) = 8.361$, $p = 0.009$, $\eta^2_{par} = 0.306$) was significant and post hoc analysis revealed a significant MSOT time reduction between T1 and T2 of about 5% for INT ($p = 0.044$), but not for CON ($p = 0.067$). The main group effect ($F(1, 19) = 0.052$, $p = 0.821$, $\eta^2_{par} = 0.003$) was not significant.

For leg strength, no significant group-by-time interaction ($F(1, 18) = 0.125$, $p = 0.728$, $\eta^2_{par} = 0.007$), main effect for time ($F(1, 18) = 0.422$, $p = 0.524$, $\eta^2_{par} = 0.023$) or group ($F(1, 18) = 3.208$, $p = 0.090$, $\eta^2_{par} = 0.151$) are present.

In respect of 1 RM upper-body strength, analysis showed no significant group-by-time interaction ($F(1, 18) = 0.709$, $p = 0.411$, $\eta^2_{par} = 0.038$). The main time effect ($F(1, 18) = 6.914$, $p = 0.017$, $\eta^2_{par} = 0.278$) reached

statistical significance. Post hoc analysis revealed a significant improvement of upper-body strength within INT of about 9% (p = 0.019), whereas the 5% improvement of CON did not reach statistical significance (p = 0.244). The main group effect (F(1, 18) = 0.352, p = 0.560, η^2_{par} = 0.019) was not significant (see Table 2).

Table 2. Changes of physical activity, 1-repetition maximum and Multisurface Obstacle Test for Older Adults results between T1 and T2

Variable	Group	n	T1 M ± SD	T2 M ± SD	Mean change (95% CI)	Effect size	Power
Physical activity (1000 kcal/week)	INT	9	13.3 ±8.1	14.8 ±11.4	1.5 (–3.2 to 6.1)	0.04	0.67
	CON	11	17.3 ±14.1	19.7 ±18.9	2.3 (–6.3 to 11.0)		
Leg press (kg)	INT	9	171.2 ±65.0	165.7 ±57.6	–5.6 (–42.0 to 30.8)	0.08	0.11
	CON	11	241.6 ±112.3	222.8 ±101.1	–18.8 (–88.5 to 50.9)		
Chest press (kg)	INT	11	59.1 ±16.9	64.6 ±15.4*	5.5 (–0.4 to 11.4)	0.20	0.39
	CON	9	55.8 ±19.4	58.6 ±20.2	2.8 (–0.1 to 5.7)		
MSOT (s)	INT	11	7.65 ±2.08	7.24 ±2.33*	–0.41 (–0.84 to 0.23)	0.03	0.06
	CON	10	7.81 ±1.03	7.43 ±1.26	–0.39 (–0.82 to 0.05)		

INT = intervention group (TRX-OldAge); CON = control group (elastic band resistance training); n = sample size; M = mean; SD = standard deviation; CI = confidence interval; MSOT = Multisurface Obstacle Test for Older Adults; *p < 0.05 significant difference in comparison to T1.

For CSX_RMS_ACC_AP, no significant time effect is present (χ^2(1) = 0.727, p = 0.523, w = 0.182). At T1 a significant group difference exists (χ^2(1) = 4.554, p = 0.033, w = 0.455) that could not be found at T2 (χ^2(1) = 0.475, p = 0.491, w = 0.147). Analysis of CSX_RMS_FOR_AP showed no significant group-by-time interaction (F(1, 18) = 1.240, p = 0.280, η^2_{par} = 0.064). The main time effect (F(1, 18) = 17.914, p = 0.001, η^2_{par} = 0.499) reached statistical significance. Post hoc analysis revealed a significant improvement within INT (p = 0.032) of 11% and within CON (p = 0.002) of 20%. The main group effect was not significant (F(1, 18) = 0.631, p = 0.437, η^2_{par} = 0.034). In respect of TSX_RMS_FOR_AP, neither group-by-time interaction (F(1, 13) = 0.249, p = 0.626, η^2_{par} = 0.019) nor main group effect (F(1, 13) = 0.121, p = 0.734, η^2_{par} = 0.009) are significant. Only the main time effect (F(1, 13) = 7.367, p = 0.018, η^2_{par} = 0.362) reached statistical significance. Post hoc analysis only yielded a significant improvement within INT (p = 0.035) of 17%. None of the remaining balance variables without the Airex Balance Pad demonstrated any significant group-by-time interactions, main time and group effects (see Appendix I and Table 3).

With the exception of TSA_RMS_ACC_ML, no balance variables on the Airex Balance Pad showed any significant group-by-time interactions; main time effect and main group effect (see Appendix II). TSA_RMS_ACC_ML analysis revealed no significant group-by-time interaction (F(1, 7) = 0.117, p = 0.743, η^2_{par} = 0.016) and no main time effect (F(1, 7) = 0.555, p = 0.481, η^2_{par} = 0.073). Only group effect reached significance level (F(1, 7) = 5.965, p = 0.045, η^2_{par} = 0.460), but post hoc analysis demonstrated no group differences for T1 or T2 (see Table 4).

Table 3. Changes of closed-leg stance, tandem stance and single-leg stance between T1 and T2

	Variable	Group	n	T1 M ± SD	T2 M ± SD	Mean change (95% CI)	Effect size	Power
CSX	RMS_ACC_ML (m/s²)	INT	11	0.09 ±0.04	0.14 ±0.09	0.05 (0.01 to 0.08)	0.52	0.87
		CON	11	0.18 ±0.13	0.13 ±0.10	–0.05 (–0.12 to 0.02)		
	RMS_ACC_AP (m/s²)	INT	11	0.06 ±0.02	0.11 ±0.08	0.05 (–0.01 to 0.11)	0.43	0.69
		CON	11	0.10 ±0.05	0.13 ±0.07	0.03 (–0.02 to 0.08)		
	RMS_FOR_ML (N)	INT	11	6.44 ±1.66	6.40 ±1.12	–0.03 (–0.62 to 0.55)	0.25	0.56
		CON	10	6.79 ±1.72	7.16 ±1.66	0.37 (–0.22 to 0.97)		
	RMS_FOR_AP (N)	INT	11	3.41 ±1.25	3.05 ±0.97*	–0.36 (–0.78 to 0.06)	0.14	0.22
		CON	9	3.17 ±1.07	2.54 ±1.01*	–0.62 (–0.89 to –0.36)		
	COP_TRA (mm/s)	INT	11	10.1 ±2.79	11.1 ±3.50	1.00 (–0,70 to 2.70)	0.33	0.83
		CON	10	12.0 ±3.18	11.7 ±3.04	–0.3 (–1.30 to 0.70)		
TSX	RMS_ACC_ML (m/s²)	INT	8	0.15 ±0.08	0.14 ±0.05	–0.01 (–0.08 to 0.05)	0.10	0.11
		CON	7	0.15 ±0.09	0.13 ±0.05	–0.03 (–0.11 to 0.05)		
	RMS_ACC_AP (m/s²)	INT	8	0.17 ±0.08	0.15 ±0.06	–0.02 (–0.07 to 0.03)	0.11	0.13
		CON	7	0.16 ±0.06	0.15 ±0.05	–0.01 (–0.04 to 0.03)		
	RMS_FOR_ML (N)	INT	8	6.98 ±1.49	7.14 ±1.34	0.16 (–0.33 to 0.66)	0.03	0.06
		CON	7	6.89 ±1.02	7.03 ±0.79	0.14 (–0.33 to 0.61)		
	RMS_FOR_AP (N)	INT	8	4.71 ±1.26	3.90 ±1.04*	–0.81 (–1.89 to 0.28)	0.14	0.17
		CON	7	4.42 ±0.82	3.87 ±0.72	–0.56 (–0.82 to –0.29)		
	COP_TRA (mm/s)	INT	8	27.34 ±9.30	26.16 ±8.82	–1.16 (–5.37 to 3.05)	0.03	0.06
		CON	7	25.19 ±5.00	24.23 ±5.31	–0.96 (–4.08 to 2.17)		
SSX	RMS_ACC_ML_DO (m/s²)	INT	8	0.19 ±0.09	0.18 ±0.06	–0.01 (–0.07 to 0.05)	0.21	0.28
		CON	5	0.18 ±0.05	0.14 ±0.08	–0.04 (–0.12 to 0.04)		
	RMS_ACC_AP_DO (m/s²)	INT	8	0.24 ±0.20	0.26 ±0.11	0.02 (–0.14 to 0.19)	0.26	0.41
		CON	5	0.22 ±0.07	0.17 ±0.05	–0.06 (–0.14 to 0.03)		
	RMS_FOR_ML_DO (N)	INT	8	8.31 ±2.60	8.72 ±2.51	0.40 (–2.42 to 3.23)	0.21	0.29
		CON	5	7.69 ±0.96	6.98 ±0.72	–0.71 (–1.79 to 0.38)		
	RMS_FOR_AP_DO (N)	INT	8	4.90 ±1.77	4.45 ±1.67	–0.45 (–2.17 to 1.26)	0.03	0.06
		CON	6	4.60 ±1.31	4.17 ±2.15	–0.44 (–1.44 to 0.56)		
	COP_TRA_DO (mm/s)	INT	8	33.54 ±10.68	33.57 ±12.38	0.02 (–7.55 to 7.60)	0.25	0.41
		CON	6	30.67 ±7.01	27.12 ±4.79	–3.55 (–8.49 to 1.40)		
	RMS_ACC_ML_NDO (m/s²)	INT	8	0.17 ±0.04	0.16 ±0.05	–0.01 (–0.07 to 0.05)	0.25	0.45
		CON	7	0.19 ±0.06	0.23 ±0.12	0.04 (–0.08 to 0.15)		
	RMS_ACC_AP_NDO (m/s²)	INT	8	0.25 ±0.09	0.25 ±0.10	0.00 (–0.07 to 0.06)	0.03	0.06
		CON	7	0.30 ±0.14	0.31 ±0.25	0.01 (–0.22 to 0.23)		
	RMS_FOR_ML_NDO (N)	INT	7	8.24 ±1.50	8.80 ±1.87	0.56 (–0.15 to 1.27)	0.37	0.68
		CON	6	7.79 ±1.65	7.49 ±1.34	–0.30 (–2.04 to 1.44)		
	RMS_FOR_AP_NDO (N)	INT	8	4.43 ±1.09	4.43 ±1.68	0.00 (–0.71 to 0.71)	0.40	0.78
		CON	6	4.48 ±0.99	3.60 ±0.76	–0.87 (–2.45 to 0.70)		
	COP_TRA_NDO (mm/s)	INT	8	33.54 ±8.84	34.33 ±13.44	0.80 (–5.07 to 6.67)	0.49	0.92
		CON	6	33.28 ±7.31	27.92 ±5.24	–5.36 (–12.10 to 1.38)		

INT = intervention group (TRX-OldAge); CON = control group (elastic band resistance training); n = sample size; M = mean; SD = standard deviation; CI = confidence interval; CSX = closed-leg stance; TSX = tandem stance; SSX = single-leg stance; RMS = root mean square; ACC = lumbar spine sensor acceleration; FOR = force plate force; ML = medio-lateral direction; AP = anterior-posterior direction; DO = dominant leg; NDO = not dominant leg; COP = centre of pressure; TRA = velocity; *p < 0.05 significant difference in comparison to T1.

Table 4. Changes of closed-leg stance, tandem stance and single-leg stance on Airex Balance Pad between T1 and T2

	Variable	Group	n	T1 M ± SD	T2 M ± SD	Mean change (95% CI)	Effect size	Power
CSA	RMS_ACC_ML (m/s²)	INT	11	0.14 ±0.05	0.12 ±0.04	–0.02 (–0.07 to 0.02)	0.12	0.19
		CON	11	0.16 ±0.05	0.15 ±0.09	–0.01 (–0.05 to 0.04)		
	RMS_ACC_AP (m/s²)	INT	11	0.13 ±0.03	0.16 ±0.05	0.02 (–0.01 to 0.05)	0.03	0.06
		CON	11	0.14 ±0.04	0.15 ±0.05	0.01 (–0.02 to 0.04)		
	RMS_FOR_ML (N)	INT	11	6.11 ±1.14	6.40 ±1.38	0.30 (–0.10 to 0.69)	0.17	0.31
		CON	9	6.48 ±1.76	6.59 ±1.91	0.10 (–0.33 to 0.54)		
	RMS_FOR_AP (N)	INT	10	3.69 ±1.15	3.65 ±1.34	–0.04 (–0.55 to 0.47)	0.04	0.07
		CON	10	3.86 ±1.37	3.90 ±1.70	0.04 (–0.83 to 0.91)		
	COP_TRA (mm/s)	INT	11	21.9 ±5.79	22.4 ±7.09	0.50 (–2.80 to 3.80)	0.14	0.22
		CON	10	23.3 ±6.46	22.7 ±6.46	–0.60 (–3.40 to 2.20)		
TSA	RMS_ACC_ML (m/s²)	INT	5	0.25 ±0.06	0.19 ±0.03	–0.06 (–0.14 to 0.02)	0.13	0.10
		CON	4	0.30 ±0.15	0.27 ±0.12	–0.02 (–0.40 to 0.36)		
	RMS_ACC_AP (m/s²)	INT	5	0.51 ±0.21	0.40 ±0.14	–0.11 (–0.21 to 0.01)	0.88	0.99
		CON	4	0.43 ±0.13	0.56 ±0.17	0.13 (–0.20 to 0.46)		
	RMS_FOR_ML (N)	INT	4	10.38 ±3.62	9.78 ±3.27	–0.60 (–2.02 to 0.82)	0.32	0.33
		CON	4	9.10 ±3.45	9.85 ±1.42	0.75 (–4.62 to 6.11)		
	RMS_FOR_AP (N)	INT	5	6.81 ±2.79	4.81 ±1.54	–2.00 (–3.89 to –0.10)	0.55	0.81
		CON	4	5.01 ±2.78	6.06 ±2.68	1.05 (–6.00 to 8.09)		
	COP_TRA (mm/s)	INT	4	37.70 ±9.34	37.00 ±9.65	–0.70 (–5.30 to 3.80)	0.68	0.89
		CON	4	38.30 ±5.24	46.20 ±8.61	7.90 (–8.00 to 23.70)		
SSA	RMS_ACC_ML_DO (m/s²)	INT	7	0.31 ±0.11	0.26 ±0.12	–0.05 (–0.18 to 0.08)	0.29	0.48
		CON	6	0.36 ±0.18	0.49 ±0.37	0.13 (–0.12 to 0.38)		
	RMS_ACC_AP_DO (m/s²)	INT	7	0.56 ±0.17	0.53 ±0.29	–0.02 (–0.26 to 0.22)	0.03	0.05
		CON	6	0.61 ±0.26	0.60 ±0.23	–0.01 (–0.21 to 0.19)		
	RMS_FOR_ML_DO (N)	INT	7	14.31 ±5.08	15.80 ±8.86	1.49 (–5.02 to 8.00)	0.31	0.53
		CON	6	15.29 ±6.59	12.88 ±2.99	–2.41 (–9.23 to 4.42)		
	RMS_FOR_AP_DO (N)	INT	6	7.31 ±2.77	7.36 ±3.70	0.05 (–3.29 to 3.40)	0.03	0.05
		CON	6	7.70 ±4.80	7.95 ±4.95	0.25 (–3.63 to 4.14)		
	COP_TRA_DO (mm/s)	INT	6	46.36 ±14.18	46.28 ±11.65	–0.09 (–6.17 to 5.99)	0.24	0.36
		CON	6	43.38 ±10.56	47.64 ±9.89	4.25 (–9.01 to 17.51)		
	RMS_ACC_ML_NDO (m/s²)	INT	7	0.30 ±0.16	0.34 ±0.14	0.04 (–0.06 to 0.13)	0.13	0.13
		CON	5	0.45 ±0.20	0.41 ±0.18	–0.04 (–0.30 to 0.22)		
	RMS_ACC_AP_NDO (m/s²)	INT	7	0.57 ±0.25	0.63 ±0.20	0.06 (–0.09 to 0.21)	0.08	0.08
		CON	5	0.55 ±0.15	0.57 ±0.23	0.02 (–0.39 to 0.43)		
	RMS_FOR_ML_NDO (N)	INT	8	15.12 ±4.77	17.78 ±7.03	2.67 (–1.44 to 6.77)	0.14	0.15
		CON	5	13.41 ±3.53	14.64 ±7.58	1.23 (–6.98 to 9.43)		
	RMS_FOR_AP_NDO (N)	INT	7	8.17 ±3.55	7.87 ±4.05	–0.30 (–2.77 to 2.16)	1.30	1.00
		CON	5	7.94 ±2.33	6.93 ±1.20	–1.01 (–5.16 to 3.14)		
	COP_TRA_NDO (mm/s)	INT	8	53.17 ±22.33	52.97 ±17.30	–0.20 (–6.71 to 6.32)	0.16	0.15
		CON	3	35.85 ±2.45	37.85 ±2.94	2.00 (0.42 to 3.58)		

INT = intervention group (TRX-OldAge); CON = control group (elastic band resistance training); n = sample size; M = mean; SD = standard deviation; CI = confidence interval; CSA = closed-leg stance on Airex Balance Pad; TSA = tandem stance on Airex Balance Pad; SSA = single-leg stance on Airex Balance Pad; RMS = root mean square; ACC = lumbar spine sensor acceleration; FOR = force plate force; ML = medio-lateral direction; AP = anterior-posterior direction; DO = dominant leg; NDO = not dominant leg; COP = centre of pressure; TRA = velocity.

Discussion

Functional mobility, measured with the MSOT walking with normal (habitual) gait speed, improved significantly by about 5% in the TRX-OldAge training group. Despite different measurement methods (MSOT and TUG), this result is consistent with previous studies, which documented functional mobility improvements of 5% to 26% for older adults (Lee, Lee, 2014; Schroeder et al., 2014).

For upper-body strength, our results are in line with reports of previous studies that could not prove significant group-by-time interactions between sling exercise training and another exercise programme (Dannelly et al., 2011; Prokopy et al., 2008). On the other hand, Bae et al. (2014) demonstrated significant leg strength improvements of 77% after six weeks of sling training. The main difference between Bae et al. (2014) and our study is that they measured muscle strength isometrically and in older patients with total knee replacement. For younger adults, sling training induced leg strength improvements ranging from 13% to 27% (Dannelly et al., 2011; Maté-Muñoz et al., 2014).

However, the significant increase of 9% in chest press strength in the TRX-OldAge training group is comparable with previous findings in younger adults. These studies showed 4% to 11% improvements in chest press strength (Dannelly et al., 2011, Maté-Muñoz et al., 2014, Prokopy et al., 2008).

The results for balance ability showed no significant differences between the two different training groups. To our knowledge, only one sling training study with older adults examined balance ability. After four weeks of training, older chronic hemiplegic patients changed balance significantly by about one point on the Berg Balance Scale (Lee, Lee, 2014). However, the improvements by Lee, Lee (2014) cannot be compared with the quantitative measurements of centre of pressure in the study presented here. In younger participants, Kim et al. (2013) showed a significant sway speed reduction of 23%. Beyond that, after eight weeks of sling training, COP sway length for normal stance significantly decreased by about 30% (Park, Hwangbo, 2014). In a study by Prokopy et al. (2008), a 12-week sling training induced single-leg stance performance enhancements of 57% and 65% for COP sway area. To our knowledge, no sling training study examined tandem stance as a balance ability measure.

Based on the mostly not significant results, some limitations in respect of sample size, measures and intervention should be mentioned. As normal for a first pilot study, the sample size was too small, as power and effect size calculations have shown. Nevertheless, these values can be used for a priori sample size calculations for future studies.

Furthermore, a core stability measurement method should be integrated in the assessment battery, because there is only a small correlation between core stability and balance ability (Granacher, Gollhofer, Hortobágyi, Kressig, Muehlbauer, 2013). However, Lee, Lee (2014) reported increased core muscle activations subsequent to their sling training intervention. Due to the instable design of the implemented TRX-OldAge exercises, it could be assumed that participants of TRX-OldAge improve their core stability, but not their balance ability. Thus, sling training alone would not be sufficient to enhance the complex balance ability of healthy older adults.

To achieve leg strength and balance improvements, the difficulty and load intensity of the TRX-OldAge exercises should be modified or increased to focus more on balance or lower-body strength. One example could be lunges with the forward foot on a board between the foot cradles, as conducted by Schroeder et al. (2012). The only study that reported balance improvements for older adults conducted bridging exercises (prone, supine and lateral) (Lee, Lee, 2014). Therefore, more exercises of this kind should be integrated in TRX-OldAge to enhance core stability and perhaps balance.

In conclusion, the new TRX-OldAge training programme can be used as a motivating alternative to improve functional mobility and upper-body strength in healthy older adults. In its current description, TRX-OldAge is probably more effectively applicable for more frail and old persons with first mobility limitations. For a further improvement of its effectiveness, TRX-OldAge could be modified to provide higher challenges for fit, healthy older adults, as in the sample of this study.

Based on the present results, it can be concluded that both strength training programmes – TRX-OldAge and an elastic band resistance training – induced similar effects on functional mobility, strength and balance ability in healthy older adults after 12 weeks of training.

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Appendix I. Non-significant results of statistical analysis of balance ability without the Airex Balance Pad

Standing position		χ^2-value/ F-value	df	p	w/ η^2_{par}
CSX	RMS_ACC_ML	1.636	1	0.286	0.273
		2.183		0.140	0.315
		0.312		0.577	0.119
	RMS_FOR_ML	1.169	1, 19	0.293	0.058
		0.830		0.374	0.020
		0.719		0.407	0.036
	COP_TRA	2.100	1, 19	0.164	0.100
		0.632		0.436	0.032
		0.915		0.351	0.046
TSX	RMS_ACC_ML	0.135	1, 13	0.719	0.010
		0.875		0.367	0.063
		0.030		0.864	0.002
	RMS_FOR_ML	0.006	1, 13	0.939	<0.001
		1.139		0.305	0.081
		0.029		0.868	0.002
	RMS_ACC_AP	0.173	1, 13	0.685	0.013
		0.803		0.386	0.058
		0.010		0.921	0.001
	COP_TRA	0.009	1, 13	0.924	0.001
		0.902		0.360	0.065
		0.301		0.593	0.023
SSX	RMS_ACC_ML_DO	0.479	1, 11	0.503	0.042
		1.610		0.231	0.128
		0.371		0.555	0.033
	RMS_ACC_ML_NDO	0.850	1, 13	0.373	0.061
		0.226		0.642	0.017
		3.140		0.100	0.195
	RMS_FOR_ML_DO	0.502	1, 11	0.493	0.044
		0.037		0.851	0.003
		1.690		0.220	0.133
	RMS_FOR_ML_NDO	1.520	1, 11	0.243	0.121
		0.135		0.720	0.012
		1.134		0.310	0.093
	RMS_ACC_AP_DO	0.756	1, 11	0.403	0.064
		0.155		0.702	0.014
		0.936		0.354	0.078
	RMS_ACC_AP_NDO	0.010	1, 13	0.922	0.001
		0.001		0.978	<0.001
		0.744		0.404	0.054
	RMS_FOR_AP_DO	<0.001	1, 12	0.987	<0.001
		0.962		0.346	0.074
		0.120		0.735	0.010
	RMS_FOR_AP_NDO	1.905	1, 12	0.193	0.137
		1.925		0.191	0.138
		0.450		0.515	0.036
	COP_TRA_DO	0.764	1, 12	0.399	0.060
		0.746		0.405	0.059
		0.945		0.350	0.073
	COP_TRA_NDO	2.831	1, 12	0.118	0.191
		1.553		0.237	0.115
		0.471		0.506	0.038

Column χ^2-value/F-value: first value = group-by-time interaction or Friedman; second value = main time effect or Kruskal-Wallis T1; third value = group effect or Kurskal-Wallis T2. CSX = closed-leg stance; TSX = tandem stance; SSX = single-leg stance; RMS = root mean square; ACC = lumbar spine sensor acceleration; FOR = force plate force; ML = medio-lateral direction; AP = anterior-posterior direction; DO = dominant leg; NDO = not dominant leg; COP = centre of pressure; TRA = velocity; df = degrees of freedom; p = statistical significance; w/η^2par = effect size.

Appendix II. Non-significant results of statistical analysis of balance ability on the Airex Balance Pad

	Standing position	χ^2-value/ F-value	df	p	w/ η^2_{par}
CSA	RMS_ACC_ML	0.291	1, 20	0.595	0.014
		0.764		0.392	0.037
		1.265		0.274	0.059
	RMS_FOR_ML	0.537	1, 18	0.473	0.029
		2.363		0.142	0.116
		0.169		0.685	0.009
	RMS_ACC_AP	0.018	1, 20	0.894	0.001
		2.454		0.133	0.109
		0.500		0.488	0.488
	RMS_FOR_AP	0.032	1, 18	0.860	0.002
		<0.001		0.998	<0.001
		0.138		0.714	0.008
	COP_TRA	0.340	1, 19	0.567	0.018
		0.001		0.982	<0.001
		0.107		0.747	0.006
TSA	RMS_FOR_ML	0.597	1, 9	0.469	0.091
		0.007		0.935	0.001
		0.092		0.772	0.015
	RMS_ACC_AP	5.459	1, 7	0.052	0.438
		0.071		0.797	0.010
		0.180		0.684	0.025
	RMS_FOR_AP	2.114	1, 7	0.189	0.232
		0.206		0.664	0.029
		0.045		0.838	0.006
	COP_TRA	2.753	1, 6	0.148	0.314
		1.903		0.217	0.241
		0.850		0.392	0.124
SSA	RMS_ACC_ML_DO	0.077	1	<0.999	0.077
		0.082		0.775	0.079
		1.306		0.253	0.317
	RMS_ACC_ML_NDO	0.676	10	0.430	0.630
		<0.001		0.993	<0.001
		1.440		0.258	0.126
	RMS_FOR_ML_DO	1.058	1, 11	0.326	0.088
		0.059		0.813	0.005
		0.107		0.750	0.010
	RMS_FOR_ML_NDO	0.204	1, 11	0.661	0.018
		1.492		0.247	0.119
		0.646		0.439	0.055
	RMS_ACC_AP_DO	0.012	1, 11	0.913	0.001
		0.066		0.803	0.006
		0.251		0.626	0.022
	RMS_ACC_AP_NDO	0.070	1, 10	0.796	0.007
		0.326		0.580	0.032
		0.175		0.685	0.017
	RMS_FOR_AP_DO	0.010	1, 10	0.921	0.001
		0.023		0.881	0.002
		0.051		0.827	0.005
	RMS_FOR_AP_NDO	0.168	1, 10	0.691	0.017
		0.576		0.465	0.054
		0.121		0.735	0.012
	COP_TRA_DO	0.586	1, 10	0.462	0.055
		0.538		0.480	0.051
		0.017		0.897	0.002
	COP_TRA_NDO	0.223	1, 9	0.648	0.024
		0.150		0.707	0.016
		1.913		0.200	0.175

Column χ^2-value/F-value: first value = group-by-time interaction or Friedman; second value = main time effect or Kruskal-Wallis T1; third value = group effect or Kurskal-Wallis T2. INT = intervention group (TRX-OldAge); CON = control group (elastic band resistance training); n = sample size; M = mean; SD = standard deviation; CI = confidence interval; CSA = closed-leg stance on Airex Balance Pad; TSA = tandem stance on Airex Balance Pad; SSA = single-leg stance on Airex Balance Pad; RMS = root mean square; ACC = lumbar spine sensor acceleration; FOR = force plate force; ML = medio-lateral direction; AP = anterior-posterior direction; DO = dominant leg; NDO = not dominant leg; COP = centre of pressure; TRA = velocity; df = degrees of freedom; p = statistical significance; w/η^2_{par} = effect size.

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ENDOCRINE RESPONSES TO PHYSICAL TRAINING AND TRIBULUS TERRESTRIS SUPPLEMEMTATION IN MIDDLE-AGE MEN

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Abstract. The aim of this study was to evaluate the effects of steroidal saponin supplementation on blood concentration of T, GH and IGF-1. The research involved 14 men between the age of 45 and 60 years. The duration of the experiment was 12 weeks. There were two series of laboratory tests. Independent tests were conducted at the beginning and after 12 weeks of the intervention.
A two-way repeated measures ANOVA revealed a statistically significant effect of the intervention on the following variables: T-Ch ($\eta^2 = 0.542$), HDL-Ch ($\eta^2 = 0.522$), LDL-Ch ($\eta^2 = 0.587$), T ($\eta^2 = 0.603$), IGF-1 ($\eta^2 = 0.512$) and GH ($\eta^2 = 0.621$). Thus, FFM significantly increased while TBF and BM decreased in comparison to pre-intervention levels. The analyzed results indicate that treatment or supplementation of individual hormone deficiencies can be a successful form of counteracting the aging process. Nevertheless, the effects of TT supplementation on the concentration of T as well as GH and IGF-1, requires further studies, especially in middle-aged and older subjects, along with different exercise programs. The analyzed results indicate that treatment or supplementation of individual hormone deficiencies can be a major form of counteracting the aging process.

Key words: steroidal saponins, testosterone, supplementation, growth hormone, insulin-like growth factor

Introduction

The neuroendocrine system plays a prominent role in controlling the rate of muscle tissue degradation and the efficiency of metabolic processes. Among the main morphological symptoms of aging the most obvious include: a decrease in lean body mass (LBM), an increase in body fat content (FM), disorders in lipid and lipoprotein profile, and a reduction in bone mineral density. The endocrine system, particularly anabolic hormones, such as growth hormone (GH) and testosterone (T), as well as the insulin-like growth factor (IGF-1) determine the anabolic processes occurring in the human body to a large extent. Hypogonadism and hiposomatropism are factors which

directly contribute to a decrease in muscle mass. There are many conflicting results regarding the effects of supplementation on the concentration of particular anabolic and lypolytic hormones. The use of supplements before, during and after exercise has a significant impact on post-exercise blood hormone concentration (Bird, Tarpenning, Marino, 2006). The effect of changes in the concentration of various hormones, as a result of supplementation, is distinctly observed among older individuals, diagnosed with hormonal deficiencies.

Tribulus Terrestris (TT) is a supplement derived from the fenugreek plant. Specific properties of saponins, such as interaction with cell membranes, combining with sterols, as well as cholesterol, leads to partial damage and greater permeability. Steroidal saponins have a high capacity for erythrocyte hemolysis. By affecting the metabolism of male androgens saponins influence the increase of T concentration (Huang, Tan Jiang, Zhu, 2003). The exact mechanism of TT is not recognized, however, steroidal saponins inhibit the activity of key enzymes responsible for the unwanted conversion of testosterone to estrogen and dihydrotestosterone (DHT). Reduced production of unfavorable metabolites stimulates the secretion of testosterone by the body, and enhances its activity within the muscle tissue. Other researchers suggest that the ergogenic effect of saponins is primarily associated with the increase in the concentration of luteinizing hormone (LH), which stimulates the secretion of testosterone (De Combarieu, Fizzati, Lovati, Mercalli, 2003). Gauthaman, Mohamed Saleem, Ravi, Sita, Niranjali (2008) showed that a TT dose of 900 to 2500 mg per day stimulates the synthesis of T in rats. Despite theoretical basis and research on animals, which confirm that TT increases the concentration of LH and T, the results of human studies are inconclusive. Studies in a group of healthy subjects with normal levels of GH and T do not confirm the impact of TT on anabolic functions (Rogerson et al., 2007).

Nonetheless, several studies have shown that TT, as well as vitamin and mineral supplementation does not increase muscle strength or muscle hypertrophy as a result of resistance training (Rogerson et al., 2010; Antonio, Uelmen, Rodriguez, Earnest, 2010). There were no significant changes in body composition and body mass; among men who were engaged in regular resistance exercise and TT supplementation (Antonio et al., 2010). A different situation occurs in case of TT supplementation among subjects with known hypogonadism and hiposomatropism. Adimoelja (2000) showed on a group of middle-aged subjects that TT has a significant impact on the concentration of LH and T.

TT supplementation in subjects with known hypogonadism is also diabetogenic, prevents cancer, reduces total cholesterol (Ch-T) and low-density lipoprotein (LDL) (De Combarieu et al., 2003). Steroidal saponin supplementation in men with physiologically reduced concentrations of T and GH may be a reasonable alternative for hormone therapy, and as research indicates an increase in the concentration of T in patients with GHD or impaired secretion of testosterone significantly affects the changes of body composition and improves the physical abilities of the organism (Zając et al., 2010).

The aim of this study was to evaluate the effect of steroidal saponins supplementation on blood concentration of T, GH and IGF-1 and changes in body mass and body composition, as well as in the lipid and lipoprotein profile in middle-aged and slightly overweight men.

Methods

Subjects

The research involved 14 men between the age of 45–60 years, body mass index of 25–33, and body fat content between 23–30%. The subjects were randomly divided into two groups – an experimental (exp) and

a control group (contr). The exp. group received steroidal saponins; for the first six weeks three capsules (900 mg) per day in split doses. Two capsules were ingested in the morning on an empty stomach (600 mg) and one at bedtime (300 mg). From weeks 6 to 12, 6 capsules (1,800 mg) were ingested per day in split doses. Four capsules in the morning on an empty stomach (1,200 mg) and two at bedtime (600 mg). The contr. group received a placebo in the form of gelatin capsules. During the 12 weeks of the experiment all subjects participated in a physical activity program. Prior to testing, as well as in the course of the experiment, participants followed an isocaloric mixed diet (55% carbohydrate, 20% protein, 25% fat).

Research methods

Test procedure

The duration of the experiment was 12 weeks. There were two series of laboratory tests. Independent tests were conducted at the beginning and after 12 weeks of the intervention. The study evaluated such morphological, physiological and biochemical variables as body mass and body composition (BM, FFM, FM, TBW, BMI), the concentration of chosen hormones and growth factors (T, GH, IGF-1), as well as the lipid and lipoprotein profile including: triglycerides (TAG), total cholesterol (CH-T), high density cholesterol (HDL-Ch), and low-density cholesterol (LD-Ch).

Determination of body mass and body composition was performed by electrical impedance using the 220 InBody apparatus.

Venous blood samples were taken from all participants (10 ml) to be assayed for the concentrations of T, GH, and IGF-1. IGF-1 concentration in the serum was determined by immunoradiometric (IRMA) methods using a diagnostic kit DSL-2800 Active IGF-1 (Diagnostic System Laboratories, Webster, Texas, USA). Determination of the concentration of T was performed using the radioimmunoassay (RIA) analysis of blood serum using DSL-2100 assay. Biochemical analysis of the lipid and lipoprotein profile TAG, T-Ch, LDL-Ch, HDL-Ch was performed with an enzymatic method by a fully automated analyzer (Siemens Dimension). All biochemical assays were performed in duplicate with the ICC between 0.92 and 0.97.

Physical activity program

The physical exercise program applied to all the participants included 4 training sessions per week, with 2 sessions directed at the improvemnt of anaerobic power (resistance exercise), while 2 consisted of aerobic endurance exercise.

Aerobic training was performed on a stationary cycle ergometer, starting with 30 minutes of continuous exercise at an intensity of 70–75% of maximum heart rate (HR max). Every two weeks, the work volume was increased by 5 minutes in order to reach 60 minutes in the last two weeks of the experiment. Strength training had a holistic aproach, involving all major muscle groups (the back, chest, abdomen, arms and lower limbs). For the first four weeks, exercises were performed in 3 sets of 8–12 reps with the resistance equal to 60–70% of 1RM and 2 min rest periods between sets. During the experiment, the number of sets of each exercise increased from 3 to 4 sets in weeks 5–8, and respectively to 5 sets in weeks 9–12 for each exercise.

The research project was approved by the Ethics Committee for Scientific Research at the Academy of Physical Education in Katowice, Poland.

Statistical analysis

The data were analyzed using the Statistica 9.1 software. The descriptive analyses consisted of the mean and standard deviation. For all measured variables, the estimated sphericity was verified according to the Mauchly's W test, and the Greenhouse–Geisser correction was used when necessary. Before using parametric tests, the assumption of normality was verified using the Kolmogorov-Smirnov test (Maszczyk et al., 2012). The comparison of analyzed values before and after the introduction of the experimental factor, was carried out with a two-way repeated measures ANOVA. When significant differences were found, Tukey HSD post-hoc tests were used. The effect size (eta-squared; $\eta^{2)}$ of each test was calculated for all analyses. Effect size was classified according to Hopkins (Hopkins, 2010). Statistical significance was set at $p < 0.05$.

Results

Table 1 presents pre- and post-intervention values of morphological variables under analysis. A two-way repeated measures ANOVA revealed a statistically significant effect of the intervention program on the following variables: T-Ch ($\eta^2 = 0.542$), HDL-Ch ($\eta^2 = 0.522$), LDL-Ch ($\eta^2 = 0.587$), T ($\eta^2 = 0.603$), IGF-1 ($\eta^2 = 0.512$), GH ($\eta^2 = 0.621$) in the exp. group. Tukey's HSD post-hoc test revealed a statistically significant decrease of T-Ch ($p = 0.002$) and LDL-Ch ($p = 0.001$), while other post-hock tests revealed statistically significant increases of HDL-Ch ($p = 0.002$), T ($p = 0.001$), IGF-1 ($p = 0.003$) and GH ($p = 0.001$) in comparison to pre-intervention values.

The increase trend of T ($\eta^2 = 0.071$) and HDL ($\eta^2 = 0.057$) was observed only in the contr. group. However, the effect of the intervention program was not statistically significant ($p = 0.052$, $p = 0.064$ respectively).

Table 1. The lipoprotein profile and hormone concentrations before and after supplementation with steroidal saponins with results of a two-way repeated measures ANOVA

Variables	Group	Before X ± SD	After X ± SD	F	*P*
T-Ch (mg/dl)	I exp	189.64 ±28.98	178.53 ±25.05	15.417	0.003
	II cont	196.42 ±26.85	192.36 ±24.89		
HDL-Ch (mg/dl)	I exp	65.44 ±16.80	70.01 ±14.50	14.261	0.003
	II cont	68.90 ±4.33	65.57 ±4.30		
LDL-Ch (mg/dl)	I exp	103.01 ±21.20	98.64 ±11.31	17.231	0.002
	II cont	127.63 ±11.35	128.78 ±8.75		
GH (ng/ml)	I exp	0.47 ±0.15	0.52 ±0.16	23.261	0.001
	II cont	0.58 ±0.14	0.57 ±0.12		
IGF-1 (ng/ml)	I exp	150.01 ±30.17	180.17 ±27.38	13.250	0.003
	II cont	191.98 ±25.87	191.57 ±23.85		
T (nmol/l)	I exp	13.19 ±5.34	14.74 ±4.06	18.510	0.001
	II cont	17.88 ±5.14	17.64 ±4.01		

Table 2 presents the pre- and post-intervention values of body composition and body mass variables. A two-way repeated measures ANOVA revealed a statistically significant effect of the intervention on BM ($\eta^2 = 0.644$), FFM ($\eta^2 = 0.417$), and TBF ($\eta^2 = 0.817$) in the exp. group. Not significant post-intervention differences were observed in

TBW (η^2 = 0.094) value. Thus, FFM significantly increased while TBF and BM decreased in comparison to the pre-intervention levels (p = 0.001, p = 0.001 and p = 0.003, respectively).

Similarly, not significant post-intervention differences were observed in the contr. group. The increase of FFM (η^2 = 0.058) and FAT (η^2 = 0.044) values, and degrease of BM (η^2 = 0.084) value (p = 0.061, p = 0.071, p = 0.581 respectively), were observed only.

Table 2. Pre- to post-intervention changes in body composition and body mass, before and after the saponins treatment with results of a two-way repeated measures ANOVA

Variables	Group	Before X ± SD	After X ± SD	F	*P*
BM (kg)	I exp	89.17 ±8.62	87.02 ±8.58	19.551	0.011
	II cont	99.54 ±7.24	99.38 ±7.57		
TBF (kg)	I exp	20.22 ±7.57	18.87 ±7.44	69.921	0.011
	II cont	20.82 ±5.86	20.22 ±5.93		
FFM (kg)	I exp	70.42 ±6.18	70.88 ±5.55	9.591	0.026
	II cont	85. 84 ±8.78	84.77 ±8.26		
TBW (kg)	I exp	51.75 ±4.49	53.37 ±5.04	1.243	0.772
	II cont	62.74 ±6.16	61.71 ±14.39		

Discussion and conclusions

Ergogenic aids, such as dietery supplements, are essential elements of competitive sports, yet they can also improve metabolic efficiency in recreationally active subjects of all ages. Milasius, dadeliene, Skernevicius (2009), showed a significant positive effect of supplements containing TT on acid-base equilibrium after short-term, high intensity anaerobic exercise in competitive athletes. This effect can also be observed among middle aged and elderly subjects. In our research project, steroidal saponin supplementation in a group of middle-aged men caused a statistically significant increase in resting T, GH and IGF-1. The results of the study partially confirmed Brown's et al., reports (2001), which showed an significant effect of saponin supplementation on serum testosterone concentration in men aged 30–59 years. However, in Brown's et al., study (2001) the ergogenic effect was not caused only by TT, as the reserchers used a complex supplement called DION. Milasius et al. (2009) also observed an increase in blood T concentration, but only during the first 10 days of the experiment with TT supplementation. The test results obtained in the experiment conducted are contrary to Neychev, Mitev's research (2005), which showed no change in concentration of testosterone, androstenadiol and luteinizing hormone (LH) after supplementation with TT. The differences between the results of our experiment and those obtained by Neychev, Mitev (2005), may be the result of different dosages used, different duration of the experiment, and most importantly, different criteria for selecting subjects for the research. In most studies where no effect of saponins on T concentration was observed, young, physically active men with a physiologically high resting concentration of T were involved (Neychev, Mitev, 2005; Poprzecki, Zebrowska, Cholewa, Zając, Waskiewicz, 2005). In our study, the research group included middle-aged men with physiologically low levels of resting T, which seems to be a key factor in the effectiveness of such supplementation. An important finding of the study includes the fact that the TT supplementation also caused an increase in resting concentrations of GH and IGF-1 in the experimental group compared to the placebo group.

Studies indicate that treatment with recombinant GH in elderly subjects significantly affects body composition (Poprzecki et al., 2005; Zając, Wilk, Socha, Maszczyk, Chycki, 2014). This effect is particularly important in case of increased concentrations of both GH and T (Blackman et al., 2002), which took place in the current study. Apart from the significant increase of GH concentration in this study, an increase in resting IGF-1 was also observed. Our research indicates significant increase in FFM and a decrease of BF with a concomitant increase in TBW. Similar results were obtained in a project by Poole et al. (Poole et al., 2010). Although statistically significant changes in the concentration of T were not shown in the Poole et al., study (2010), there was a trend for increased FFM ($p < 0.001$) and a decrease in BF ($p < 0.001$). Adverse changes in the lipid profile which increase the risk of coronary heart disease are typical for middle-aged men. Our study, in which men aged 45–60 were supplemented with steroidal saponins, revealed significant changes in the lipid and lipoprotein profile after 12 weeks of the experiment. A significant decrease of total cholesterol (T-Ch), an increase in high density cholesterol (HDL-Ch), a decrease in low density lipoprotein (LDL-Ch) and a reduction in plasma triglycerides (TAG) were observed. It may be assumed that TT supplementation is not necessarily directly responsible for changes in the lipid and lipoprotein profile. We hypothesize that it is the result of higher resting cocentrations of T and GH, which was also observed in studies by Zając et al. (2014). It seems that both GH as well as T have a profound effect on the lipid and lipoprotein profile. Testosterone metabolism inhibits the uptake of triglycerides and lipoprotein lipase activity (Amore, 2005). Studies indicate that testosterone treatment reduces the levels of LDL-Ch (Hare et al., 2014), and exerts additional effects on lipids, depending on the dose and form of treatment. Munzer, Harman, Sorkin, Blackman (2009), also describe the impact of recombinant GH treatment on decreases in LDL–Ch, but not T-Ch. Combined treatment with rGH and T affects the decrease in T-Ch and LDL-Ch as well. Research conducted by Zając et al. (2014) on a similar group of middle-aged men indicate that injections of T and GH resulted in a decrease of T-Ch, an increase in HDL-Ch, a marked reduction in LDL-Ch. This justifies the assumption that it is the increase in the concentration of T and GH which affects the changes in lipid profile and not the direct effect of TT supplementation. The increase in the concentration of resting T and GH, stimulates changes in the lipid and lipoprotein profile in overweight subjects, which was also observed in the current study. The ergogenic effects of TT supplementation are not limited to incresed concentrations of T and GH, what affects the lipid and lipoprotein profile, but also related to incresed physical activity. In this research, contrary to most studies in this area, the subjects involved in the study were physicaly active prior to the experiment, so regular exercise was a continuation of the current lifestyle and the changes in the lipid profile were mainly caused by the TT supplementation. The analyzed results indicate that treatment or supplementation of individual hormone deficiencies can be a major form of counteracting the aging process.

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THE ANALGESIC EFFICACY OF KINESIOLOGY TAPING IN DELAYED ONSET MUSCLE SORENESS (DOMS)

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Abstract. *Aims and scope*: Delayed Onset Muscle Soreness (DOMS) develops after intense physical activity and its mechanisms are due to inflammation. Kinesiology Taping (KT) improves microcirculation, supports myofascial functions and relieves the tissue. The aim of this study was to verify whether KT has an analgesic action in the DOMS and whether somatotype is associated with this action. *Materials and Methods:* There were 20 healthy subjects aged 27.7 ±6.4 years with moderate or high physical activity included into the study. The training with emphasis on eccentric muscle work was performed. Somatotype of respondents was assessed by Heath-Carter method. While DOMS occurred, KT muscle application on one of the limbs was done. For the next five days subjects filled out questionnaires in which they served intensity of pain on the basis of Visual Analogue Scale (VAS). *Results and conclusions:* In the limb where KT application was used a significant ($p < 0.05$) reduction in the intensity of DOMS compared to the limb without application was observed. It was found that the somatotype has no effect on the reduction of DOMS ($p > 0.05$). *Conclusions:* KT exhibits analgesic properties in DOMS. Somatotype has no relation to the effectiveness of KT analgesic efficacy in DOMS.

Key words: Delayed Onset Muscle Soreness, Kinesiology Taping, analgesic efficacy

Introduction

Delayed onset muscle soreness (DOMS) is an example of exercise-induced muscle damage (EIMD) first described in 1902 by Hough. DOMS arises in 6 to 12 hours after physical activity and lasts 5 to 7 days. The characteristic symptoms include pain, tenderness and stiffness of muscles. The strongest pain is felt 24 and up to 72 hours after exercise, which correlates with the highest levels of markers of muscle damage in serum (Gomes et al., 2014; Hough, 1902; Kanda et al., 2013). The symptoms are of diverse nature ranging from slight muscle stiffness to severe, debilitating pain, limiting the possibility of movement. Tenderness is usually observed in distal muscle, within 24 to 48 hours after exercise spreads to the proximal parts. It was suggested that this is due to the accumulation of a number of nociceptors at the point where the muscle passes into tendon. In addition, the

cross-arrangement of the muscle fibers in this area reduces its resistance to high tensile strength, making it more susceptible to microinjuries in comparison to other muscle regions (Garrett, 1996; Gulick, Kimura, 1996).

Delayed onset muscle soreness occurs due to overloading the muscle, in particular a large amount of eccentric contractions. When the external load exceeds the capacity of the muscle, its stretches and active tension occurs thus increasing the risk of damaging the musculoskeletal connection (Armstrong, Warren, 1993; Stauber, 1989).

Although ultimately EIMD supports the regeneration process and increases the strength of tissue during the active phase of EIMD it increases the risk of injury associated with impaired proprioception, mobility of joints and muscle strength. In women increased muscle stiffness and further reduction in the flexibility of ligaments was observed. These disorders and especially pain develop to protect the tissue from additional damage (Cheung et al., 2003; Dutto, Braun, 2004; Hedayatpour, Falla, 2014; Lee et al., 2013; Serinken et al., 2013).

Kinesiology Taping (KT) is a method of physiotherapy, which aims to restore the body functions using sensory-motor system communication rules. Through the application of flexible Kinesio Tex patch (K-Active Tape), the therapy effects on the skin surface receptors and Ruffini corpuscles, responsible for the degree of tension and stretch of the skin. These receptors are related to A-α motor neurons and sarkomeres, which allows achieving the therapeutic effects (Kase, 2000; Mikołajewska, 2011).

Kinesiology Taping method has local and systemic effects on the human body without showing any invasiveness. These factors determine the attractiveness of methods and its application in the states accompanied by pain. KT effectiveness was confirmed in athletes experiencing pain after spinal-stress training (Garczyński et al., 2013; Merino-Marban et al., 2013). It was also shown that KT helps to reduce chronic lumbar-sacral pain (Bae et al., 2013; Castro-Sánchez et al., 2012; Lemos et al., 2014; Paolini et al., 2011) and Czyżewski et al. found that KT decreases pain in the case of rib fractures and exhibits an anti-swelling properties (Czyżewski et al., 2012).

The literature suggests that somatotype (structural features) is related to body's homeostasis and exercise capacity (Chaouachi et al., 2005; Lewandowska et al., 2011; Özkan et al., 2012). Many authors draw attention to the relationship between athletes sport efficacy and their somatotype (Brocherie et al., 2014; Carvajal et al., 2009; Fidelix et al., 2014; Purenović-Ivanović, Popović, 2014).

There has been increased interest in healthy lifestyle and fitness for several years. Many people starting intensive training experience DOMS being the reason for discontinuation of activity. The aim of this study was to evaluate the analgesic efficacy of Kinesiology Taping in DOMS and to determine whether somatotype is related to the analgesic effectiveness of the method.

Materials and Methods

Participants

The study group consisted of 20 people, aged 27.7 ±6.4 years, with a moderate or high level of physical activity. All participants declared their state of health as good. People taking part in the survey were familiar with its purpose and course and gave written consent which was prepared in compliance with the ethical principles formulated by Kruk (2013). The project was positively evaluated by the Bioethics Commission of the Pomeranian Medical University in Szczecin (Resolution No. KB-0012/35/15).

Methods

In order to assess the degree of physical activity the International Physical Activity Questionnaire (IPAQ) short version was applied. People with at least moderate level of physical activity were included into the study group. Somatotype was evaluated by Heath-Carter method. In case of ecto and mesomorphic types 7-point scale Sheldon assessment was expanded to 9 and in case of endomorphic to 12 degrees. The subjects underwent training concentrated on arms or legs, once. The training was conducted with an emphasis on eccentric muscle work using free weights. The physical activity was tailored to the individual capabilities of each of the respondents. The power used in the training ranged from 60 to 90% of the maximum possible load.

While DOMS occurred, in each of the participants, we applied K-Active Tape (Nitto Denko, Japan), in the specified muscle area, where the highest pain was expressed. Then participants were asked to fill in two identical surveys including the visual-analogue scale (VAS), which evaluated the pain in limbs with and without the application of KT. The evaluation was carried out for five days, one time a day at the same time time, starting 5 hours after the KT application.

To determine whether the method exhibits analgesic activity in DOMS we analyzed the intensity of pain each day. The average values reflecting the intensity of pain each day were compared between the two limbs (with and without application) using the following designations: the difference in the first measurement of Δ1, by next measurement Δn etc. Additionally, we analyzed the difference in the intensity of pain (scale 1–10) between limbs on the first (5 hours after application) and on the last day, ΔVAS.

In addition, the influence of participants somatotype on KT analgesic effectiveness was analyzed. In order to do this we compared the somatotype with ΔVAS separately for the area with and without KT application.

Statistical analyses

Continuous variables were characterized by the average value (M) and standard deviation (SD). In the case of qualitative variables there was amount (n), also expressed in the percentage (%) given. To assess the association of somatotype with analgesic efficacy of KT, ANOVA test was used. All the analyses were performed using Stat View Package Version 5.0 (SAS Institute Inc., Cary, NC, USA). The level of significance was set at $p < 0.05$.

Results

In 18 (90%) of the 20 participants, the physical activity level was assessed as high. There were 2 (10%) subjects with moderate level of physical activity. Using anthropometric measurements we identified four types of somatotype: ectomorphic (n = 3; 15%) endomorphic (n = 4; 20%), mesomorphic (n = 8; 40%) and mixed (n = 5; 25%).

After strength training we applied KT and one respondent received one application. KT were applied to the following muscles: *gastrocnemius* (n = 3; 15%) *quadriceps femoris* (n = 8; 40%), *biceps femoris* (n = 3; 15%) *gluteus maximus* (n = 2; 10%), *biceps brachii* (n = 2; 10%), *pectoralis major* (n = 1; 5%) and *deltoid* (n = 1; 5).

Comparing the intensity of pain perception between the area with and without KT we observed smaller, statistically significant ($p < 0.05$) sensation of pain in case of KT application, since the first day until the end of the study. The results are given in Table 1. There was no effect of participants somatotype on analgesic efficacy of KT ($p > 0.05$). The results are shown in Figures 1 and 2.

Table 1. The differences in the intensity of DOMS

	Area without KT application			Area with KT application			p
	M ± SD	min.	max.	M ± SD	min.	max.	
VAS 1	6.75 ±1.94	2	10	6.20 ±1.90	1	8	0.0020
VAS 2	6.70 ±1.89	2	9	5.55 ±1.95	1	8	0.0001
VAS 3	5.70 ±1.75	2	8	4.35 ±1.92	1	7	<0.0001
VAS 4	4.25 ±1.91	1	8	2.90 ±1.71	0	6	0.0002
VAS 5	2.75 ±1.99	0	8	1.45 ±1.53	0	5	0.0001
ΔVAS	4.00 ±2.20	–1	8	4.75 ±2.15	0	8	0.0039

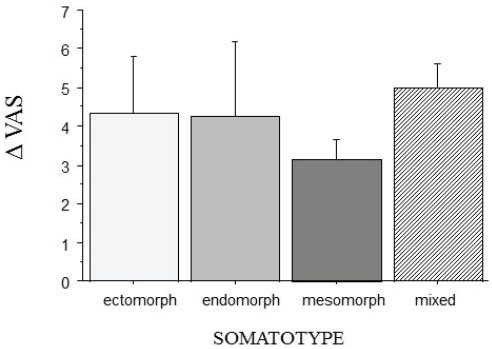

Figure 1. The somatotype in relations to DOMS reduction in limbs without KT application ($p > 0.05$). Bars indicate standard errors

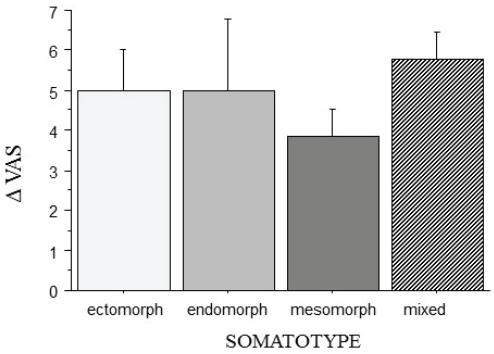

Figure 2. The somatotype in relations to DOMS reduction in limbs with KT application ($p > 0.05$). Bars indicate standard errors

Discussion

In 2010 Tiffert (2010) described that KT application results in tissue relief, increased blood flow and lymph circulation thus accelerating the healing process and pain reduction. In present study we observed a reduction of pain since the first day of KT application and a statistically significant difference ($p < 0.05$) was maintained throughout the whole study period. The results of our study are therefore consistent with the findings of tests carried out by Nosaka and Clarkson. They induced DOMS in upper limbs in a group of untrained students by using strength eccentric exercises in two sessions, two weeks apart. The subjects were divided into two groups, during the first series of exercises KT wasapplied in the first group, while the second session in the second group. The results obtained by the researchers confirmed the effectiveness of KT in removing pain, reducing muscle stiffness and increasing range of motion and strength (Nosaka, Clarkson, 1990).

Other researchers analyzed the effectiveness of KT in DOMS only in the study group. The control group consisted of people who carried out observations of DOMS regression without any therapeutic method. The intensity of pain was assessed using VAS scale; before KT application and in 24, 48 and 72 hours after the treatment. It was found that KT accelerates the pain and has a positive effect on the muscle strength. Moreover, it was proved that thickened, as a result of DOMS, muscles return to proper morphology faster when applying KT patch (Lee et al., 2015). Bae et al. also confirmed the effectivenes of KT in abolishing pain as well as in supporting the correct perception of temperature (Bae et al., 2014a, 2014b). Nevertheless, there is also a body of evidence indicating no positive effect of KT in DOMS. Among many works on the analgesic efficacy there are also ones which have not confirmed the positive effect of KT in DOMS. Ozmen et al. studied a group of female students with low physical activity and reported no statistically significant efficacy of KT in case of DOMS. The authors noted, however, that 48 hours after the application muscle flexibility increased (Ozmen et al., 2015).

Pain is a subjective sensation thus the opinion of the authors of this study states that the difference can be shown only in the same sample, when all other modifiable factors are eliminated. Moreover, in case of works by Nosaka and Clarkson (1990) and Ozmen et al. (2015) too short period of time between the training sessions could influence the results. In recent years it was shown that muscle tissue affected by DOMS returns completely to its homeostasis within 6 weeks (Hyldahl, Hubal, 2014). We therefore assume that performing experiments in people previously adapted to a more intensive effort could interfere with the results obtained by the researchers.

According to the literature, one's metabolism depends on individual somatotype (Harmon, 2010). In 2010, Harmon found that people of endomorphic and then mesomorphic somatotype are most likely to develop DOMS. In contrast, ectomorphic people show the greatest resistance to pain (Harmon, 2010). In our studies, we confirmed no impact of the somatotype on the analgesic efficacy of KT. This may be due to small sample size and the fact that 25% of the study group ($n = 5$) presented a mixed somatotype.

The present study confirms that KT exhibits an analgesic effect in DOMS. According to the literature KT also contributes to an increase in range of muscle motion and strength, improve surface tension and reduction in muscle tone. These phenomena suggest that KT in DOMS acts not only mechanically but also affects physiological processes involved in the regeneration of damaged muscle tissue (Bae et al., 2014a, 2014b; Nosaka, Clarkson, 1990; Lee et al., 2015; Ozmen et al., 2015).

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LONG-DISTANCE RUNNING AND ITS EFFECTS ON CARDIORESPIRATORY ADAPTATION AND PHYSIOLOGICAL STRAIN IN MARATHON RUNNERS

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Abstract. Popularity of long-distance running has increased as well as number of female and male marathon runners. Whilst research into physiological characteristics of endurance trained athletes has significantly increased there are only few studies on the risk factors for respiratory failure in marathon runners. Therefore, the aim of the study was to evaluate the differences in respiratory function and the physiological strain in the response to exercise stress in marathon runners. Twenty three subjects (aged 36.1 ±11.6 years) participated in a marathon running. Prior to the run and after its completion, body mass and composition, spirometry and body temperature were measured. Based on pre- and post-run temperature and changes in heart rate, the physiological strain index (PSI) was calculated. Long-distance running significantly decreased the temperature of body surfaces ($p < 0.05$); no significant effects were observed regarding aural canal temperature and physiological strain index (PSI). Compared to resting values, post-marathon spirometry revealed a significant decrease in post-marathon forced expiratory volume ($p < 0.05$), peak expiratory flow ($p < 0.05$) and maximal expiratory flow values ($p < 0.05$). In conclusion, the long-distance running results in functional changes within the respiratory system which may limit the adaptive potential and decrease exercise tolerance.

Key words: marathon, spirometry, physiological strain index

Introduction

Functional adaptations of the respiratory system during endurance exercise is important for increased gas exchange in the lungs. Balance between muscle oxygen uptake (VO_2) and carbon dioxide removal (VCO_2) depends on the adaptation of alveolar ventilation to lung perfusion as well as on changes in blood flow distribution. It has been shown that a decrease in physical performance of long-distance runners might be related to the limitation of respiratory tract adaptive capacity, an increase in physiological strain including the cardiovascular system and thermoregulatory processes (Vogiatzis et al., 2007; Hölmich et al., 1998).

The results of previous investigations emphasize the role of the respiratory system as well as nervous and hormonal mechanisms in the regulation of local blood flow and, consequently, in the reduction of oxygen transport to the locomotor muscles. In long-lasting physical activity, arterial O_2 content (CaO_2) and/or lower extremity blood flow (Q_L) may reduce competitor's aerobic capacity (Amann, 2012; Moran et al., 1998). Reduction in arterial oxygen saturation (SaO_2) observed during strenuous exercise can be associated or non-associated with the function of the respiratory system. If it is, metabolic factors and thermal stress play a significant role. Arterial hypoxemia induced by decreased oxygen diffusion and a decrease in cardiac output (CO) resulting from increases in intrathoracic pressure are considered mechanisms associated with respiratory system function during long-lasting endurance exercise (Peters, Bateman, 1983; Neilan et al., 2006). Additionally, increased energy expenditure required by the respiratory muscles during exercise causes stimulation of metabolic receptors, which – due to adrenergic stimulation – decreases the peripheral blood flow. A lot of indices have been proposed to determine physiological strain accompanying muscular activity. Moran et al. (1998) suggested that the Physiological Strain Index (PSI) which reflects the combined burden on the thermoregulatory and cardiovascular systems may be important factor in determining the physiological responses and overreaching symptoms in athletes.

Long-distance running become a more and more popular sport discipline; marathons and ultra-marathons attract an increasing number of participants. Hence, a number of investigations have been undertaken to determine physiological responses and risk factors for health problems in marathon runners (Predel, 2014; Zilinski et al., 2015).

In the light of the above-mentioned observations it seems important to examine differences in respiratory function and the physiological strain during the marathon running.

Material and methods

The study comprised 23 individuals (8 women and 15 men) aged 36.1 ±11.6 years who participated in the VII Marathon Festival organized in autumn 2014 by the Jerzy Kukuczka Academy of Physical Education in Katowice. The inclusion criteria were satisfactory results of the physical examination, participation in at least two marathons and written consent to take part in the study. During the run and immediately after finishing, the participants were under medical supervision. The study protocol was approved by the Ethics Committee of the Academy of Physical Education in Katowice, Poland, and conformed to the ethical standards (Kruk, 2013).

Prior to the run and after its completion, body mass and composition of all participants were estimated using bioelectrical impedance analysis (Tanita BC-418MA Analyzer). Body height was measured and fat mass (FAT), fat-free mass (FFM), total body water (TBW) and body mass index (BMI) were calculated. The study subjects' data are presented in Table 1.

All participants underwent spirometry testing to determine vital capacity (VC), forced vital capacity (FVC), and forced expiratory volume in one second (FEV1). FEV1/FVC ratio, peak expiratory flow (PEF) and maximal expiratory flow at 25%, 50% and 75% of the FVC were all calculated.

All examinations were carried out according to the recommendations for the performance of spirometry (Stanojevic et al., 2008; Boros et al., 2004) with a portable spirometer (Pony-FX desk spirometer, Cosmed). Prior to the run and within 20 minutes after its completion, arterial oxygen saturation (SaO_2; Pulse Oximeter, ChoiceMMed) and blood pressure BP (semi-automatic blood pressure monitor M1 Compact, Omron) were measured, and heart rate was registered (HR; Sportester Polar FT1).

Aural canal temperature (T_{ty}) was measured with a ThermoScan, thermometer (Type 6201, BRAUN) at baseline (T_{ty0}) and within 15 minutes after run completion (T_{tyT}). Body temperature was also taken of exposed body surfaces (ET) and covered body surfaces (CT) (RayTemp® 6 Infrared Thermometer, MERA). Based on pre- and post-run temperature and changes in heart rate (HR_0 vs. HR_T), the physiological strain index (PSI) was calculated using the following formula (Frank et al. 1996):

$$PSI = 5(T_{tyT} - T_{ty0})\cdot(39.5 - T_{ty0})^{-1} + 5(HR_T - HR_0) \cdot (180 - HR_0)^{-1}.$$

The obtained data were subject to statistical analysis using Statistica Software version 10 (StatSoft Poland, 10.0). Descriptive statistics were used to summarize data and the significance of differences between the means was tested (Wilcoxon test). The results of the analyses were presented as means and standard deviations (means, SD). The significance level was set at $p < 0.05$.

Results

Significant differences were found between female and male marathon runners regarding body height (172 ±3.5 vs. 184 ±3.8 m; $p < 0.01$), body mass index (19.9 ±1.5 vs. 21.2 ±1.8 kg/m^2; $p < 0.05$) and percent of body fat content (13.2 ±2.4 vs. 8.8 ±1.5%; $p < 0.01$). The mean marathon time was 3.48 ±0.35 hours. A comparison of somatic parameters confirmed a significant post-marathon decrease in body weight and fat mass compared to pre-marathon values (Table 1).

Table 1. Anthropometric characteristics of the study subjects before and after marathon running

Variables	Before marathon n = 23	After marathon n = 23	Statistical significance
Body mass [kg]	68.7 ±11.3	66.4 ±11.2	P < 0.05
BMI [kg/m^2]	22.8 ±2.7	22.3 ±2.6	NS
FFM [kg]	57.9 ±10.5	57.1 ±10.2	NS
FAT[%]	15.5 ±5.6	14.5 ±5.5	P < 0.01
FAT[kg]	10.4 ±4.1	9.6 ±3.9	P < 0.01
TBW[kg]	42.4 ±7.7	41.9 ±7.5	P < 0.05

BMI – body mass index; FFM – fat free mass; FAT % - body fat percentage; FAT – fat mass; TBW – total body water.

High energy expenditure resulted in thermoregulatory changes manifested by a decrease in the temperature of covered (CT) $p < 0.01$ and exposed body surfaces (ET) $p < 0.05$); no significant differences were observed regarding aural canal temperature (T_{ty}). The level of physiological strain index (PSI) was 2.2 ±0.7. PSI reflects combined cardiovascular and thermoregulatory strain on a universal scale of 0 to 10. Lower value and no significant PSI increase during a 15-minute post-marathon recovery period indicating good adaptation of the study participants to the marathon distance. Heart rate was higher and blood pressure (BPs and BPd) was significantly lower in 15 minutes recovery period compared baseline levels. There were no significant differences in SaO_2 before and after marathon running (Table 2).

Table 2. Temperature, blood pressure and heart rate before and after marathon running

Varibles	Before marathon n = 23	After marathon n = 23	Statistical significance
Tty [°C]	36.07 ±0.4	36.4 ±0.5	NS
CT [°C]	29.01 ±1.5	26.6 ±3.1	P < 0.01
ET [°C]	28.0 ±2.1	27.0 ±2.3	P < 0.05
HR [b/min.]	61.0 ±10.0	94.0 ±18.0	P < 0.01
BP_s [mm Hg]	135.0 ±15.7	120.0 ±15.8	P < 0.05
BPd [mm Hg]	84.0 ±8.7	77.1 ±15.2	P < 0.05
SaO_2[%]	97.6 ±1.6	98.2 ±1.6	NS

Tty – aural canal temperature; ET – temperature of exposed body surfaces; CT – temperature of covered body surfaces; HR – heart rate; BPs – systolic blood pressure; BPd – diastolic blood pressure; SaO_2 – arterial oxygen saturation.

Compared to resting values, post-marathon spirometry revealed a significant decrease in post-marathon FVC (FVC% 83.5 ±15.2 vs 73.4 ±22.3; p < 0.05); forced expiratory volume in one second FEV1/FVC% (91.5 ±5.0 vs 80.1 ±18.1; p < 0.05) and peak expiratory flow (PEF 7.0 ±2.3 vs 5.0 ±2.3 p < 0.05). Maximal expiratory flow (MEF 75%) was significantly reduced; MEF50% and MEF25% also showed a decreasing tendency.

Table 3. Spirometry variables before and after marathon running

Variables	Before marathon n = 23	After marathon n = 23	Statistical significance
FVC [L]	4.7 ±0.5	3.64 ±0.8	P < 0.05
FVC [%pred]	83.5 ±15.2	73.4 ±22.3	P < 0.05
FEV1 [L/s]	18.8 ±2.9	10.04 ±1.2	P < 0.05
FEV_1 [% pred]	95.7 ±14.0	79.4 ±10.0	P < 0.05
PEF [L/s]	7.0 ±2.3	5.0 ±2.3	P < 0.05
$FEF_{(25-75)}$ [L/s]	6.4 ±1.5	4.7 ±1.7	P < 0.05
FEV_1/FVC [%]	91.5 ±5.0	80.0 ±18.1	P < 0.05
MEF75% [L/min.]	7.5 ±2.2	4.9 ±1.8	P < 0.05
MEF50%[L/min.]	5.5 ±1.3	4.2 ±1.5	P < 0.05
MEF25%[L/min.]	3.9 ±0.8	2.9 ±1.3	P < 0.05

FVC – forced vital capacity; FEV1 – forced expiratory volume in one second; PEF – peak expiratory flow; $FEF_{(25–75)}$ – mean forced expiratory flow at 25–75% FVC; FEV_1/FVC [%] ratio; MEF 75% – maximal expiratory flow at 75% of the FVC; MEF 50% - maximal expiratory flow at 50% of the FVC; MEF 25% – maximal expiratory flow at 25% of the FVC.

Discussion

Breathing involves integrated actions of the respiratory and cardiovascular systems. Synchrony between the cardiovascular and respiratory systems allows regulation of pulmonary blood flow. Hence, gas exchange between the air within the alveoli and the pulmonary capillaries is maintained depending on the demand for oxygen by the cells in a tissue. The function of the respiratory system alters markedly during high-intensity endurance exercise (Dempsey et al., 2012; Stickland et al., 2004). These adaptive changes result in deepened respirations and more forced airflow through air passages. Efficient respiration is associated with an improvement in cardiovascular

reserve capacity. This, in turn, helps increase oxygen uptake and carbon dioxide elimination according to the metabolic rate; constant levels of respiratory gases in the blood help maintain homeostasis (Green et al., 2012; Harms et al., 1997; Frank et al., 1998). The observed disturbances in physiological adaptation as well as the potential impact of environmental factors on oxygen pressure in alveolar air increase the risk of respiratory failure and may lead to serious health problems.

We evaluated lung function and adaptive changes in the respiratory and cardiovascular systems with respect to the physiological strain associated with long-distance running. FEV1, as well as forced and mean expiratory flow decreased after the run compared to resting values. Hypoxia and cardiovascular complications were not observed. The effort might have caused transient airflow obstruction in the respiratory tract; the diminished strength of the expiratory muscles might have resulted from respiratory muscle fatigue (Mahler, Loke, 1981).

Mahler, Loke, (1981) and Dempsey, Hanson, Henderson, (1984) also observed significant decreases in FVC, FEV1 and PEF after an ultramarathon and believed they resulted from impaired efficiency of the upper respiratory tract and respiratory muscle fatigue. Hypoxemia induced by lowered SaO_2 also had a significant effect on aerobic efficiency of the long-distance runners.

In healthy individuals, pulmonary ventilation and pulmonary blood flow are subjects to dynamic changes; thus, the levels of respiratory gases in the blood remain constant, i.e., systemic arterial blood has an average oxygen tension (PaO_2) of approximately 95 mm Hg while the partial alveolar pressure of CO_2 ($PACO_2$) is normally 40 mmHg. Impairments of respiratory homeostasis caused by, for example, hypoxia or hypercapnia, may have deleterious effects, and especially on metabolically active cells with highly oxidative metabolism including neurons of the central nervous system, heart and kidney cells (Vogiatzis et al., 2007; Dempsey et al., 2012; Roberts, Maron, 2005). Increased breathing rate promotes heat loss associated with evaporation of water from the alveoli and respiratory passages (Hölmich et al., 1988; Amann, 2012). It is important to note, that insufficient heat loss results in an increase in physiological strain including the thermoregulatory and cardiorespiratory system (Pilch et al., 2014). Physiological Strain Index (PSI) based upon heart rate and body temperature measurements, allowing the instantaneous assessment of overall physiological strain on a scale of 0–10. Predictions of physiological strain may be important in determining physiological endurance and in protecting athletes against exercised induced thermal stressors (Moran et al., 1998; Pokora, Żebrowska, 2016). Physiological Strain Index calculated in our study reflects low cardiovascular strain (PSI 2.2 ±0.7). Lower value and no significant PSI increase during a 15-minute post-marathon recovery period indicating good adaptation of the study participants to the marathon distance. Despite differences in morphological characteristics and cardiac function there was only a slight effect on PSI. However, the contribution of the respiratory system differed significantly could potentially impair endurance performance and consequently impacting negatively on running economy.

Respiration during muscular work is known to be regulated by neural and humoral factors. Changes in hydrogen ion concentration, oxygen and carbon dioxide pressures affect respiration – either directly via central control of ventilation (chemosensitive areas, pre-Bötzinger complex) or indirectly, i.e., through activation of the chemoreceptor reflex. The activity in the pre-Bötzinger complex can be modified by impulses from metabolic receptors in the muscles. The receptors are activated through changes in chemical composition of the interstitial fluid in the muscles caused by increased energy metabolism during muscle contraction.

According to previous investigations, several factors might be responsible for disturbances in functional adaptation of the respiratory system to long-lasting physical effort, and among them: 1) contraction of the bronchial

smooth muscle and increased resistance of the respiratory tract to airflow resulting in decreased blood flow into the left atrium and cardiac output, 2) constriction of the upper respiratory tract, decreased pressure gradient in the pulmonary capillaries and resultant tissue hypoxia, 3) fatigue of the respiratory muscles, primarily the diaphragm, resulting in reflex-mediated contraction of peripheral vasculature and hence decreased arterial blood flow to lower limbs (Vogiatzis et al., 2007; Busotti et al., 2014; Eldridge et al., 2004). Paradoxically, it has been shown that individuals achieving better results in sport are more susceptible to respiratory failure and upper respiratory tract infections (Peters, Bateman, 1983).

In summary, it should be emphasized that long-distance running results in functional changes within the respiratory system which may limit the adaptive potential and decrease exercise tolerance.

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THE INFLUENCE OF DIFFERENT TYPES OF REST ON FOOTBALL PLAYERS' ABILITY TO REPEAT PHOSPHAGEN EXERCISE

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Abstract. The aim of the study was to asses the influence of the type of rest on football players' ability to repeat a phosphagen exercise. Twelve football players from the Polish third league were involved in the study and were subjected to a maximum power test on a cycloergometer. Respiratory parameters, lactic acid concentration in capillary blood and acid-base balance parameters were registered before, during and after the test. The test was carried out twice. During the first test the subjects used an active rest break (A) and during the second one they used a passive rest break (B). In part A the quantity of relative work was 87.61 ±9.25 J/kg and in part B it was 78.5 ±6.58 J/kg (p = 0.012). In test A during exertion and during restitution (4th minute) we registered higher values of the respiratory parameters (Rf, VE, VO_2, VO_2/kg). Our conclusion is that passive rest should be used when the objective is the fastest resynthesis of PCr and ATP. An active rest break should be used when the goal is to remove the accumulated LA as soon as possible.

Key words: phosphagen power, RAS – repeated sprint ability, football, restitution, acid-base balance

Introduction

In recent years the evolution of football has made the requirements of the game increase (Vaeyens et al., 2006). Football professionals search for new possibilities of development to improve the quality of the training process and to achieve better results in coaching players. Success can only be achieved by complex training which consist of physiological, psychological, tactical and technical aspects (Bangsbø et al., 2000; Elferink-Gemser et al., 2004; Reilly et al., 2000; Williams, Reilly, 2000). Appropriate physical preparation is very important to gain high and stable physical shape during long and hard seasons (best teams play over 60 matches per year). Modern football makes significant energetic demands on players and their ability to repeat submaximal and maximal effort a lot of times is crucial for accomplishing tactical and technical aims (Iaia et al., 2009). On average, every 90 seconds a player accelerates with a maximum speed of over 32 km/h (Hoff 2005; Michalczyk et al., 2010). Sprint distances covered during sports competitions range from 5 to 30 meters and last for 1 to 4 seconds (Chmura, Zatoń, 2011;

Michalczyk et al., 2010). They constitute 96% of all sprints observed during football matches (Mohr et al., 2003). Most of the sprints are preceded by rapid deceleration and rapid and frequent changes of the direction of movement (Miller et al., 2007). Explosive efforts undertaken by players constitute 5% of the whole game time (Cometti, 2002). They include: dynamic starts, low distance accelerations, changes of the direction of movement, tackles and jumps to head the ball. The ability to undertake these kinds of efforts in the shortest possible intervals is a parameter that distinguishes top class players from amateurs. Only players who can overcome fatigue, have high resources of phosphocreatine (PCr) in the muscles and the ability to restore its resources fast, who have a higher proportion of type-II muscle fibers are able to compete with opponents and participate at the highest levels of football competition (Chmura, Zatoń, 2011).

A player's organism responds differently to a single maximal short-time exercise and differently to its further repetitions. It is important to use an appropriate break before the next maximal exercise. If the time and character of the break is not appropriate, a rapid build-up of fatigue occurs. Overcoming fatigue barriers leads to the development of adaptive changes whose direction and dynamics depend on the type and intensity of the stimulus (Abbiss, Laursen, 2005; Gharbi et al., 2015). Exercise that is continued for a long period of time and accompanied by excessive fatigue, with a break too short for the restoration of energy reserves (creatine phosphate and glycogen) to take place, leads to a faster activation of the glycolytic transition whose byproduct is lactate accumulating in the muscles and the blood (McAinch et al., 2004). This results in prolonged reaction time, a decrease in the speed of decision making and in the speed of locomotion. Not only can the time of the rest break be chosen but it is also possible to determine its character (passive or active). The type of rest break and its duration will affect the whole process of regeneration and an athlete's readiness to do another exercise (Rey et al., 2012). The most suitable type of break should be chosen individually. The same type of break and the same duration may affect players in various ways, which is associated with differences in the level of aerobic capacity, fatigue tolerance, muscle fiber structure and energy resources (Chmura, 2001). Passive rest is not often used in phosphagen training. More often some kind of active rest is used (jog trot, march). Anaerobic efforts are mostly interrupted by active rest breaks which accelerate the restoration of energy compounds (ATP and PCr), and maintain the alertness of the nervous-muscular system (Chmura, 2001). Dupont, Moalla, Guinhouya, Ahmaidi, Berthoin (2004) believe that during maximal short-time efforts (<6 seconds), which are separated by a short break (<30 seconds), a passive break is more appropriate for the reconstruction of ATP and PCr, but during an active break the removal of the accumulated lactate from the muscles proceeds faster. Phosphagen training should be planned in such a way as to prepare the player for conditions similar to the match load. Depending on the situation on the pitch the player may undertake in a very short period of time (10 to 15 seconds) several different actions based on phosphagen energy pathways, e.g. tackling, jumping, sprinting, or striking the ball into the goal, and repeat them at irregular intervals, and then stand a bit longer on the pitch, jog trot or march. According to Spencer et al. (2004) players who do sprints lasting for up to 6 seconds require rest breaks of up to 30 seconds in order to perform another maximal exercise.

The aim of the study was to assess the influence of the type of rest breaks on football players' ability to repeat phosphagen efforts in order to achieve maximum power and to determine which type of break – passive or active has a more favorable impact on the rate of restitution. The additional objective was to determine whether the degree of acidification of the body is different after passive and active breaks in repeated phosphagen efforts.

Methods

A group of 12 third league players was involved in the investigation. The subjects were provided with detailed information about the experiment and they gave their written consent to participate in the study. Table 1 shows selected anthropological parameters of the study group and the practice period.

Table 1. Averages and standard deviations of the selected parameters from tests A and B before the tests

Test	Parameter						
	age (years)	body mass (kg)	body height (cm)	BMI	fat tissue (%)	LBM (kg)	years of experience
A	22.09 ±3.77	71.75 ±7.98	177 ±6.24	22.87 ±1.43	11.74 ±2.63	63.18 ±5.62	12.08±3.63
B		72.23 ±8.19		22.98 ±1.50	11.99 ±3.25	63.37 ±5.35	

The study was conducted in the Laboratory of Testing Efforts at the University School of Physical Education in Wroclaw (Certificate PN-EN ISO 9001: 2001). The study began on 8th October, 2012 and was completed on 30th October, 2012. The research was conducted during the ongoing league games. For this reason the experiment was not conducted sooner than 72 hours after the last match of the investigated players so that they were fully rested. During this period the players were subjected to two independent maximum power tests on a cycloergometer. The research was done in compliance with good ethical standards (Kruk, 2013).

Procedures

The maximum power test was conduced twice; an active break was used in the first test and a passive break in the second one. The interval between the first and the second tests was 9 ±5 days. The test was performed on a Monark 894 EA ergometer (*Monark Exercise AB, Sweden*). It was preceded by a 5 minute warm-up on a cycloergometer and the test objective was to obtain the maximum power (P_{max}) as soon as possible. The test was similar to the Wingate test. External load during the warm-up ranged from 0.5 to 2 kg. The intensity of the warm-up enabled the subject to reach the heart rate of 140 to 160 beats/min. In both tests each of the players performed 5 repetitions. The test involved obtaining P_{max} as soon as possible in each successive repetition. The duration of each repetition was 7.56 ±1 seconds. Subsequent repetitions of the test were terminated when the value of the obtained maximum power decreased by 5%. The interval between successive repetitions was 90 seconds in both types of break. The active break consisted in the work of the lower limbs on a cycloergometer without external load, while the passive break consisted in a subject sitting on the cycloergometer and not doing any exercise. The weight, height and body composition of the players were also examined. The value of body weight was used to calculate the individual load for the lower limbs in the exercise test. It equaled 74 N/kg of the subject's body mass. The measurement of body composition was performed with FUTREX 6100/XL (*Futrex, USA*) prior to the effort test. The absolute fat content was examined (% kg), BMI and LBM (kg) were calculated. Respiratory parameters were measured with a Quark b^2 gas analysis system (*Cosmed, Milan, Italy*). The subjects breathed through a facemask, which using appropriate wiring, was connected with the exhaled breath analyzer. The entire process of the registration of respiratory parameters started 2 minutes before exercise and finished 5 minutes after its completion. It measured oxygen uptake, which was automatically reported in litres per minute and in millimeters per minute per kilogram of body mass (VO_2/kg), respiratory rate (Rf), minute ventilation (VE). Lactic

acid concentration (LA) in the blood was assayed with a Lactate Cuvette Test colorimetric reagent kit (*Dr. Lange, Germany*). The normal value was 0.6–0.9 mmol/l. LA measurements were performed before the test – at rest, 2 minutes after the second repetition, 2 minutes after the completion of the test. Acid-base balance parameters were determined with a Rapidlab 348 analyzer (*Bayer, Germany*) at the same time as LA concentrations. The blood pH, partial pressure of oxygen (PO_2), partial pressure of carbon dioxide (PCO_2), base buffering deficit (BE), oxygen saturation (O_{2SAT}) were also measured.

Statistical analysis

The obtained results of breath-by-breath measurements of respiratory parameters (VO_2, VO_2/kg, Rf, VE) were recorded at 5-second intervals, then the results of five repetitions of exercise and restitution were individually averaged out. STATISTICA 10 was used for statistical analysis. Wilcoxon matched -pairs signed-rank test was used to assess differences between tests A and B. In the applied statistical test the level of $p < 0.05$ was considered statistically significant.

Results

In the study we observed significant differences in the tested respiratory parameters during five repetitions of maximum intensity efforts and 4 minutes after the completed tests, as well as in the amount of relative and total work. The recorded results showed that the average total work done during test A with an active break was larger compared with test B with a passive break and equaled 6.26 ±0.76 kJ. In test B the total average work done by players was 5.66 ±0.6 kJ ($p = 0.015$) (Figure 1). Also, the relative work was higher in test A (87.61 ±9.25 J/kg). In test B the average relative work equaled 78.5 ±6.58 J/kg ($p = 0.012$) (Figure 2).

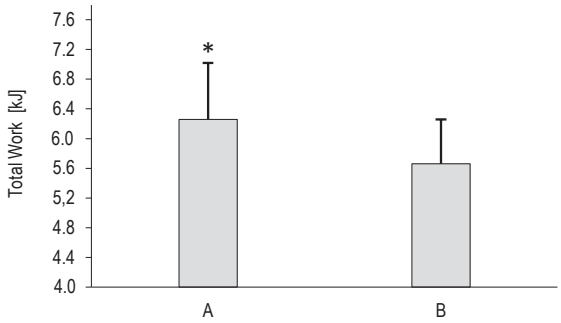

Figure 1. Total work done by participants during tests with active (A) and passive (B) rest breaks. * $p = 0.015$

Our study did not show that the application of various types of rest breaks has an impact on maximum power indicators. In test A the players generated the maximum average power which equaled 780.29 ±77.43 W. In test B the average maximum power was 783.51 ±72.36 W. The differences were not statistically significant. Analysis of the time needed to obtain and maintain maximum power shows that the type of rest break (passive or active) had no significant effect on these parameters. In test A the average time for the subject to reach maximum power was

4.82 ±0.56 seconds. In test B it was 4.92 ±0.77 seconds. In test A the subject was able to maintain maximum power for 2.72 ±0.25 seconds, in test B it was 2.65 ±0.29 seconds.

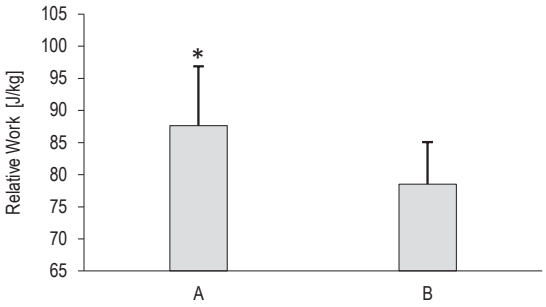

Figure 2. Relative work done by participants during tests with active (A) and passive (B) rest breaks. * p = 0.012

Table 2. Averages and standard deviations of the respiratory parameters in tests A and B. * – significant differences

	Respiratory parameters	A (N = 12)	B (N = 12)	p
Rf b/min	baseline values	16.37 ±5.32	15.68 ±6.13	0.937
	during rest breaks	27.84 ±6	29.03 ±9.98	0.638
	during exertion	36.78 ±9.17	29.83 ±4.69	0.008*
	after exertion	29.26 ±4.14	27.77 ±4.66	0.084
	1st minute of restitution	29.37 ±6.85	26.76 ±4.13	0.209
	4th minute of restitution	33.48 ±4.40	24.75 ±4.72	0.003*
VE l/min	baseline values	17.54 ±7.36	17.19 ±7.75	0.583
	during rest breaks	44.04 ±10.13	40.33 ±15.57	0.695
	during exertion	80.99 ±7.22	64.65 ±20.19	0.003*
	after exertion	72.48 ±12.62	64.09 ±23.5	0.041*
	1st minute of restitution	56.38 ±11.27	51.04 ±16.56	0.583
	4th minute of restitution	47.35 ±8.28	26.14 ±10.29	0.002*
VO_2/kg ml/min/kg	baseline values	7.30 ±2.63	7.42 ±2.79	0.937
	during rest breaks	15.15 ±2.19	13.61 ±2.07	0.023*
	during exertion	30.15 ±3.88	26.53 ±4.14	0.004*
	after exertion	31.36 ±4.75	29.13 ±3.71	0.071
	1st minute of restitution	20.96 ±4.26	20.36 ±3.98	0.272
	4th minute of restitution	17.52 ±2.53	9.31 ±2.41	0.002*
VO_2 ml/min	baseline values	533.83 ±233.16	533.29 ±210.51	0.875
	during rest breaks	1084.2 ±176.73	979.19 ±161.1	0.034*
	during exertion	2149.75 ±265.17	1892.61 ±218.81	0.005*
	after exertion	2240.71 ±355.12	2090.96 ±284.48	0.060
	1st minute of restitution	1497.44 ±295.5	1449.95 ±210.54	0.308
	4th minute of restitution	1254.13 ±211.24	668.18 ±172.34	0.002*
R	baseline values	1.1 ±0.13	1.09 ±0.16	0.937
	during rest breaks	1.3 ±0.17	1.36 ±0.15	0.239
	during exertion	1.16 ±0.09	1.2 ±0.08	0.117
	after exertion	1.05 ±0.07	1.06 ±0.08	0.583
	1st minute of restitution	1.18 ±0.08	1.19 ±0.11	0.875
	4th minute of restitution	1.08 ±0.11	1.19 ±0.1	0.002*

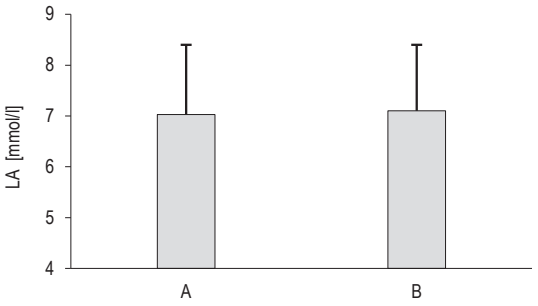

Figure 3. LA concentration in the blood, 2 minutes after the second repetition in tests with active (A) and passive (B) rest breaks

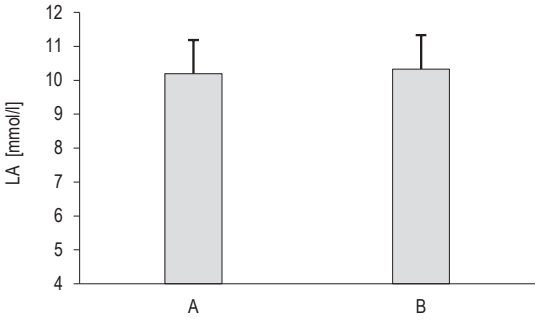

Figure 4. LA concentration in the blood, 2 minutes after the completion of tests with active (A) and passive (B) rest breaks

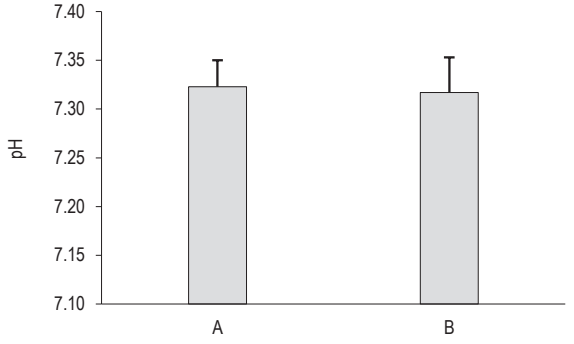

Figure 5. Blood pH values, 2 minutes after the second repetition in tests with active (A) and passive (B) rest breaks

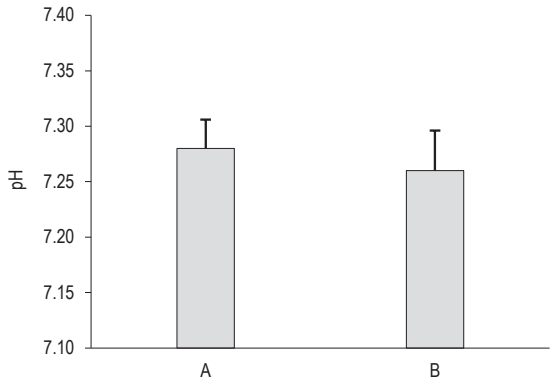

Figure 6. Blood pH values, 2 minutes after the completion of tests with active (A) and passive (B) rest breaks

We did not register any differences between the selected respiratory parameters at rest, while significant differences were noted in all the parameters during exercise and 4 minutes after its completion. Statistically significant differences were found in VE after completing the exercise. Significantly higher values were recorded during rest breaks in test A. It was ascertained that the respiratory parameters were significantly different at corresponding stages in both tests.

Data analysis of acid-base balance and concentration of lactate did not reveal any significant influence of the type of rest break on these parameters. After finishing the tests the concentration of LA in test A was 10.19 ±1.67 mmol/l (Figure 4), while in B it was 10.33 ±1.57 mmol/l. The pH of the blood after finishing test A decreased to 7.280 ±0.026, whereas after finishing test B it was 7.260 ±0.036.

Discussion

According to Maughan, Geeson, Greenhaff (1997) restoration of 90% of the stock PCr takes about two minutes. McAinch et al. (2004) claim that an active rest break is more beneficial between successive maximal repetitions. Thiriet et al. (1993) state that an active rest break performed with an intensity of 30–40% VO_2max facilitates utilization of lactic acid which has been accumulated in the muscles as a result of performed maximal efforts. These authors claim that this type of rest break has a beneficial effect on power indicators obtained in subsequent repetitions. In contrast, Dupont et al. (2004) show in their study that a 15-second active break (40% VO_2max) applied after subsequent 15-second efforts (120% VO_2max) leads to more rapid exhaustion (427 ±118 seconds) than when a 15-second passive break is used. The authors noted that in a test with a passive break the participants performed their work much longer (962 ±314 seconds) ($p = 0.001$). It may be connected with the observed drop in the concentration of oxyhemoglobin in the blood. Furthermore, according to these authors, and Yoshida, Watari, Tagawa (1996) an active break limits re-oxidation of myoglobin and causes slower re-synthesis of phosphocreatine (PCR) in the muscles. McAinch et al. (2004) claim that during an active break the ATP produced in the mitochondria could be partly used during active work between subsequent repetitions. In contrast, during a passive break a greater number of mitochondria could be involved in PCR re-synthesis. The arguments seem to be confirmed by

Spencer, Bishop, Dawson, Goodman, Duffield (2006). In their research they noticed that after six 4-second runs on a cycloergometer separated by 25-second intervals with active (32% VO_2max) and passive rest breaks in two independent tests the reconstruction of phosphocreatine was more effective during a passive break. Baseline PCr concentration in the muscles before the test was 72.7±6.6 mmol/kg. In the study by Spencer et al. (2006) after the completion of the test a muscle biopsy was performed in 21st second of restitution which revealed the reconstruction of phosphocreatine at the level of 52.3 ±11.3 mmol/kg (71.7 ±14.1%) in the test with a passive break. The test with an active rest break allowed the muscles to rebuild PCr at 39.2 ±11.00 mmol/kg (54.6 ±9.6%, p = 0.06). The concentration of PCr immediately after the test was 23.4 ±10.4 mmol/kg (32.6 ±10.6%) for the test with an active break and 33.2 ±15.3 mmol/kg (45.3 ±18.6%, p = 0.06) for the test with a passive break. It should also be noted that during the study statistically significant differences in maximum power were noted only in the sixth repetition. It was lower in the test with an active rest break (14.9 ±1.5 W/kg) than in the test with a passive rest break (15.3 ±1.5 W/kg) p = 0.02. Dupont et al. (2004) point out that the use of active breaks (40% VO_2max) for supramaximal exercise (120% VO_2max) will cause its working time to be twice as short as when a passive break is used. Our research shows that during the test with an active break the participants did a lot more work. It should be noted that in our study the ratio of exercise time to pause time was 1 to 12 ±1. Implementation of more work during the first test may be related to an increased volume of blood flowing through the muscles, providing them with significant amounts of oxygen, which can improve lactate transport from the muscles by MCT transporters (Brookes, 1986; Harmer et al., 2000; McKenna et al., 1997). Chmura, Zatoń (2011) suggest that repetition of 90-second efforts might lead to energy from glycolytic processes being used. This is also confirmed by our study, in which LA concentration after the second repetition (Figure 3) was >7 mmol/l. During 6-second maximal effort the participation of phosphocreatine in ATP resynthesis is approx. 50% (Gaitanos et al., 1993). However, if the effort lasts for 30 seconds, PCr reserves are depleted by approximately 60–80% relative to the resting value (Gaitanos et al., 1993; Medbø et al., 1999). In their study Bogdanis, Nevill, Lakomy, Boobis (1998) observed PCr resynthesis at 86% after 10 seconds of maximal effort on a cycloergometer, and after 20 seconds it reached 76%. These values were observed in the 2nd minute of restitution after a single effort. Therefore, it can be concluded that in our own study in which subsequent efforts lasted from 7 to 9 seconds anaerobic processes were more engaged in ATP re-synthesis. The obtained results of maximum power in tests A and B suggest that the type of rest break did not affect the rate of PCr re-synthesis, but because of the higher level of work in test A it can be assumed that ATP re-synthesis is less difficult than in test B. ATP resynthesis is more effective during an active rest break after short intense exercise as compared with a passive break (in accordance with Sechenov's principle). Thevenet, Tardieu-Berger, Borthoin, Prioux (2006) claim that both passive and active rest breaks between efforts improve the body's oxygen systems. The type of break should be chosen consciously and properly and should be determined by changes which we expect to achieve in the body. An active rest break will cause faster neutralization of LA while a passive rest break will cause faster re-synthesis of PCr and faster adaptation of the muscles to work in conditions of disturbed acid-base balance. After two independent tests on a cycloergometer with active and passive breaks, McAinch et al. (2004) documented that a passive rest break has a better influence on PCr re-synthesis and ATP restoration. In the 15th second of restoration they even observed supercompensation of ATP and PCr in relation to the baseline. ATP concentration recorded prior to the test was 26.1 ±1.6 mmol/kg, and after the test, 26.4 ±1.8 mmol/kg. In contrast, PCr concentration prior to the test was 79.4 ±2 mmol/kg and after the test it rose to a value of 87.6 ±2.9 mmol/kg (p < 0.05). Higher values

of VO_2/kg observed in our study testify to the body's higher ability to perform more work, which is confirmed by Krustrup, Bangsbø (2001), Weston, Brewer (2002), Wisløff, Helgerud, Hoff (1998). Our research has shown that higher Rf, VE, VO_2/kg VO_2 recorded during efforts do not affect the maximum power obtained in tests A and B. Tomlin and Wenger (2001) are of the opinion that a high level of aerobic capacity increases anaerobic performance during short-time intense exercise. The values of Rf, VE, VO_2/kg, VO_2, R measured 60 seconds after the completion of the tests showed no statistically significant differences between tests A and B. In contrast, higher values of these parameters were recorded in the group performing the test with an active rest break. The values of some of these parameters from test A exceeded even twice the values of the corresponding parameters in test B. Taking the body's ability to return after load to resting values as a determinant of the effectiveness of restitution, we should conclude that passive rest is more effective. While analyzing the changes in other parameters, such as the concentration of lactate and the pH, it cannot be unequivocally concluded that a passive rest break is more advantageous.

Practical Applications

1. The type of rest breaks must be chosen after considering the purpose and the changes that we intend to achieve in players' bodies by introducing specialized training which is responsible for shaping and improving the capacity of selected physiological abilities.
2. In phosphagen training not only the type but also the time of restitution must be selected individually, taking into account fitness levels of competitors and the efficiency of their particular metabolic pathways.
3. A passive rest break should be used when the objective is the fastest resynthesis of PCr and ATP and improvement in the muscles' adaptation to work in disturbed acid-base balance.
4. An active rest break should be used when the goal is to remove LA accumulated in the muscles as soon as possible during subsequent maximal repetitions in anaerobic training. The use of an active rest break is preferred to prepare a player for doing subsequent maximal repetitions in the shortest possible time intervals as is the case in real game conditions. The intensity of work during an active rest break should be 30–40% VO_2max.
5. Time of both active and passive rest breaks should be considered individually for each player. It is possible to apply the principle of the higher the VO_2max level and the speed abilities of a player are, the shorter the rest break between subsequent repetitions should be.

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OPINION ABOUT EXERCISES IN WATER AND LIFESTYLE OF WOMEN ATTENDING AQUA AEROBICS CLASSES

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Abstract. Aqua aerobics, as one of the modern forms of movement, is becoming more and more popular among the public. The main objectives of this study is to get to know the lifestyle and opinion on the aqua aerobic classes of women participating in this type of activities. According to the authors, people who take part in aqua aerobics classes probably care about their fitness. They should also be aware of the need to lead a healthy lifestyle, because it is one of the most important factors in human health.

The study group included 50 participants of aqua aerobics classes in "AQUA STYL" company in Szczecin. Each subject received a questionnaire. It contained 23 questions. Most of the questions related to information about participants and their way of life. The other concerned the opinion about aqua aerobic classes.

Most of the respondents answered that they lead a healthy lifestyle. More than 70% of women felt that they follow rather healthy diet. The analysis showed that aqua aerobics gave pleasure to almost all respondents. The benefit of participation in aqua aerobics classes is generally better mood.

Despite the large number of people declaring a healthy lifestyle, it is advisable to increase the awareness of the lifelong need for physical activity. As many as 30% of respondents did not know if they lead a healthy lifestyle. There should be greater promotion of healthy behavior. Instructors should know more about the group attending the classes, in order to make the exercises more attractive and effective.

Key words: aqua aerobics, life style

Introduction

Aqua aerobics, as one of the modern forms of movement is becoming more and more popular among the public (Pietrusik, Mroczek, 2003; Eider, Eider, 2006). Among others, Zysiak-Christ, Figurska, Stasikowska (2010) describes its positive influence on the human locomotion and the development of various motor skills. One of the elements that affect such a broad interest in aqua aerobics are specific characteristics of the aquatic environment (Mosakowska, 2007). From the standpoint of physics and physiology, aqueous media are preferred in the treatment

of various diseases of the musculoskeletal or neurological system, also in the pathology of heart and lungs (Jung, Chung, Kim, Lee, Lee, 2014). Katz (2003) points out that many pregnant women attend various activities taking place in an aqueous environment, because it has a significant beneficial effect on the cardiovascular system due to hydrostatic pressure. The diverse nature of activities, based on the appropriate accessories and appliances usage that shapes the individual parts of the body is also a factor encouraging to participate in this form of exercises (Zysiak-Christ, Figurska, Stasikowska, 2010).

According to the authors, people who take part in aqua aerobics classes probably care about their fitness. They should also be aware of the need to lead a healthy lifestyle, because it is one of the most important factors in human health (Drabik, Resiak, 2010). Sęk (2000) defines lifestyle as characteristic behavior of a particular individual or social group, which is essential for health. Some lifestyle behaviors are considered as possible determinants and causes of not only coronary heart disease and other diseases of the cardiovascular system, but also cancer and high mortality (Menotti, Puddu, Maiani, Catasta, 2014, 2015; Prinelli et al., 2015). These behaviors can be: regular physical exercises, proper nutrition, lack of bad habits, adequate sleep and avoidance of stimulants (Mędrela-Kuder, 2004; Sęk, 2000; Sygit, Sygit, 2008). One of the most important factors in lifestyle is physical activity (Drabik, Resiak, 2010; Nowak, 2008).

The main objectives of this study is to get to know the lifestyle and opinion on the aqua aerobics classes of women participating in this type of activities. Instructors' knowledge about the needs, expectations and beliefs of participants is an important factor contributing to the increase of the classes' attractiveness. Thanks to such an attitude companies operating in recreation industry will be able to improve employees' qualifications. This study is designed to reveal the participants' opinion and assess the services provided by the company "AQUA STYL" in Szczecin.

Personal questionnaire included questions verifying the healthy lifestyle of participants of aqua aerobics classes, according to the criteria given by the literature (Sęk, 2000; Mędrela-Kuder, 2004; Nowak, 2008; Sygit, Sygit, 2008; Drabik, Resiak, 2010). The study aimed at verifying the above theses and introducing potential changes in the life habits of individuals.

Subjects and methods

The study group included 50 participants of aqua aerobics classes in "AQUA STYL" company in Szczecin. The classes took part in two swimming pools in Szczecin, three times a week, at the Gymnasium no. 9 (Dunikowskiego Street 1), and twice at the SDS swimming pool (Wąska Street 16). The company has been providing its services since November 2009.

Each subject received a questionnaire before the session, which she took home, filled in and brought to the next class. It contained 23 questions. Most of the questions related to information about participants and their lifestyle. The other associated with the opinion about aqua aerobics classes.

The questionnaire consisted of questions closed and open questions which enabled the subjects to enter their own response. The results were compiled and presented on the charts in percentages.

Results

The majority of respondents – 68% – answered affirmatively to the question: "Do you lead a healthy lifestyle?". For comparison, only 2% answered negatively (Figure 1).

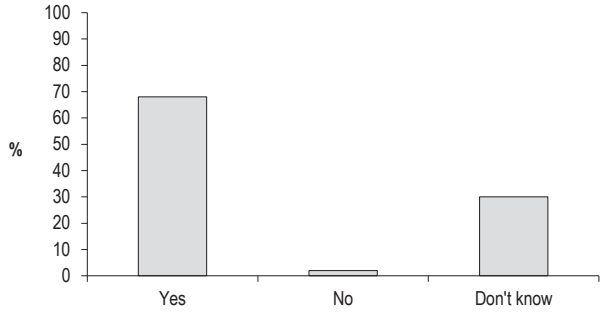

Figure 1. Respondents living a healthy lifestyle

Women participating in the study were asked for a subjective assessment of the current state of health. Almost 60% of respondents rated their health as good, while 10% found it to be very good (Figure 2).

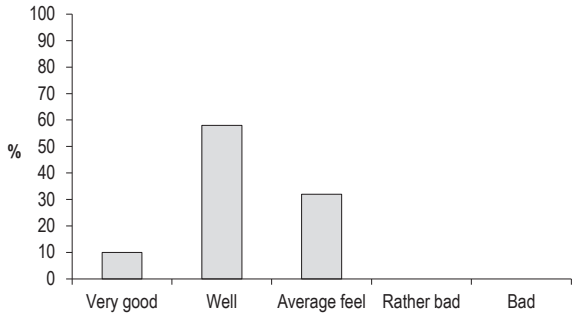

Figure 2. Respondents' current health in self-opinion

Studies have shown that a majority of respondents – 82% did not smoke cigarettes (Figure 3).

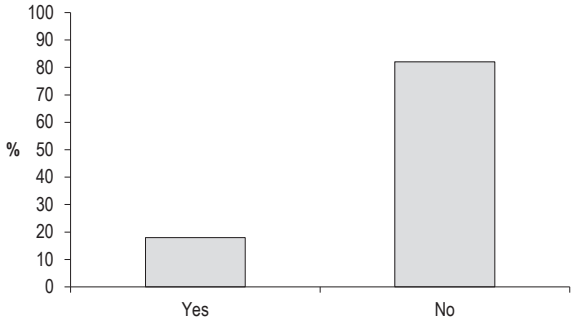

Figure 3. Smoking cigarettes

Next question required the respondents to express an evaluation of their diet. In the study group, 72% of women felt that they eat rather healthily. On the other hand, only 2% of respondents marked that they do not follow healthy diet and also 2% "don't know" if they follow it (Figure 4).

The majority of respondents – 66% – were active-in their free time. Other subjects – 34% – spent it passively (Figure 5).

The analysis of the study shows that aqua aerobics gave pleasure to almost all the respondents (Figure 6).

Most of the study group – 82% – answered that they like the music proposed during aqua aerobics classes. The remaining percentage – 18% – suggests changing tracks (Figure 7).

The next question concerned the benefits, that the respondents noticed through participation in aqua aerobics. Most of subjects selected the answers "better mood" and "fitness improvement". Answers: "weight loss" and "eliminating ailments" were marked by 20% of women (Figure 8).

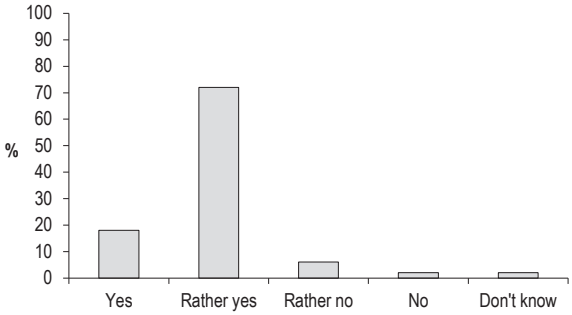

Figure 4. Respondents following healthy diet

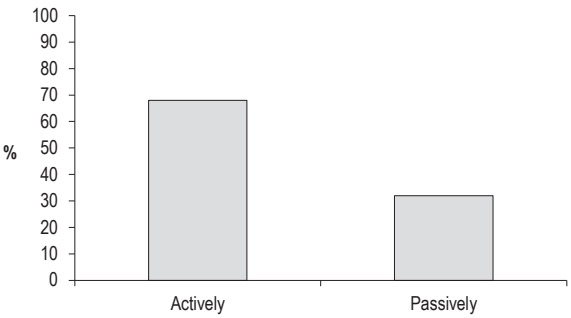

Figure 5. Respondents' leisure time

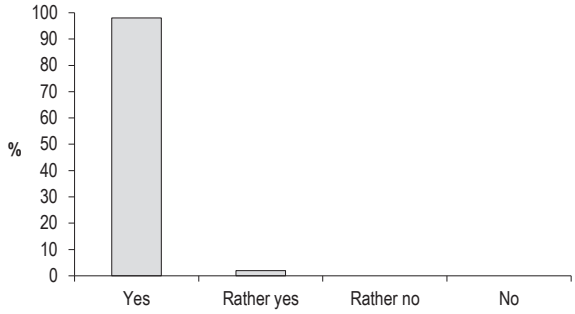

Figure 6. Deriving pleasure from aqua aerobic classes

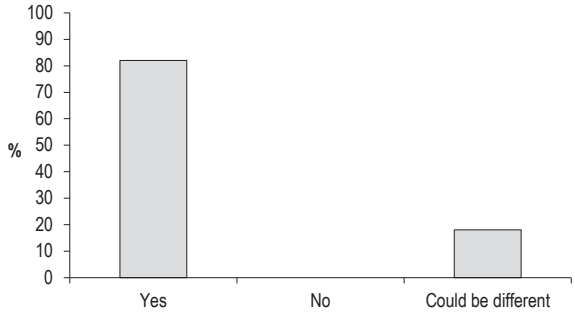

Figure 7. Do respondents like music, which is played during aqua aerobic

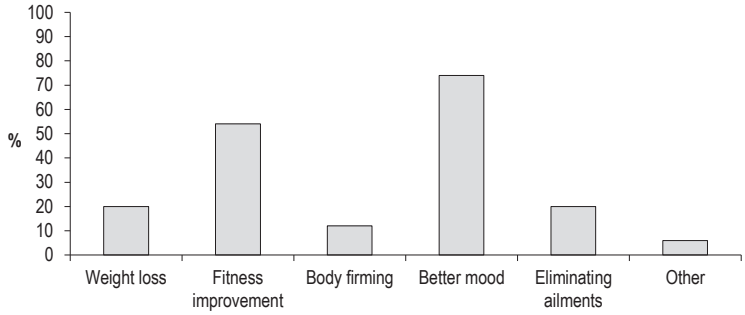

Figure 8. Benefits noticed through participation in aqua aerobic classes

Discussion

As expected, the study showed that participants of aqua aerobics classes were women. A similar statement was present in the work of J. Eider (1999), describing a similar form of physical activity that is aerobics. Also Wiażewicz (2014, 2014b) emphasizes the advantage of women in aqua aerobics. Almost 40% of participants had jobs of an intellectual nature. A little less, 30% were engaged in physical and intellectual work. Wiażewicz (2014, 2014b) also highlights the advantage of the participation of subjects working intellectually. Eider (2004, 2004b, 2004c) examining the aerobics class participants obtained similar data.

Over 50% of respondents stated that they lead a healthy lifestyle. In contrast, 30% of people marked the answer "don't know". Perhaps the public is not aware of the exact definition of a healthy lifestyle. Only 10% of participants rated their health as very good, 30% as moderate, and only 12% answered that they do not have any complaints. Moreover, following healthy diet was declared by more than 70% of respondents. Olech-Himkowska (2012) obtained similar results for the people "reporting" healthy eating.

The majority of subjects – 82% – did not smoke cigarettes. Drinking alcohol was admitted by 18% of respondents. Most of the women taking part in aqua aerobics classes declared active leisure time activities. A similar result was obtained by Olech-Himkowska (2012) which showed that almost 80% of people engaged in recreational dance prefer active rest.

All participants declared that aqua aerobics classes gives them pleasure. Most women preferred classes, where the "pool noodles" or "mixed" exercises were used, performed using a number of different gears.

Among the notable changes, the largest number of women indicate a better mood after classes. This is consistent with the Pietrusik's (2005) conclusions, who says that aqua fitness is a form of physical activity in the water, with the aim to find the well-being. A similar assumption was placed in Ahn's (2003) work, noting that aqua aerobics gives a significant positive psychological effect. More than half of participants reported improved condition, and 20% – weight loss. Other results were obtained by Kim and O'sullivan (2013) who noted a significant reduction in body weight in the elderly. Olech-Himkowska (2012) adds that 58% of respondents noticed changes in the body proportions thanks to dance classes.

Baena-Beato, Arroyo-Morales, Delgado-Fernández, Gatto-Cardia, Artero (2013) reported that exercises in water therapy reduce back pain and also help to improve the quality of life and health in adults with chronic low back pain. A similar conclusion was reached by Svedenhag (1992), who determined aqua aerobics as very effective in reducing pain in patients with arthritis. Wiażewicz (2014, 2014b) reports that about 96% of aqua aerobics participants noticed health improvement. Jung, Chung, Kim, Lee, Lee (2014) reported that exercise in an aquatic environment is more effective than training applied on the ground. Kim and O'sullivan (2013) found that aquatic exercises are an effective method to reduce the risk of falling in the elderly.

Knowing the participants' preferences can help to recognize their expectations and increase the attractiveness of classes. Knowledge about the lifestyle of respondents allowed to hold talks with them in the field of proper nutrition and active leisure. Thanks to this, part of the ladies attending aqua aerobics expressed a desire to change their lifestyles and improve diet habits.

Conclusions

Based on the results, authors obtained the following conclusions:

1. Although the majority of people declare a healthy lifestyle, it is advisable to continuously spread-information about the need for lifelong physical activity.
2. As many as 30% of respondents did not know if they lead a healthy lifestyle. Therefore, a greater promotion of healthy behaviors should take place.
3. Aqua aerobics gave pleasure to all participants. Instructors should continue the way of training, taking into consideration some suggestions of the respondents.
4. Aqua aerobics instructors should know more about the group attending classes in order to make the exercises more attractive and effective.

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NON-FORMAL EDUCATION IN THE ANIMATION OF LEISURE AND RECREATION VERSUS THE DEVELOPMENT OF SOCIAL COMPETENCE

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[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation

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Abstract. This article is an empirical study on the possible use of non-formal education in the broadly understood animation of leisure time. The study was conducted using a diagnostic survey method, as well as the techniques of questionnaire and observation, during the last meeting under the project "Non-Formal and Formal Partnership in Adult Education" (Grundtvig Reference Number 2013-RO1-GRU06-29569 2) in Romania, at the turn of February and March 2015. The study included 16 non-formal education trainers from Greece, Latvia, Poland and Romania. The aim of the study was to show the impact of the project on the beneficiaries and the development of their individual social competence, as well as to demonstrate the work techniques of trainers with different social groups. An animator plays an important role in the organization of leisure time of the society, hence their continuous education seems almost necessary. The improvement of individual social competence of the trainers surveyed will certainly contribute to their attempt to pass a various range of games, plays and other activities (including non-formal education) to the participants of the classes.

Key words: leisure time animation, non-formal education, games and activities, social competence, recreation

Introduction

Leisure time animation is the increasing need of tourists travelling to different parts of the world. Thereby it "has become (...) an indispensable element of operation of multiple hospitality facilities" (Paczyńska-Jędrycka, Eider, 2015, p. 281). Currently, the notion of leisure time animation can be encountered almost everywhere. Its most popular form is definitely a hotel animation service. However, it can also take place while travelling, as mentioned by R. Szafranowicz-Małozięć (2015). Animations are organized with the help of animators in different places, for example popular children's birthday parties in amusment parks or ropes courses. Animators frequently organize games and fun activities during integration trips, so you can get to know the whereabouts of the place and its history (Eider, Paczyńska-Jędrycka, Krupecki, 2014).

Leisure time animation as a service within the organization of leisure of different social groups certainly requires appropriate preparation of the staff of animators. On the one hand, the availability of courses educating for this purpose is large. On the other hand, it should be emphasized that the training itself, and thus acquiring skills in the knowledge of various ways of spending leisure time, is nowadays certainly not enough. It is necessary to possess the appropriate personality traits allowing for conducting any animation and continuous further training in this regard. It is thus about a lifelong learning, which aim is learning through experience.

Therefore referring to the current demand of the market of leisure time services, as well as to the increasing role of human capital, it would be a good idea to focus on the use of non-formal education in the broadly understood leisure time animation. Non-formal education is understood, inter alia, as the one which takes place "in passing" (Fatyga, 2005, p. 20). "Non-formal education actually lasts a lifetime, it is this form of gaining knowledge which is based on the experience. The significant advantage is "touching" the life, experiencing it and drawing conclusions and knowledge from these experiences, and thanks to it acquiring the practical skills" (Kurzępa, 2005, p. 48). Such unconscious acquisition of knowledge and specific skills or competencies in the course of play will certainly raise the quality and standard of animation services. On the one hand we are discussing here the process of teaching, on the other hand the process of marketing. In the educational aspect it should be noted that the organization of leisure time puts "emphasis on personality development and implementation of the potential capabilities of an individual" (Ostaszewski, 2007, p. 509). In terms of marketing, however, we should refer to the concept of rivalry that K. Wrona (2013, p. 25) defines in the following way: "the implementation of the structure and mechanics of games (points, distinctions, levels, challenges, awards) into the real world in order to stimulate the involvement of users, changes in their behavior and solving the problems of different types". It is therefore necessary to underline the fact that the animation of leisure time, a variety of games and recreation activities, are frequently not only autotelic, but they are also used to achieve various effects, including the promotion of a particular brand.

So is playing just for fun enough in the reality in which we live? According to the authors – not any more. A good solution is to move forward and make use of fun (eg. during increasingly popular children's birthday parties in the mini clubs, during the holidays – hotel animation service, animation during the trip, playing games and having fun at camps for children and youth, during training – group animation) to pass on the broadly understood knowledge, skills and social competence. This should be done in such a way that children, youth or adults automatically absorb the aforementioned knowledge and skills. The combination of traditional games and activities, along with their modifications should be enriched with new activities based on a model of non-formal education and creativity of animators. As defined by K.J. Szmidt (2013, p. 25): "Creativity training is a system of individual or group exercises, used to stimulate and develop the capacity to generate new and valuable ideas of solving the cognitive and practical problems". While animating the leisure time of both children and adults, a good idea is to take advantage of educational elements that will improve the quality of services provided. T. Boris (2010, p. 59) emphasizes the need to move away from the classical education in favour of education for sustainable development, "which should include various dimensions of quality of life". This will surely contribute to shaping the social competence of an individual, and thus of human capital (Paczyńska-Jędrycka, Frąckowiak, Łubkowska, 2014; Paczyńska-Jędrycka, Łubkowska, Jońca, 2015) which is an inherent link in the development of the region and country (Łubkowska, Eider, 2014). "Animation (...) has become the method of work, going beyond the issue of internal analysis of the group process. It recognised the environmental and institutional context in which groups operate" (Litwicka, 2011, p. 10). The functioning of the group, the emergence of a leader, are also the elements of many games or fun activities.

Making use of these on the one hand allows the animator to create an appropriate atmosphere in the group, on the other hand, it allows to show to a distinguishing person the role of a leader. As a rule, a person is a leader not only while having fun, but also beyond. The tasks of the animator of recreational activities also include the appropriate stimulation of a group. He is responsible for the way it will proceed. That is why he should be a person who constantly develops and improves his existing qualifications and competence. Then he will certainly become a role model.

Methods

The study was conducted during the last project meeting (evaluation) "Non Formal and Formal Partnership in Adult Education" (Grundtvig Reference Number 2013-RO1-GRU06-29569 2) in Romania, at the turn of February and March 2015.

The study involved 16 non-formal education trainers from Greece, Latvia, Poliand and Romania. As shown by the previous studies, theay are mainly persons with extensive experience (Paczyńska-Jędrycka et al., 2015).

The main aim of the study was to demonstrate the impact of the project on its beneficiaries and the development of their individual social competence, as well as to demonstrate the trainers' working techniques with different social groups. The intention of the authors is to show the usefulness of various techniques of working in the field of non-formal education within the range of improving the training skills and methods, as well as promoting them among the public, regardless of age and the place where we are.

The study was conducted using a method of diagnostic survey and the techniques of questionnaire and observation (Siwiński, 2006).

Results

The Project "Non Formal and Formal Partnership in Adult Education" (Grundtvig Reference Number 2013-RO1-GRU06-29569 2) started in August 2013 and lasted till July 2015. Participation in the project involved five meetings in the territory of partner countries: Poland (November 2013), Romania (March 2014), Latvia (May 2014), Greece (October 2014), Romania (February-March 2015). Each of them served mainly the exchange of international experiences and views, as well as practical activities in the field of non-formal education, where it should be emphasised that each partner country was obliged to be represented both by the institution dealing with formal, and with non-formal education. In addition to the aforementioned meetings, each country conducted workshops with different social groups. In the case of Poland, the workshops were mainly addressed to teachers, students (Faculty of Physcial Culture and Health Promotion, University of Szczecin), as well as to begining trainers in the field of non-formal education (http://nieformalna.com.pl/wp-content/uploads/2014/01/Podr%C4%99cznik-Dobrych-Praktyk-PL.pdf).

Active participation in the project allowed all the trainers (100%), participating in the evaluation meeting in Romania to develop individual social competence (Tables 1 and 2). Primarily they developed their openness to others (69.2% of responses). In second place were: team building and leadership ability, as well as overcoming the language barrier (61.5% of responses). Overcoming the language barrier was extremely important, because the official language of the project was English. Thus, it was not the native language of any of the partners. Each country had to share the content of its conducted trainings along with the achieved effects. It can therefore be

stated that overcoming the language barrier was a prerequisite for the implementation of the project. "The ability to cooperate" was developed by 53.9% of respondents.

On the one hand, it was conditioned by the necessity of cooperation during the project, as well as the exchange of experiences. On the other hand, during all the meetings the trainers acquired new techniques and methods of non-formal education, inter alia a new range of energizers, ice-breakers or team building activities. Definitely the least developed were social skills such as: the ability to talk about their emotions or difficult issues (23.1%), assertiveness (15.4%), ability to cope with stressful situations (15.4%). It is important, however, to develop these competencies. In non-formal education each activity must be summarized, as opposed to games and animation activities. Nevertheless, the summary can be moved also to the ground of animation, drawing upon the experience of trainers involved in non-formal education. It is important that each of the participants has a possibility to express their opinion on what they liked and what they did not like, what was the most difficult part of a particular activity. If a particular "game, fun" was not successful, what was the reason. Individual, as well as collective problem solving related to a given activity will certainly help both the individual and the group become a better, more open to others, freer in their comments.

Table 1. Development of social competence

Development of social competence	%
Yes	100
No	0

Source: own development based on conducted study.

Table 2. Social competence developed in trainers in the course of project

Social competence	%
Openness to others	69.2
Team building and leadership ability	61.5
Overcoming the language barrier	61.5
Ability to cooperate	53.9
Creative thinking	46.2
Self-improvement	46.2
Increase in self-confidence	38.5
Ability to discuss own emotions and difficult issues	23.1
Ability to cope with stressful situations	15.4
Asertiveness	15.4
Ability to help others	0.0
Other	0.0

Source: own development based on conducted study (due to the possibility of choosing more than one answer, the sum % is bigger than 100%).

What definitely contributed to the development of social skills mentioned above (Table 3) during the duration of the project were interpersonal contacts (53.8% of responses), including any conversations. What should be taken

into account are contacts at two levels, namely: international (between the partner countries), as well as contacts with the participants of particular training sessions. Each of the project trips included the possibility of various meetings outside of the classroom, which influenced also the personal development of the individual. Participation in various activities, games and plays (38.5% of responses) also contributed to the development of social skills of the trainers who currently train and will train the new generations of trainers, animators and class educators. Typical educational activity (including Art classes) had the least impact on their development (7.7% of responses).

Table 3. Activities that contributed most to the development of the above-mentioned social competence

Activities	%
Interpersonal contacts (any conversations)	53.8
Animation games (energizers, ice-breakers, etc.)	38.5
Educational activities (painting, "handiwork")	7.7
Sightseeing trips	0.0
Other	0.0

Source: own development based on conducted study.

Continuous personal, as well as professional development of trainers is extremely important from both the educational and psychological point of view. Participation in the project certainly contributed to the development of their social competence, as well as to acquisition of some specific knowledge, which they can share with others while conducting animation activities or a variety of workshops. In their previous work, the trainers are principally engaged in animation games (69.2% of responses), educational activity (53.8%), classes within the scope of broadly understood physical culture (38.5% of responses) and tourism (15.4% of responses) (Table 4).

Table 4. Types of workshops conducted by trainers with various social groups

Workshops	%
Animation games (energizers, ice-breakers, etc.)	69.2
Educational activities (painting, "handiwork")	53.8
Physical activity	38.5
Sightseeing trips	15.4
Other	0.0

Source: own development based on conducted study.

As it can be observed, the trainers involved in the project have broad horizons and interests, which they share with others in their work. It should also be noted that animation games referred to in this paper, can include both an element of educational activities, physical activity or sightseeing.

Discussion and conclusions

In connection with the ongoing development of society, you should ask yourself whether the animation of leisure time both in everyday life, as well as during business trips or holidays, should remain merely good fun? On the one hand, the answer is obvious, and it it "yes". A man of today is often exposed to a lack of economic and

family stability, as well as to growing stressful situations. On the other hand, in the face of these conditions, there may be a need for lifelong learning, but learning just through play, and therefore unknowingly acquire or improve their social competence.

As shown by the survey conducted by CBOS – the Public Opinion Research Center (Boguszewski, 2015) on "Activities and experiences of the Poles in 2014", the Poles throw parties for friends and acquaintances in their spare time at a level similar to previous years. During such a meeting you can easily use an element of animation, eg. through active participation in board games, which again have been enjoying increasing popularity in the recent years. According to these studies, an increase in the use of the restaurant for the whole families is observed. Therefore, arranging the children's play areas or organization of family events such as collective gingerbread baking at Christmas, painting Easter eggs, etc., are becoming more commonplace. There is also an increase in the number of family recreational trips, hence the tour operators in addition to the classic range of products also create the ones which are intended mainly for families. In terms of marketing they create family catalogues, so as to get to the parents via their children.

Further on the same survey (Boguszewski, 2015) shows that more and more people are using the Internet in their leisure time. Therefore, we talk more frequently about the skilful use of modern technologies for a variety of games and recreational activities (Nadobnik, Łubkowska, 2014). CBOS survey (Boguszewski, 2015) also points out that cultural life, like the visits to galleries or museums, is still at relatively low level. B. Gradišar (2010) shows the museum tours and the acquisition of knowledge in a variety of ways, ranging from the classical, through various tasks ("worksheets" or swapping roles – a student becomes a guide). Perhaps it is worth taking advantage of such objects, making them the game board. Then exploring the history of various works of art would certainly become more easily absorbed. During holidays optional excursions are also frequently offeed. Perhaps the use of new ways to explore and get to know culturally attractive destinations will encourage tourists to visit them more often.

Mentioning the CBOS survey was to show different forms of promotion of a few selected ways of spending free time. On the one hand we speak here about animation, but on the other, there was also a component of non-formal education. The question therefore arises how to connect it and use the methods of non-formal education in the leisure time animation. First, we should start with the animator. This will be the person who the form and content of the classes will depend on. Secondly, what counts will be the ability to summarize a particular game or activity. This will also give the possibility to have a say to each of the participants of the activity.

Studies carried out at the evaluation meeting of the project "Non-Formal and Formal Partnership in Adult Education" (Grundtvig Reference Number 2013-RO1-GRU06-29569 2) were designed to show that although the trainers participating in it had a lot of experience, this project enriched them both with new methods and techniques of non-formal education, as well as social competence. As it can be observed, non-formal education is an essential part of everyone's life (including leisure time animation and all forms of recreational behaviours) because coming in contact with it we acquire new skills and qualifications, often without being aware of it. The task of the leisure time animator is to create such activities and such impact, that the participants enjoy themselves, but also enrich their social competence and gain new knowledge by means of non-formal education. Non-formal education should constitute only a part of the repertoire of animation activities, because fun in itself is also needed. The use of non-formal education in leisure time animation definitely requires from the animator a lot of experience in this field, as well as the creativity and skills to adapt different activities depending on the group, their age, efficiency, skills, and a degree of "initiation".

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THE RESULTS OF EARLY AND DELAYED TREATMENT OF INJURIES OF THE EXTENSOR TENDONS OF THE FINGERS IN OWN MATERIAL

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Abstract. The aim of this study was to evaluate the results of early and delayed surgical treatment and the rehabilitation of patients with traumatic injury in zone I of the extensor tendon of the fingers II–V. 47 patients after traumatic, closed damage of the extensor tendons of the fingers II–V of the hand were treated and examined. 17 women (36.2%) and 30 men (63.8%) aged 14–80 years were included in the study. Patients with a delayed first degree damage of the extensors tendon, as well as fourth degree damage, according to the Doleyle scale qualified for surgical treatment. Surgical treatment consisted of suturing the tendon band or restoring its attachment to the phalanx bone, as well as the arthrodesis of the distal interphalangeal (DIP) joint with Kirschner wire in extension. The wire was removed after 6 weeks. Rehabilitation treatment was carried out in order to restore a full range of motion of the fingers. Patients were under constant supervision of the medical team. The examination of the patients took place before and 3 months after the surgery. The presence of the pain was assessed by means of a 10-point VAS scale (Visual Analog Scale). A goniometer was used to measure the range of motion of patient's fingers. Crawford's scale was used to assess the results of treatment of injuries to the extensor tendons of the fingers. The early stages of treatment to these yielded excellent results in 84.2% of patients, 14.3% good results, 17.8% of satisfactory results and 3.6% of patients had poor results. The differences in the results were not statistically significant. Further operative intervention should be considered for patients with extensive damage to the tendon of the extensor finger with a greater detachment of a fragment of phalanx bone shortly after the injury. In patients with extensive damage to the tendon of the extensor finger with greater detachment of bone fragment of phalanx further surgery in the early period after injury should be considered.

Key words: damage to the extensor digitorum tendon, early and delayed treatment

Introduction

The most common damage to the tendon is closed tearing of the tendon band extensor in zone I. It is often associated with the dislocation of the bone from the dorsal portion of a distal phalanx. The abolition of activity sidebands and oblique extensor retinaculum leads to finger setting called "mallet, baseball or drop finger". No active

extension phalanx further and continuing pain leads to a reduction in efficiency of hand (Doyle, 1999; Wańczyk, Pieniążek, Pelczar-Pieniążek, 2008).

Traumatic injury of the extensor tendons most commonly happens by hitting a hard object with the finger while practicing recreational activities or sports, during a fall, and while performing normal activities in daily life or work. Extensor tendon damage in sport often appears during team handball games (Cheung, Fung, Ip, 2012; Doyle, 1999; Mc Murtry, Isaacs; 2015; Wańczyk et al., 2008). Usually the patients undergo conservative treatment.

Surgical treatment according to most authors should be initiated in patients with a delayed diagnosis of injury of the extensor tendons of the fingers or substantial damage to the tendon from the bone fragment detachment without the possibility of bringing together fragments or subluxation phalanx (Gurnani, Hogendoorn, Rhemrev, 2014; Smit, Beets, Zeebregts, Rood, Welters, 2010). The surgical treatment of extensor tendon damage consists of stapling finger tendons, restoring its attachment and determining further interphalangeal joint in light hyperextension. If no improvement is observed, DIP arthrodesis in functional position it is sometimes necessary (Smit et al., 2010). Delay in treatment of the recent injury should not exceed two weeks (Altan, Alps, Baser, Yalcin, 2014). Surgical treatment shortens the treatment time by means of the earlier DIP joint immobilization which leads to earlier restoration of hand efficiency (Wańczyk et al., 2008).

The correct rehabilitation can help in obtaining good results. Active resistance exercises or redressing tractions are also used. The Oppenheimer dynamic rail plays a significant role in enhancing the treatment. Patients should have an established program of exercise and remain under the control of the therapists (Wańczyk et al., 2008).

The aim of this study was to evaluate the results of early and delayed surgical treatment and rehabilitation of patients with damage in zone I of the extensor tendon in fingers II to V.

Material and methods

In the years from 2008 to 2011, 47 patients were treated surgically for closed damage in zone I extensor tendon injury II to V finger There were 17 (36.2%) and 30 men (63.8%) aged between 14 and 80 years. The treatment and examination were carried out in SP Hospital at the Nowogard by the authors. Patients were treated surgically in the early period of up to 2 weeks (group I) and the delayed period (group II) 2 weeks after the extensor digitorum tendon damage.

Patients with a delayed treatment for closed digitorum tendon damage or avulsion fracture of a small piece of bone, as well as all those with further damage or attachment of the tendon to the bone with abnormal bone splinter group setting were qualified for surgery. They were patients with I and IV degree damage on the scale shown by Doyle (Doyle, 1999; Orhun, Dursun, Orhun E., Gurkan, Altun, 2009; Wańczyk et al. 2008). The diagnoses were confirmed by X-ray.

Surgical treatment consisted of suturing the tendon band or restoring its attachment to the phalanx bone, as well as the arthrodesis of the distal interphalangeal (DIP) joint with Kirschner wire of a thickness of 1–1.2 mm in light extension. The wire was removed after 6 weeks.

Rehabilitation treatment was carried out in order to restore a full range of movement of the fingers. Sometimes the dynamic rail was used. Patients were given an exercise program to do at home and they were under the constant supervision of the medical team.

Randomized patients were examined before treatment and at 3 months after surgery. The presence of pain was assessed by a 10-point VAS (Visual Analog Scale). The finger range of movement was measured

using a goniometer and compared with the mobility of the appropriate finger of the healthy hand. The results of the treatment of extensor digitorum tendon damage were marked according to Crawford's skale (Doyle, 1999). The result was determined as follows: exellent – full extension, full flexion, no pain; good – 0–10 degrees extension loss, full flexion, no pain; fair – 10–25 degrees extension loss, insignificant flexion loss, no pain and poor – >25 degrees, small extension loss and persistent pain.

Evaluation of the results was made using Statistica's 10.0 Stat Soft. All tests were analyzed at a significance level of p = 0.05. Non-parametric statistics were used: chi-square test and the Mann-Whitney test.

Results

We studied 47 patients treated for extensor tendon traumatic injury of the fingers II–V in zone I. Most tendon affected males (63.8%), and in general people aged 31 to 50 years (Table 1).

Table 1. Number of patients treated for traumatic injury of the extensor tendons of the fingers divided according to sex and age

The age of patients	The number of patients treated with extensor tendon injury				Together	
	women		men			
	n	%	n	%	n	%
14–30	1	2.1	8	17.0	9	19.1
31–50	10	21.3	13	27.6	23	48.9
51–80	6	12.8	9	19.2	15	32.0
Together	17	36.2	30	63.8	47	100.0

Damage to the extensor digitorum tendons of the hands frequently concerned the right hand (68.1%) rather than the left hand (31.9%). The most common injury was a broken finger V (36.2%), followed by IV (31.9) and III (21.3). The majority (56%) of the cases of extensor tendon damage occurred during sport or recreational activities.

The number of ratings obtained after the treatment of the damaged extensor tendons of patients of group I and II were compared. In group I the percentage of patients with good results was higher and the other ones lower than in group II, the differences were not statistically significant (p = 0.41836), (Table 2, Figure 1).

Table 2. Results of the treatment of traumatic injuries to the extensor digitorum tendons in patients in group I and II according to the Crowford's scale

Results of treatment	The number of damaged extensor digitorum tendons hands patients in group I and II				Together	
	I		II			
	n	%	n	%	n	%
Excellent	16	84.2	18	64.3	34	72.3
Good	2	10.5	4	14.3	6	12.8
Fair	1	5.3	5	17.8	6	12.8
Poor	0	0.0	1	3.6	1	2.1
Together	19	100.0	28	100.0	47	100.0

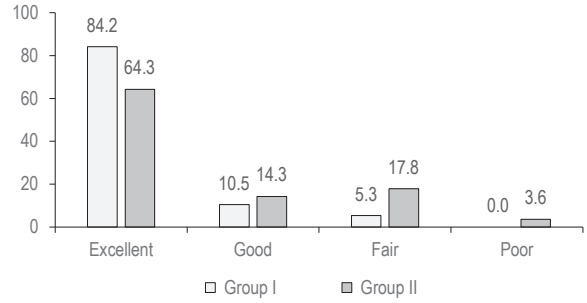

Figure 1. Results of treatment of traumatic injuries of the extensor digitorum tendons in patients in group I and II according to the Crawford's scale (%)

The comparison of the average scores of group I and II indicates a slightly higher average score in Group I than II (Table 3). It can be assumed that a longer period of observation may allow for a greater difference in the results.

Table 3. Comparison of the average values of the damaged extensor tendons of fingers in patients in group I and II

Grupa	n	x	SD	v	min	max	p
I	19	4.79	0.54	11.18	3	5	0.115865
II	28	4.39	0.92	20.86	2	5	

Discussion

Traumatic injuries of the extensor tendons are most common in physically active people aged between 31–50 years. These injuries often occur during sports or recreational activities. The damage usually occurs in the dominant hand and fingers V, IV and III (Doyle, 1999; Wańczyk et al., 2008).

Most of the closed damage in this region within the early period is treated conservatively. Respective rails, such as Zimmer, Stack or plaster casts are used for such immobilization. (Cheung et al., 2012; Doyle, 1999; Gurnani et al., 2014; Haagsma et al., 2014; Smit et al,. 2010; Wańczyk et al., 2008). Conservative treatment often fails due to a delay in diagnosis, incorrect immobilization or a lack of self-discipline in patient (Wańczyk et al., 2008). Furthermore, prolonged immobilization causes difficulties in maintaining proper hygiene, contributes to the formation of lesions in the form of pressure ulcers or necrosis at the site of the oppression rail. Treatment of neglected cases is difficult and requires a lot of experience (Doyle, 1999; Wańczyk et al., 2008).

Delays in conducting appropriate treatment on the damaged extensor tendon often results from the fact that either the patient or the treating team neglects this problem.

The early recognition of a significant degree of injury to the extensor tendon of the digitorum can be determined by the inability of an active extension of the distal phalanx. The loss of mobility of 10–20 degrees in an extensor distal phalanx indicates a partial failure and the total loss of a significant extension of the damaged tendon rupture DIP joint capsule or tendon detached from the bone attachment distal phalanx. Adherence to the recommended

indications regarding surgical treatment of the corresponding damaged finger and hand with early treatment of the injury rather than late is likely to achieve better results. In order to restore optimal finger mobility rehabilitation treatment needs to be carried out by the therapeutic team. Inappropriate treatment can lead to permanent disability (Mc Murtry, Isaacs, 2015).

Recently, several authors have reported the results of surgical treatment of injuries to the extensor tendon in 15 to 34 people, scored the results according to the Crawford's scale and obtained excellent results of 53.3–79.4%, good 11.8–40%, fair 6.6% to 9% and poor 3% (Jiang, Wang, Zhang, Zhao, Dang, 2015; Orhun et al., 2009; Wańczyk et al., 2008).

Many injuries were diagnosed and treated too late and not well enough. Treatment of neglected damage is difficult and will achieve worse results.

Altan et al. (2014) reported the results of conservative treatment assessed according to Crawford's scale in 28 patients treated in the period from 1 to 14 days after the injury, and have obtained 72% of excellent results and in 17 people treated in the period from 15 to 30 days obtained 59% excellent results. Early treatment rather than delayed led to better results.

Skillfully conducted rehabilitation treatment achieves positive results. Most authors state that a delayed or incorrectly diagnosed extensor tendon injury with extensive tendon damaged or with a large detached fragment of bone covering 30% of the articular surface qualify for surgery (Doyle, 1999; Makhleufow, Deek, 2011; Smit et al., .2010; Wańczyk et al., 2008). The most common surgical treatment is to suture the strand tendon, the attachment to the distal phalanx and immobilization of the DIP joint using Kirschner wire (Doyle, 1999; Jabłecki, Kaczmarczyk, Domanasiewicz, 2009; Smit et al., 2010; Wańczyk et al., 2008). Surgical treatment compared with conservative treatment reduces the time, increases the range of movement of the finger, and improves the efficiency of a subjective assessment of the hand (Altan et al., 2014; Wańczyk et al., 2008).

Conclusions

1. Traumatic injury of the extensor tendons of the digitorum in the hand frequently occur in people who are physically active while doing fitness training and sports, during work or at home.

2. Most of the injuries of the extensor tendon of the digitorum can be treated conservatively, delay in the implementation of surgical treatment can result in many complications.

3. Greater damage to the tendon and the bone attachment, without the possibility of improving the fraction settings and cases neglected are an indication for surgery in the early period after injury of the extensor tendon of the digitorum.

4. Extensor tendon injury of the fingers qualified for surgical treatment in the early period after injury may allow for faster implementation of rehabilitation treatment and achievement of better outcomes.

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THE DIVERSITY OF THE PLACE OF RESIDENCE OF STUDENTS AND THEIR LEVEL OF PHYSICAL ACTIVITY

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Abstract. The aim of the research was to study the diversity of the level of physical activity among the students according to their place of residence: a house (a detached house) or a flat (a residential block). The research was carried out in 2015 among 730 students (373 women and 357 men) of John Paul II State School of Higher Education in Biała Podlaska (PSW). The method used in the research was the International Physical Activity Questionnaire (IPAQ) in its long version. The results have shown that there were no significant differences in the overall level of physical activity of both men and women according to their place of residence.
However, significant differences have been noticed among female and male students as regards the physical activity connected to housework in favour of people living in houses. The same correlation was observed in favour of women living in flats (residential blocks).

Key words: physical activity, IPAQ, students, place of residence

Introduction

The research concerning physical activity of Polish students by means of the International Physical Activity Questionnaire (IPAQ) becomes more and more popular (Bergier, Kapka-Skrzypczak, Biliński, Paprzycki, Wojtyła, 2012; Biernat 2011; Mynarski, Rozpara, Czapla, Garbaciak, 2009). Collecting research data using the same tool (IPAQ) in many different countries is of a particular significance (Ainsworth et al. 2006; Bergier, Kapka-Skrzypczak, Biliński, Paprzycki, Wojtyła 2012; Crinière et al. 2009; Ekelund et al. 2006; Gomez, Duperly, Lucumí, Gamez, Venegas, 2005; Sebastiano et al. 2012; Soguksu 2011; Tsos, Bergier, Bergier 2014). The researches on physical activity of students that concern searching for the factors determining this activity such as eating habits (Bergier,

Kubińska, Bergier, 2011; Bergier, Bergier, Tsos., 2015; Pengpid, Peltzer, 2013; Szczodrowska, Krysiak, 2013), sex (Bergier, Stępień, Niźnikowska, Bergier, 2014; Frömel. Górna,2001; Mynarski, Rozpara, Czapla, Garbaciak, 2009; Suchomel, Sigmundova, Frömel, 2008; Sygit 2009) and local infrastructure (Bauman et al. 2012; Cerin, Vandelanotte, Leslie, Merom, 2008; McCormack, Shiell, 2011) are also of a particular value. The factor connected to the place of residence during studies, on the campus or a family house, is analyzed relatively rarely (Baar, Romppel, Igel, Brahler, Grande, 2014; Brevard, Ricketts, 1996; Peachey, Baller, 2015).

Research methodology

The aim of the research was to study the diversity of the level of physical activity among the students according to their place of residence: a house (a detached house) or a flat (a residential block).

It must be presupposed that living in a house creates more occasions for physical activity, for example as far as housework, gardening or taking care of family members are concerned. There is no doubt that the differentiation of the students' physical activity can occur in case of living on the university campus. Taking into consideration the fact that only 4,8% of the respondents live on the university campus, this place of residence was not taken into consideration in the analysis of research results.

Material and Methods

730 students of John Paul II State School of Higher Education in Biała Podlaska (PSW), representing 10 different areas of study, participated in the research carried out in 2015. The demographic characteristic including sex, place of residence and area of study is presented in Table 1. The method used in the research was the International Physical Activity Questionnaire (IPAQ) in its long version

Table 1. Demographic characteristics of respondents

Sex		
women	men	
373 (51.10%)	357 (48.90%)	
Place of residence		
house	flat	campus
447 (61.20%)	248 (34.00%)	35 (4.80%)
Area of study		
humanistic	medical	technical
261 (35.75%)	228 (31.23%)	241 (33.01%)

Results

Students' level of physical activity

The value of overall physical fitness of students was 6363.5 MET-min/week. In certain areas of activity the following values were noted: work/study – 2068.8 MET-min/week, sports – 1.621.6 MET-min/week, locomotion – 1402.2 MET-min/week, house and surroundings – 1270.9 MET-min/week (Figure 1).

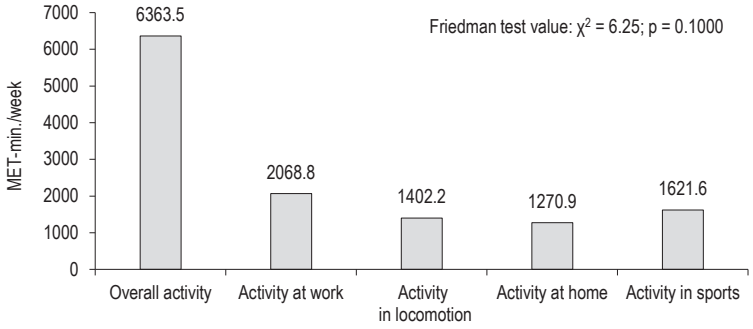


Figure 1. Areas of physical activity of students

Students' level of physical activity according to their place of residence

Taking into consideration the fact that only 4.8% of examined students lived on the campus, only the students living in flats and houses were included in the research. Students who live in houses are characterized by higher overall physical activity (6609.2 MET-min/week) than those who live in flats (5680.2 MET-min/week), however the difference is not statistically significant. Students who live in houses are characterized by significantly higher physical activity in the area of housework (Figure 2, Table 2). The data from the three levels of students' physical activity, high, moderate and low, did not show any statistically significant differences between the compared groups (Figure 3).

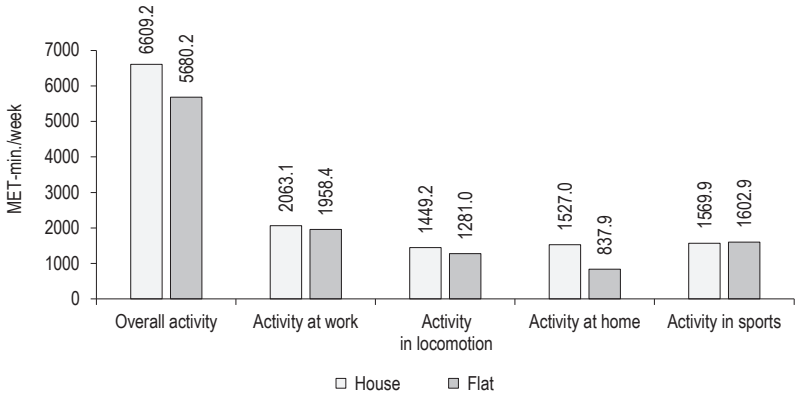


Figure 2. Areas of physical activity of students according to their place of residence

Table 2. Differentiation of the areas of student' physical activity according to their place of residence

area of activity	Mann-Whitney U test			
	rank-sum		Z	p
	house	flat		
Overall activity	82,395	159,466	–1.54	0.1232
Activity at work	84,952	156,908	–0.54	0.5913
Activity in locomotion	84,588	157,273	–0.68	0.4984
Activity at home	71,919	169,942	–5.67	0.0000*
Activity in sports	88,184	153,677	0.74	0.4575

* Significant differentiation at $p < 0.05$.

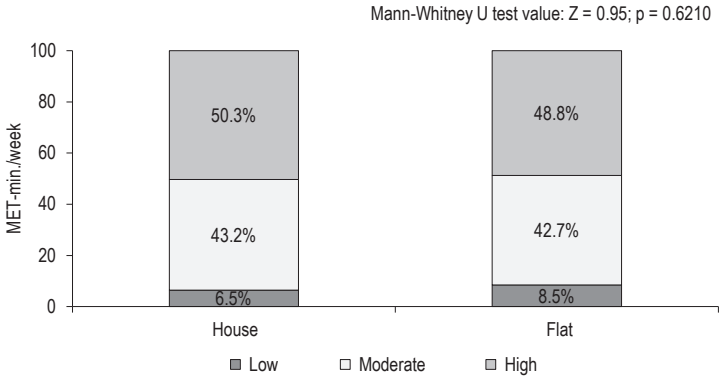


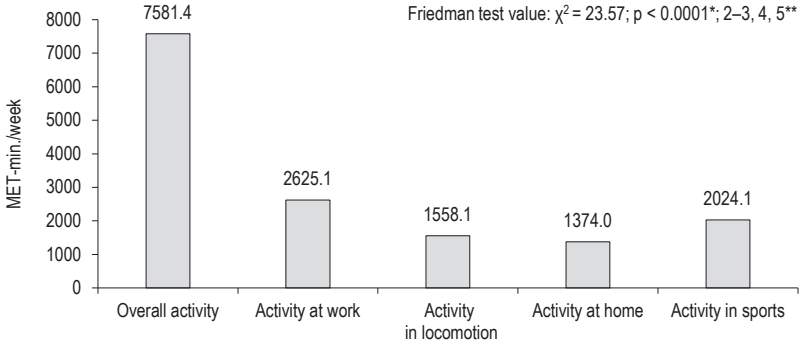
Figure 3. The level of students' physical activity according to their place of residence

The level of physical activity of male students

The studying men are characterized by high level of physical activity – 7581.4 MET-min/week with the highest values connected to the activity at work/study – 2625.1 MET-min/week and in sports – 2024.1 MET-min/week, and the lowest values concerning the activity in locomotion – 1558.1 MET-min/week and housework. Substantially the highest physical activity was observed in activity at work/study (Figure 4).

Students living in houses are characterized by higher overall physical activity – 8020.8 MET-min/week than their peers who live in flats – 6597.5 MET-min/week, however, the differences are not statistically significant.

The only statistically significant difference in favour of higher physical activity of men living in houses was observed in the area of housework (Figure 5, Table 3). The comparison of both analyzed groups according to their place of residence did not reveal any significance of differences in their physical activity levels (Figure 6).



* Significant differentiation at $p < 0.05$.

** Areas among which statistically significant differences occur $p < 0.05$.

Figure 4. Areas of physical activity of men

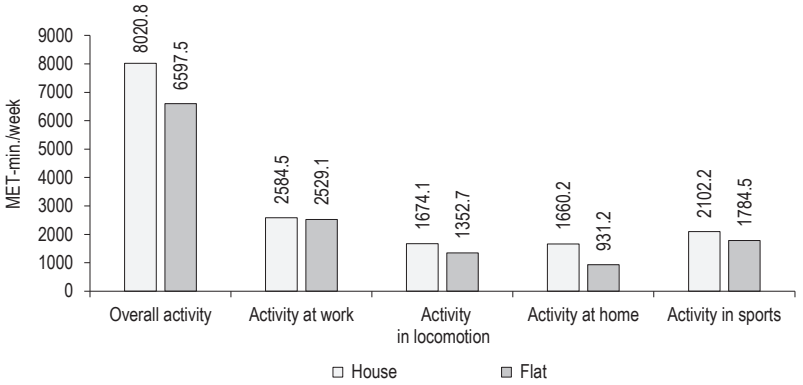


Figure 5. Areas of physical activity of male students according to their place of residence

Table 3. Differentiation of the areas of physical activity of male students according to their place of residence

area of activity	Mann-Whitney U test			
	rank-sum		Z	p
	house	flat		
Overall activity	20,273	37,697	–1.57	0.1155
Activity at work	21,631	36,340	–0.03	0.9794
Activity in locomotion	20,844	37,126	–0.92	0.3559
Activity at home	17,579	40,391	–4.65	0.0000*
Activity in sports	20,780	37,190	–1.00	0.3183

* Significant differentiation at $p < 0.05$.

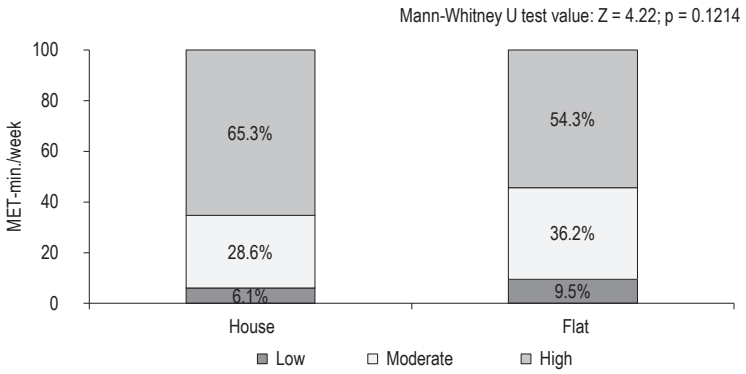


Figure 6. Level of physical activity of male students according to their place of residence

The level of physical activity of female students

The rate of overall physical activity of studying women was 5197.9 MET -min/week. However, no significance of differences between different areas of activity was revealed (Figure 7).

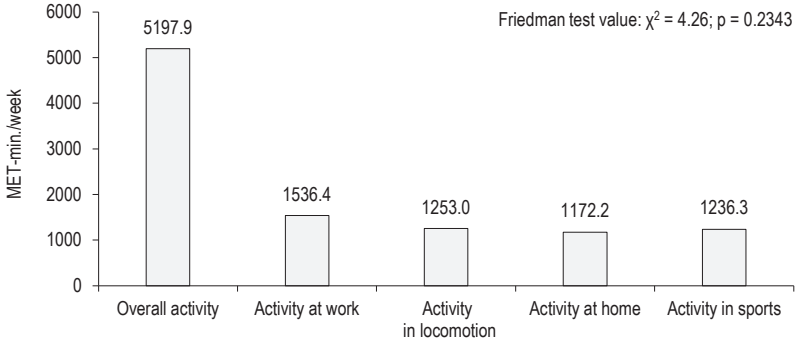


Figure 7. Areas of physical activity of female students

Women living in flats, as well as in houses, were characterized by similar overall physical activity, respectively 5324.2 MET-min/week and 4717.4 MET-min/week (no significant differences).

Statistically significant differences were observed in two areas, that is housework (in favour of women living in houses) and sports (in favour of women living in flats) (Figure 8, Table 4).

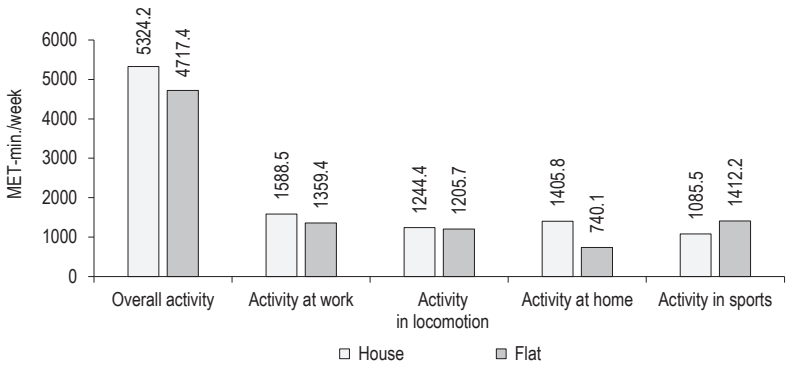


Figure 8. Areas of physical activity of female students according to their place of residence

Table 4. Differentiation of the areas of physical activity of female students according to their place of residence

Mann-Whitney U test				
area of activity	rank-sum		Z	p
	house	flat		
Overall activity	20,770	42,421	–0.84	0.4021
Activity at work	20,686	42,505	–0.94	0.3476
Activity in locomotion	21,405	41,786	–0.15	0.8846
Activity at home	18,522	44,668	–3.29	0.0010*
Activity in sports	23,377	39,813	2.01	0.0442*

* Significant differentiation at $p < 0.05$.

In three areas of physical activity no significant differences according to the place of residence were observed (Figure 9.)

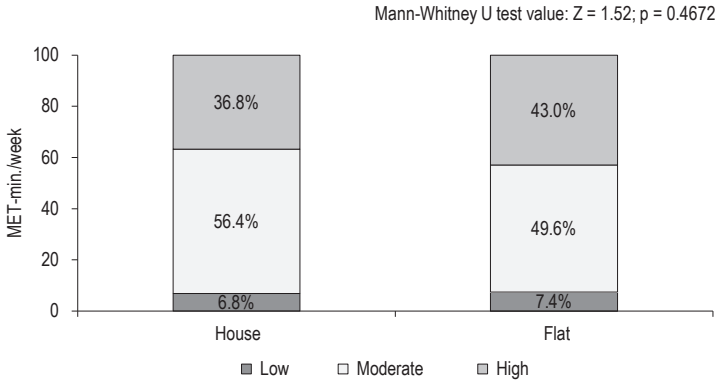


Figure 9. Level of physical activity of female students according to their place of residence

Discussion

The students who took part in the research are characterized by high level of overall physical activity compared to other researches (Bergier et al., 2012; Biernat, 2011; Mynarski et al., 2009; Tsos et al., 2014). The research did not reveal significant differences in the level of overall physical activity according to the place of residence in both male and female students. It may result from the fact the available offer of physical activities does not differ according to the place of residence. Such a relation of higher physical activity was revealed in case of students from the USA living on the campus (Peachey, Baller, 2015). Multidirectional analysis of the relation of the living environment with the physical activity among German students did not show any significant dependencies (Baar et al., 2014).

However, it should be noticed that the analysis carried out revealed important relations between the fact of living in a house and higher physical activity as far as housework is concerned, what is more, this characteristic was present in both, male and female students. Therefore, it can be concluded that housework by virtue of place of residence is an important factor determining physical activity of students.

Also significantly higher activity in the area of sports and recreation among female students living in flats is worth mentioning, as no similar relation was found in male students which can be the reason of less healthy attitudes among male students as far as participation in physical activity is concerned.

Conclusions

The comparative analysis of the place of residence of students and their physical activity helped to formulate the following conclusions:

1. Students, according to their place of residence, are characterized by the lack of significance of differences in the level of their overall physical activity. This difference occurred however in the area of activity associated with the housework in favor of the group living in their family houses.
2. In male students the dominant area of physical activity is work / study and it is significantly higher than other areas.
3. There were no significant differences in overall physical activity of men according to the place of residence. Such a difference has been shown in the area of activity concerning household duties in favor of subjects living in family houses.
4. Additionally, as far as female students are concerned, no significant differences in the level of their total physical activity according to the place of residence were observed. Such differences have occurred in two areas of physical activity. Significantly higher values in terms of household duties were observed in subjects living in houses, while subjects living in flats (residential blocks) were more active in the area of sports.

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DOPING IN SPORT: THE CASE OF FENCING

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Abstract. Most athletes in order to achieve satisfactory results have to train long and hard. However, some of them, aiming at victory at all costs, resort to doping. The benefits of winning are relatively small when compared to the damage of the human organism caused by doping. The phenomenon has been present in cycling, athletics, boxing, football, weightlifting and many other sport disciplines for many years. In fencing only few instances of the use of illegal substances during the competition were revealed, which was reflected in Polish and foreign sports press. In many European countries the use of doping is regulated by the anti-doping rules, regulations and policies that define these practices as penal acts. In Poland the problem of doping was first regulated by the Act on Physical Culture of 1984 and 1996 as well as the he Act of 1985 on Prevention of Drug Abuse. The regulations of FIE fencing competitions, prepared on the request of Polish Fencing Federation on the basis of the FIE competition rules in the disciplinary regulations of competitions prohibited the use of artificial stimulants during or before the competition. The aim of this paper is to present the threats in modern sports with particular attention to the phenomenon of doping in fencing, as well as in social terms. It is a case study and a study of selected issues connected to doping in contemporary sports. The author poses the question whether the fencers often are tempted to support their bodies with doping in order to achieve better results than the representatives of other sports? What percentage of the fencers were using illegal stimulants? Is there is a problem of doping in fencing, and if so, what is its scale?

Key words: sport, fencing, doping, law

Introduction

The study outlines the history of doping understood as undesirable, unethical, and illegal uses of performance-enhancing practices and drugs in professional and Olympic sports and in the Olympic movement, with particular consideration of fencing. The study is based on the most recent literature on the subject. The applied research methods include induction, deduction, comparative analysis, and analysis of literature.

The following research questions were posed: What are the current research achievements in the area of sport and, in particular, fencing? How big a problem is doping in fencing compared to other sports? What banned substances have been predominantly used by fencers? What are the training and competitive periods in which the use of illegal substances by athletes intensifies? What sort of substances (soft or hard drugs) have been detected in samples from fencers?, and What are the consequences of the use of performance-enhancing drugs?

The word *doping* was first used in the context of sport in 1889 as the name for illicit preparations of drugs and opiates designed to influence (purportedly) the performance of racehorses.[1] It has entered the general English use in 1935 (Yesalis, Bahrke, 2002).

The word *sport* originated in Vulgar Latin in the late Roman Empire. Its initial form was *disporto*, i.e. 'outside the gate' (*porta* – gate, *dis* – beyond). In the 18th century sport was defined as a total of all playful competitions. In Poland the term *sport* was used for the first time in a one-act play *Wyścigi konne w Warszawie* (Horse races in Warsaw) by Konstanty Gaszyński from 1856 (Lipoński, 2002, pp. 203–204).

Today, sport is understood as "all forms of physical activity, spontaneous or organized, aimed to develop or improve physical and mental fitness, positively affecting the development of social relations or attainment of performance results at all levels" (Badura, Basiński, Kałużny, Wojcieszak, 2011, p. 27).

In competitive sports, doping refers to the use of banned performance-enhancing drugs by athletes, and it is widely used by organizations that regulate sporting competitions. The use of drugs to enhance performance is considered unethical by most international sports organizations, including the International Olympic Committee. The Polish Law on Sport from June 25, 2010 (Art. 43) defines doping as "the presence of a prohibited substance or its metabolites or markers in a sample from a athlete in training or competition".[2] Doping can be categorized in terms of methods (pharmacological, physiological, gene doping, technology doping) and types (strength, endurance, stimulating) (Sahaj, 2008, pp. 85–91, 2002).

Research on doping in sport

Research on doping in sport, including fencing, became prolific at the turn of the 20th and 21st century. Articles on the use of doping in different sports can be found in journals on ethics, law, psychology, medicine, in the sporting press and popular science magazines. There have been, however, relatively few publications on the history of doping in sport. They are mainly German language studies tackling various legal and historical aspects, English language studies on hazards related to the abuse of stimulants.

In 1933 Dr Otto Rieser wrote an article entitled *Doping and doping substances*. He pointed to the proliferation of performance-enhancing drugs among athletes and blamed physicians for the spread of such practices (Yesalis, Bahrke, 2002). In 1935, the magazine "Zeitschrift Physiologische Chemie" published an article co-authored by K. David, E. Dingemanse, J. Freud, and E. Laqueur on the use of testosterone by athletes (1935, pp. 281–293). More publications on the topic appeared after World War II. Charles E. Yesalis and Michael S. Bahrke (2002) in their article *History of doping in sport* discussed the most significant cases of use of stimulants and anabolic steroids in the 19th and 20th centuries, and in particular, in the early 21st century by Olympic and professional athletes. A. Singler and G. Treutlein (2012) in their book *Doping im Spitzensport. Sportwissenschaftliche Analysen zur nationalen und internationalen Leistungsentwicklung* (Doping in competitive sport. Sports and scientific analyses of national and international developments) mentions that anabolic doping was used as early as in the first decade after the foundation of the Federal Republic of Germany. G. Spitzer (2013), in his work *Doping in East Germany. A historical outline of secret practices* demonstrated the harmful effects of using prohibited substances

[1] Most likely to reduce the performance capabilities of a rival horse, i.e. as anti-doping or para-doping.

[2] Cf. International Fencing Federation (FIE) Anti-Doping Rules 2015, based on and compliant with the 2015 revised World Anti-Doping Code, p. 6; see Klimczyk.

and discussed the role of the VEB Jenapharm company, the manufacturer of a anabolic steroid called turinabol. A monograph by G. Spitzer, E. Eggers, H.J. Schnell, and Y. Wisniewska (2013) *Zwyciężyć za wszelką cenę. Doping w Niemczech, historia, prawo, etyka 1972–1990* (To win at all costs. Doping in Germany: history, law, ethics, 1972–1990) reveals the inside story of doping in West Germany in the 1970s and the 1980s. M. Krüger, Ch. Becker, S. Nielsen, M. Reinold (2014) in their book *Doping in der DDR: Ein historischer Überblick zu einer konspirativen Praxis. Genese – Verantwortung – Gefahren* investigated the development, organizational structure and state policy on doping in East Germany. Before 1960 doping was not a subject of scientific research in West Germany. However, ten years later major doping scandals forced the German sports authorities to tackle the problem. T. Kistner (2015) in *The secret history of doping in football* described the consequences of using prohibited substances in football. He discussed cases of Italian soccer players in the 1970s and 1980s who died of doping-related causes a few years after completing their sports careers, Algerian Golden Team players and their children born with severe disabilities, and numerous doping scandals in German soccer.

In Poland, R. Dzierżanowski (1980) wrote a brief history of the use of doping substances from ancient times until today in sport and outside sport in *Doping* by Stanisław Kozłowski and Wojciech J. Rewerski (eds.). Similar issues were discussed by K. Sas-Nowosielski (2002) in *Doping nie tylko w sporcie* (Doping not only in sport). Another popular science article was published in the „Sport Wyczynowy" (Competitive Sport) magazine (1991, 7–8), titled *Próbka nr 0708104, czyli jak w NRD produkowano mistrzów* (Sample no. 0708104 or how the DDR manufactured sports champions). It was based on articles from the Stern magazine (1990, 49) authored by Teja Fidler and Martin Hägele and concerned state-endorsed doping practices in East Germany (Łuczak 1993, p. 10; *Próbka nr*..., 1991, p. 130).

Outline history of doping in sport

The use of stimulant drugs in sports can be traced back to ancient times. An old Chinese drawing from c. 3000 BCE shows an emperor chewing a sprig of ma huang (ephedra) containing ephedrine which is known to have stimulating effects. Homer mentioned the use of drugs in *The Iliad* and *The Odyssey* (Swaddling, 2004, p. 49). During the games in ancient Thebes in the 6th century BCE, it was prohibited for the participating athletes to consume wine before competition, and priests inspected the breath of all competitors entering the stadium (Rewerski, Nazar, 1995, pp. 17–18).

In 1904, the marathon race at the 1904 Olympics in Saint Louis, which was held in a 30-degree heat, was won by the American runner Thomas Hicks. As Hicks was flagging during the race his assistants gave him doping substances: strychnine, proteins and even brandy, for which he would have been disqualified today (Besala, 2006, p. 47).

One of pioneers of doping research was Alfons Bukowski – a Polish pharmacist from Warsaw who collaborated with the Warsaw Horseracing Society. He tested samples of horse saliva for the presence of alkaloids such as morphine, cocaine, and heroine. He detected doping in racehorses, and his discoveries were reported in an Austrian newspaper "Sportzeitung" in 1912 (278, 280). Soon after, Austrian physicians confirmed Bukowski's test results (Pokrywka, Gorczyca, Jarek, Kwiatkowski, 2013, pp. 68–72). The first official observations of doping use by athletes were made during the 1932 Olympic Games in Los Angeles. Vials with a concoction containing nitroglycerin were found in the quarters of Japanese swimmers, who won a number of Olympic medals (Lis, Olszański, 2000, p. 171).

During the 1952 Winter Olympics athletes were found to have used amphetamine, and at the Summer Olympic in the same year – testosterone. The 1952 Olympic weightlifting tournament was totally dominated by Soviet athletes who took testosterone before competition. It must be stressed that the Olympic successes of athletes from the so-called Eastern Block countries had an important political dimension, and that the communist state authorities wanted to demonstrate the dominance of their athletes over their counterparts from Western Europe (Pasko).

In Rome, in 1960, a Danish cyclist Knut Enemark Jensen died during a race held in searing heat due to overdosing and, most probably, dehydration. The plague of doping would affect almost all Olympic Games afterwards.

The first French and Belgian anti-doping legislation considering doping as a criminal act from 1965 did not change the situation, due to ineffective enforcement of the law. Only in the period 1960–1967, were more than thirty doping-related lethal cases recorded all over worldwide (Łuczak, 1993, p. 10).[3]

In the late 1960s the use of anabolic steroids became widespread, especially in East Germany. Athletes in the East German state training system were given performance-enhancing drugs (Lis, Olszański, 2000, p. 171), and then their performance was systematically monitored. The supervisor of the state-endorsed project was the Physical Culture Research Institute in Leipzig. A specially designed performance-enhancing drug called "Turibanol" was manufactured in Jena. It was used, for example, by Kristin Otto, a six-time Olympic medalist and seven-time world swimming champion as well as many other athletes (*Próbka nr...*, 1991, pp. 10–12).

W 1967 the Council of Europe adopted a resolution on anti-doping in sport, and the International Olympic Committee established its own Medical Commission charged with the conduct of the fight against drugs in sport (Smorawiński, Pokrywka, Rynkowski, 2011, pp. 72–83). One year later the first international conference on doping in sport was organized. Mandatory drug tests began to be conducted; however, they were initially inefficient. Different national sports associations also began developing their own anti-doping programs.

One of the most outrageous doping practices was abortion doping used in the 1970s and the 1980s. The practice consisted of inducing pregnancy in female athletes three months before competition. The physiological and hormonal changes in the athlete's body during pregnancy positively affected the athlete's aerobic capacity and muscle strength. The surplus of the red blood cells and a surge in hormone production was used to increase the athlete's performance. Right after a competition the athlete would have an abortion. Good sport results were attained in total disregard of human life (Łuczak, 1992, p. 10).

During the 1976 Olympics in Montreal and the 1988 Olympics in Seoul, in order to avoid detection of illegal substances in Soviet athletes, the USSR authorities provided a special hospital ship, where the athletes were tested for the presence of prohibited substances (Dzierżanowski, Wysoczański, 1995, pp. 35–36). Until 1989 prohibited substances had been detected in three Polish athletes. The first who tested positive was weightlifter Zbigniew Tadeusz Kaczmarek. In 1976, eleven doping cases were revealed (Pasko, pp. 3–4).[4] However, state-endorsed

[3] The German Criminal Code provides for penalties for the use of doping in § 263. However, the execution of this provision is generally put into question. In 1991 there were no legal anti-doping regulations in Germany, and the Independent Doping Commission questioned German national legislation against doping, arguing it would contradict the idea of sport autonomy. In Greece, for example, two legislative acts from July 12, 1975 and September 12, 1986, provide for criminal responsibility for the use of performance-enhancing substances (Szwarc, 1992, pp. 16, 113).

[4] 2 from Poland, 2 from Bulgaria, 1 from Romania, 1 from Czechoslovakia, 2 from the USA, and 1 from Sweden. All of them used anabolic steroids. At the 1976 Olympics in Montreal the discus thrower Danuta Zofia Rosani also tested positive for anabolic steroids.

doping was practiced on a much lower scale in the Polish People's Republic than in East Germany or the USSR (Pasko).

The Los Angeles Olympic Games in 1984 witnessed the use of blood doping (known already in 1947). After the Olympics seven US cyclists (including four Olympic medalists) admitted practicing this method, which had been officially prohibited by the IOC in 1981. The use of erythropoietin (EPO) as a performance-enhancing drug was pioneered in the USA (Chrostowski, 1991, pp. 47–48). Many 1984 Olympic medalists were patients of the notorious endocrinologist Robert Kerr from San Gabriel, California. Kerr prescribed steroids to athletes from twenty countries, including the late sprinter Florence Griffith Joyner, a multiple Olympic medalist from 1984 and 1988 (*Internet doping*, March 19, 2010).

In Seoul, the Olympic champion in the 100 m event, Ben Johnson was disqualified for using an anabolic steroid called stanazolol (improving muscle growth). Also seven Bulgarian weightlifters were suspended, including two Olympic champions (*Etyka i moralność*..., 1991, p. 10; Łuczak, 1993, p. 10).

At the 2006 Winter Olympic Games in Turin the local police and prosecutor's office acting on a tip about organized doping practices, made an overnight raid on the quarters of Austrian biathlonists. Austrian coach Walter Mayer, who had once been suspended for doping violations during the 2002 Winter Olympic Games, fled back to Austria, for which he would be disqualified in 2010. The police found syringes, blood transfusion equipment, and anti-asthma drugs (used illegally to prevent detection of anabolic steroids and EPO). Walter Mayer was interrogated, but no charges were filed.

In the 1990s, Chinese female swimmers trained by coaches from former East Germany who after the fall of the Berlin Wall had immigrated to China, were found to use human growth hormone (HGH) and a number of masking agents. Like their East German counterparts from the 1980s, they trounced their rivals to an extent that the 1996 Olympics were dubbed the Growth Hormone Games (Nosidlak, 2016).

The early 21st century witnessed a huge scandal in doping involving the cycling star Lance Armstrong, an idol to athletes and fans all over the world. Armstrong won the Tour de France seven times (1999–2005), was a UCI Road World Champion in 1993, and the bronze medalist at the Sydney Olympic Games of 2000. He was subsequently stripped of all his achievements after 1996. Armstrong used blood transfusion banned by the World Anti-Doping Agency (WADA) and other prohibited techniques, for instance, the use of erythropoietin (EPO) (Hamilton, Coyle, 2013, p. 37) – a hormone stimulating the renal function by increasing blood carrying capacity and red cell production, and thus muscle strength and endurance[5] – steroids,[6] cortizone, and growth hormone. He probably also used human chorionic gonadotropin (hCG)[7] (Walsh, 2013, pp. 146, 167, 224). Lance Armstrong collected data on his rivals, and analyzed their reports (Walsh, 2013, p. 152). Michele Ferrari consulted with Chris Carmichael (Armstrong's personal coach) dietary plans, hypoxic training, and the use of altitude tents, i.e. natural means of performance enhancement.

In response to widespread doping practices, in February 1999 the International Olympic Committee in Lausanne organized the World Conference on Doping in Sport attended by representatives of all countries and associations involved in the campaign against illegal doping. The conference adopted the Lausanne Declaration on

[5] EPO began to be used in the 1980s as a stimulating agent by patients with chronic kidney disease and cancer.

[6] Cyclists began to use doping (cocaine, ether, amphetamine) to reduce fatigue and stimulate brain function.

[7] Human chorionic gonadotropin (hCG) is considered a "pregnancy hormone" since its level is elevated during pregnancy.

Doping in Sport, which on February 10, 1999 led to the establishment of the World Anti-Doping Agency (WADA). Soon the World Anti-Doping Code and the Anti-Doping Convention of the Council of Europe were adopted. WADA officially began its activities in 2004, and in the same year it banned the use of gene doping.[8] In Poland, the first anti-doping lab was opened in the Institute of Sport in Warsaw in September 1987, and one year later the Anti-Doping Sport Commission was established to implement and develop the anti-doping program in Poland (Smorawiński et al., 2011, pp. 72–83). These actions were legally regulated by the Polish Physical Culture Act from July 3, 1984, the Physical Culture Act from January 1996, and the Prevention of Drug Abuse Act from January 31, 1985. The last legislation defined the legal responsibility for taking intoxicants and psychotropic drugs. Regulations of the International Fencing Federation (FIE) from 1962, 1966 and 1978 r. included disciplinary provisions banning the use of artificial stimulants in and out-of-competition.[9]

The list of prohibited doping drugs and methods [in:] *Załącznik do zarządzenia Prezesa Urzędu Kultury Fizycznej i Turystyki* (Appendix to the Directive of the President of the Physical Culture and Tourism Office from June 20, 1997 (line 432), p. 8, includes substances banned under specific circumstances or in specific sports: A. alcohol, B. marihuana, C. local anesthetics, D. corticosteroids, and E. beta blockers.

In Poland, between 1987 and 1991, 109 positive doping cases were detected in 5200 tested athletes, who included 17 track and field athletes, 55 weightlifters, 5 cyclists, 17 bodybuilders and powerlifters. The majority of drug tests were undertaken out-of-competition (Physical Culture Act, 1984, 1996; Directive of the President of the Physical Culture and Tourism Office from June 1997, approving the list of prohibited drugs and methods; Wysoczański, 1992, p. 83; Dzierżanowski, 1980, pp. 7–39).

Doping in fencing

Doping cases in fencing have been fairly sporadic (Physical Culture Acts 1984, 1996, Directive 1997). Some fencers were said to take small doses of strong alcohol before important final bouts. Occasionally, fencing coaches recommended to their fencers drinking strong coffee, tea, or beer before tournaments.

The Polish sporting press revealed a number of cases of doping in fencing. During the 1971 World Championships in Vienna all participating fencers underwent drug tests for amphetamine (Jeleń, 1971a, p. 2). The world vice-champion, Michael Maffei, tested positive, however, his case was not resolved. The infuriated editors of the Polish newspaper "Sport" submitted after the scandal a number of anti-doping proposals to the FIE (Jeleń, 1971b, pp. 1, 4).

In 2002 anti-doping rules were violated by Laura Flessel (France), a two-time Olympic champion from 1996, and world epee champion from 1998 and 1999 (Google). Flessel claimed that she had obtained the banned substance from the French team physician, who took responsibility for the violation, and Flassel was disqualified for three months in between competitions. Her suspension expired on December 18, 2002 (Shortnews, 2002). In 2003, Loic Atelly (France) was suspended for 10 months for using nandrolone (an anabolic steroid) and David Boudreault (Canada) for 3 months for taking cannabis (FIE, 2003, p. 4; World Anti-Doping Code, Art. 3). In the 2003/2004 season only one case of doping was detected in Caitlin Thompson (USA) who used l-methamphetamine. She received an

[8] Gene therapy is aimed at correcting or supplementing damaged genes responsible for development of diseases. It consists of therapeutic delivery of correct genes into the genetic structure of specific cells (Chrostwoski, 2005, p. 91).

[9] The Prevention of Drug Abuse Act from January 31, 1985 stipulates that doping practices can be penalized, if they are related to the use of "intoxicants", "psychotropic drugs" and "preparations" (Szwarc, 1992, p. 121).

official warning and was stripped of all points scored in the competitions in which she was tested positive (FIE, 2004, p. 6). In the 2004/2005 season hydrochlorothiazide (medication used to treat high blood pressure) was detected in samples from Jung Hwan Kim (South Korea). The FIE then suspended him for a year (FIE, 2005, p. 6).

On August 1, 2008, a 22-year-old top Italian foil fencer Andrea Baldini was tested positive for banned substances after a team tournament in Kiev won by Italy against Poland 45-30. According to FIE Anti-Doping Rules (1.11) "If a member of a team is found to have committed a violation of these Anti-Doping Rules during an event in which he fenced, the team shall be disqualified from the event with all of the resulting consequences including forfeiture of any medals, points and prizes and the other teams ranked after the team disqualified move up one place in the results of the competition". This disqualification meant that the tournament champion title went to the Polish team. As reported by the Polish newspaper "Rzeczpospolita": "The Italian Fencing Association commenced its investigation (…) Badini tested negative twice by the end of June. The use of doping after the Olympic qualifications would have been pointless. After the scandal, Baldini stated that he felt wronged by not qualifying for the Olympics. The investigation revealed that a third party was accountable for providing Baldini with the prohibited substance. It was considered a mitigating circumstance" (Sportowe Fakty WP, 2009). In 2008 he was a third athlete caught using performance-enhancing substances after Fracesco Ricco in the Tour de France, and UCI World Road Champion, Marta Bastianelli (mat-fencing.com, 2016).

In 2009 a 20-year-old Polish foil fencer Michał Majewski tested positive for cocaine after the World Cup in Espinho, Portugal. The FIE Disciplinary Tribunal in its ruling from May 24, 2009 disqualified Majewski for two years (Wikipedia; FIE).

Fifty violations of anti-doping rules were recorded in 2013. A comparison of data from Poland and other countries shows that this number is disturbingly high. Also athletes have been shown to reach for stimulants present in dietary supplements less often than for anabolic androgenic steroids, i.e. for "hard" doping. If they had realized the hazards of using these substances, they may have probably given them up (Smorawiński, 2013, p. 1).

A two-year ban (January 23, 2013 – January 22, 2015) was received by the Russian fencer Yann Pishchikov for using stanozolol and methylhexaneamine during a men's epee satellite tournament in Antalya, Turkey in November 2012. Nasr Alsaadi (Qatar) was also suspended for two years (May 8, 2014 – July 7, 2016), after testing positive for Clenbuterol during out-of-competition anti-doping control (FIE, 2014).

According to a WADA report, 305,888 samples were taken from athletes from all over the world in 2014, including 22,584 samples as part of the athlete biological passport testing program. Prohibited substances were detected in 3,153 cases. As far as particular sports were concerned, the highest number of positive samples were found in weightlifters (169 positive samples out of 8,806 – 1.9%), boxers (55 out of 4,258 – 1.3%), wrestlers (60 out of 5,15 – 1.2%), taekwondo practitioners (22 out of 2,034 – 1.1%), track and field athletes (261 out of 25,830 – 1%), cyclists (221 out of 22,471 – 1%), judoists (40 out of 4,453 – 0.9%), sport shooters (23 out of 2,616 – 0.9%), rugby players (57 out of 6,961 – 0.8%), basketball players – 37 out of 5,439 – 0.7%), soccer players (144 out of 31,242 – 0.5%), and fencers (4 out of 1,609 – 0.2%) (FIE, 2003).

According to fencing coaches, doping cases in fencing are sporadically detected every few years. It might be assumed that fencers performing intense exercises in the precompetitive training period may be occasionally tempted to use anabolic steroids, e.g. testosterone. They might also be tempted to use beta2-adrenergic agonists as they cause dilation of bronchial passages and improve pulmonary ventilation and exercise performance (endurance) (WADA, 2014).

The low number of detected cases of the use of banned substances in fencing may indicate that the problem of doping in fencing is negligible.

Conclusion

Stimulating substances have been known since ancient times. They became used on a greater scale in the 1970s and the 1980s. Doping is used in a variety of sports. Data from anti-doping studies show that performance-enhancing drugs are most often taken by strength athletes (weightlifters), combat athletes (boxers, wrestlers, taekwondo practitioners, judoists) and cyclists. In comparison, doping cases in fencing have been negligible. Fencers have predominantly used less harmful substances, although they also occasionally resorted to anabolic steroids. The scale of drug use in sport is curbed by anti-doping tests; however, the desire to win often outweighs the common sense.

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Zarządzenie Prezesa Urzędu Kultury Fizycznej i Turystyki z dnia 20 czerwca 1997 r. w sprawie zatwierdzenia listy zabronionych środków farmakologicznych i metod uznanych za dopingowe.

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A SUBJECTIVE ASSESSMENT OF ACCIDENT RISK IN DOWNHILL SKIING BY BEGINNER SKIERS AND SKI INSTRUCTORS

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Abstract. Nowadays downhill skiing is one of the most popular form of winter recreation. Although skiing fulfills a number of contemporary health and leisure needs, even skiing on very well-prepared terrain poses several dangers and risks. Objective safety would be the state of being protected or free from all danger. The subjective aspect relates to one's mental state and is based on their feeling of confidence of another person, organization, or situation. Subjective risk is connected with perception and is dependent not only on how one perceives a threat but also how can assess its possible outcomes. There are three factors composing the qualitative dimension of risk perception, being 'the fear of risk', 'an unknown risk', and 'the level of risk'. The first factor is associated with such features as worrying about potential consequences, anxiety, negativity, voluntariness, and the ability to manage risk. Data was collected by use of a diagnostic survey designed by the study's author (Risk Assessment Questionnaire). In total, 53 participants completed the survey (26 instructors, 27 beginners). Beginner skiers believed there to be a higher level of risk in skiing than ski instructors, especially among aspects that assessed their perception of risk that concerned themselves. Beginner skiers clearly assessed the risk of downhill skiing higher when it concerned their own welfare and declared higher levels of fear of being involved in an accident.

Key words: winter recreation, risk, skiing safety, accidents

Introduction

The obvious benefits of regular outdoor physical activity are improved physical and mental health. Moreover, it enhances one's sense of security by not only producing a general feeling of well-being and improved self-esteem but also through gaining confidence and familiarity with the outdoors (Ambroży, Ambroży, 2000; Gracz, Sankowski, 2001). Nonetheless, outdoor recreation does possess a number of risks, although involvement in all its forms is considered to be a form of conscious and positive risk-taking behavior, one connected with the desire for adventure, testing one's abilities, and taking advantage of the experiences active outdoor activities offer (Gracz, Sankowski, 2001).

One of the most popular outdoor recreational activities both in Poland and the world is skiing. Not only does this winter sport provide a number of clear health benefits but it can be practiced by any age group regardless of

social status. Rising participant numbers show that more and more people are interested in winter sports (Chojnacki, 2005).

The positives of skiing have been recognized since its early beginnings, with a famous Norwegian skier stating "Nothing else strengthens the muscles, provides greater flexibility, strengthens the will, nor clears the mind than skiing" (Nansen, 1891 in: Krasicki, 2001), words still as current as they were in his time. Besides being an attractive and active form of leisure, skiing's positive contribution to health and well-being also stem from its winter mountain setting (Krasicki, 2001). Recreational skiing helps to release stress and provides enjoyment stemming from the excitement of sliding on snow and the satisfaction one receives from overcoming the technical difficulties inherent in skiing. In addition, it has been linked with improving social contacts and with developing self-awareness and self-control (Gracz, 2013).

Although skiing fulfills a number of contemporary health and leisure needs, even slow skiing on very well-prepared terrain poses several dangers and risks, most in the form of experiencing an accident and, therefore, injury (Chojnacki, 2005). Naturally, the increasing popularity of skiing and the rising number of ski areas have seen a dramatic rise in the number of on-slope injuries. Interdisciplinary research has indicated various reasons for the increase in the number of accidents/injuries, with the literature paying increasingly more attention to the issue of regulating safety. The most commonly cited causes for this increasing trend include changes in skiing technique, the growth of carving, the rising popularity of snowboarding, self-taught mistakes, teaching errors, and failure to follow the Skier Responsibility Code (Chojnacki, 1994).

When considering issues surrounding the concepts of risk and safety in a given physical activity, it is important to define their meaning first as a subject of research and then understanding what assessment criteria are available. Safety is generally the objective condition of being free from any threat or danger, although it may be perceived subjectively by an individual or group. As a result, the concept of safety always needs to be reported in two aspects – the objective and subjective. Objective safety would be the state of being protected or free from all danger. The subjective aspect relates to one's mental state and is based on their feeling of confidence of another person, organization, or situation. It can be expressed by the concept of 'feeling safe', which is connected with one's awareness of the existence of a threat as well as one's knowledge about the specific threat and ways of avoiding it (Korzeniowski, 2008; Janosec, Korzeniowski, 2011).

Although safety is the idea that there is no danger and that the presence of danger creates an unsafe situation, even the presence of a real danger does not necessarily mean that loss, damage, or injury must take place. However, the idea of danger does hold a destructive value, as the recognition of danger can itself potentially cause an unwanted condition. The presence of danger is nonetheless dependent on the specific functions or capabilities of a given object or subject. Dangers that are not intrinsically dangerous must always relate to the given object or subject and on those grounds they can be determined as harmful or destructive. In this regard, every object or subject has certain weaknesses that can transform a potential danger into an injury.

This needs mention, as risk, in turn, is defined as the expectation of loss or danger that takes into account both the amount of damage that could occur but also the likelihood of it occurring (Gasparski, 2003; Makarowski, 2008). It is nonetheless a very ambiguous word and can be defined in different ways depending on which scientific approach, and its theoretical basis, is adopted. The lack of homogeneity in defining risk allows it to be studied in various contexts; it can be treated as danger, uncertainty, chance, the probability of a loss or gain, the weighted sum of some negative consequences, or a combination or all of the above factors (Makarowski, 2010). The general

understanding of risk is perceived as the possibility or probability that something will not succeed or an activity that can threaten something of value (Szymczak, 1981; Kurcz, Skarżyńska, 2000). Regardless of the different concepts of risk, the chance of loss, injury, or an unwanted situation is a common feature. Psychology treats the acknowledgment of risk are being based on previous experience, an individual must have had a previous situation where certain feelings were accompanied by the introduction of given stimuli. It is in this way they inform a person about the risk itself and what kind of complications may occur. Perceiving risk requires a single, coherent, and subjective image of oneself, or any other persons, and their relation to a danger. This image affects our preferences and choices in decision-making situations (Studenski, 2004).

In the literature, psychological work has three types of definitions for the concept of risk. Risk, understood as the uncertainty of one's own actions and their consequences in the presence of random/uncontrollable factors or cognitive limitations, has a person act in conditions unknown and obscure to them. Second, risk is associated with the consequences of a conscious decision that may feature potential loss or danger, made by cognitively balancing the positive and negative outcomes of one's own actions. The next definition defined risk as an action performed by a person that has an unknown, uncertain, and possibly problematic result that exposes one to danger, damage, or loss (Makarowski, 2010).

Every person, and therefore every skier, has two roles when it comes to a situation involving risk when skiing, where they may be the subject or object of risk. Regardless of this duality, the basis behind taking a risky decision involves consequences that are likely to end in loss or damage. The negative consequences of one's own or someone else's actions can be either direct or indirect (Ratajczak, 2004).

One of the primary risk classification systems assumes that there is both subjective and objective risk in a given situation. Subjective risk is connected with perception and is dependent not only on how one perceives a threat but also how can assess its possible outcomes. Objective risk involves the aspect of risk that can be statistically analyzed (Makarowski, 2010). In this way, the perception of risk may be assessed by numerous quantifiable factor including the probability of a loss, the size of the loss, the expected loss, the expected variance if a loss may occur or not, and linear relationship between the hoped for result and possible variance. In this case, risk is perceived as being higher when the type of loss or the probability of it occurring is higher. Expected loss, in turn, is the sum of all the expected negative outcomes weighted by the probability of them occurring. The above dimensions of risk help to illustrate the mathematical approach to calculating risk, which can help to determine which choice would be the most rational.

However, the use of such standardized dimensions of risk is rarely used by people, as risk is perceived by conditioned physiological and emotional processes (Zaleśkiewicz, 2005). Risk perception in this case is the result of cognitive, emotional, and personality-based determinants reflected in the model created by Rudiger Trimpop. It involves a relationship between individual factors and situational factors. Among the most significant situational factors is the type of activity being performed. Risk perception here includes the perceptions of one's emotional and physiological symptoms and a cognitive assessment of risk, with this last factor based on components such as one's education, skills, experience, and ability to draw conclusions based on the experiences of others (Zaleśkiewicz, 2005; Makarowski, 2010).

There is also brought to light three factors composing the qualitative dimension of risk perception, being 'the fear of risk', 'an unknown risk', and 'the level of risk'. The first factor is associated with such features as worrying about potential consequences, anxiety, negativity, voluntariness, and the ability to manage risk. This factor is most

strongly correlated with a direct assessment of an activity's riskiness. Second, 'an unknown risk' refers to concepts such as if the risk had ever been experienced before, what is known about it, and what consequences may emerge later in time. Its nature is grounded in the fact that a person may be aware that a risk exists but is unable to precisely define the risk in question due to confusion or a lack of information surrounding it. The last factor is related to the number of individuals likely to be exposed to a given danger. The more people that can concurrently experience the negative effects of a given risk, the higher the risk is assessed. The structure of these factors is considered to be universal, meaning that they affect risk assessment regardless of who assesses the risk or the type of activity being evaluated (Slovic in: Sokołowska, 2000).

In light of the above, the aim of this study was to research subjective risk in downhill skiing and to search for differences in the level of risk assessment by beginners and expert-level skiers. With this in mind, the following research questions were formulated:

1. How is risk assessed by beginner and expert skiers?
2. Does experience and skill level determine risk assessment in downhill skiing?

Methods

Data was collected by use of a diagnostic survey designed by the study's author. Titled the Risk Assessment Questionnaire, it evaluates how the risk of accident is assessed in recreational skiing. The questionnaire consists of 17 items (15 closed- and 2 open-ended) which assess the qualitative dimension of risk assessment, with respondents specifying what they feel to be the level of risk in skiing, the voluntariness of risk, the ability to manage risk, the level of fear of being involved in an accident, what may be the injury-related consequences of an accident, and what they felt to be the percentage of people at risk of an accident when skiing. The close-ended items of the questionnaire were rated using various scales, whereas the open-ended portions asked about the years and number of days per season involved in skiing and if the participant had ever been involved/witnessed an accident. Three closed-ended questions assessed the level of risk or the level of fear in skiing using an ordered scale from 1 to 7, with 1 being the lowest and 7 the highest level of risk/fear. Items measuring the voluntariness of risk and management of risk when skiing used a 7-point Likert scale, with respondents specifying their level of agreement from 'definitely yes' to 'definitely no'. The part of the questionnaire that assessed what the potential consequences of an accident could be was evaluated using the International Commission for Alpine Rescue's Injury Scale (IKAR-CISA). Respondents had to estimate the probability of various injuries occurring as a result of a skiing accident, ranking its probability between 3.5 and 35, with 3.5 indicating the least risk whereas 35 the highest amount of risk.

In total, 53 participants completed the survey. The sample was selected by opportunity sampling of individuals based on their skiing experience, targeting expert or beginner skiers. The first group consisted entirely of qualified ski instructors (n = 26, 13 males and 13 females, mean age 25 years) of which 20 were certified Polish Ski Association (PSA) instructors, five were PSA assistant instructors, and one was a recreation instructor with a specialization in downhill skiing. The second group (n = 27, 4 males and 23 females, mean age 21 years) was composed of university students majoring in Tourism and Recreation taking skiing lessons as part of their coursework. The skiing experience of the groups showed that the instructors had been practicing skiing for more than 10 years, spending an average 45 days per season on the slope. In the beginners group, 24 respondents had been skiing for less than

1 year, two had been involved in the sport from 4 to 6 years, and one for more than 10 years. The average number of days spent on the slope was 6 for this group.

Results

The basic characteristics of the respondents are presented in Table 1.

Table 1. Characteristic of the respondents

		Ski instructors	Beginner skiers
Sex	women	13	23
	men	13	4
Avarage age		25	21
Education	university	11	3
	secondary	15	24

The beginners group achieved higher mean scores than the instructors for the items assessing the level of accident risk for the average skier and for themselves, the fear of being involved in an accident, and the ability to manage risk when skiing (Figure 1), although statistically significant differences were found only for fear of being involved in an accident ($p = 0.006$) and the level of risk only in regards to their own welfare ($p = 0.013$). Here, the potential risk of an accident directly involving the respondent was assessed as 1 by 11.5%, 2 by 23.1%, and 3 by 19.2% of the instructors (Figure 2). Among the beginners, the majority evaluated the risk of an accident occurring as 4 by 37%, 5 by 29.6%, and then 3 by 22.3%.

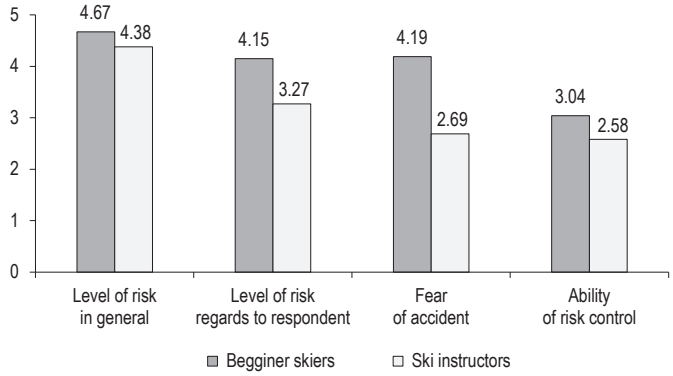

Figure 1. The dimensions of risk perception

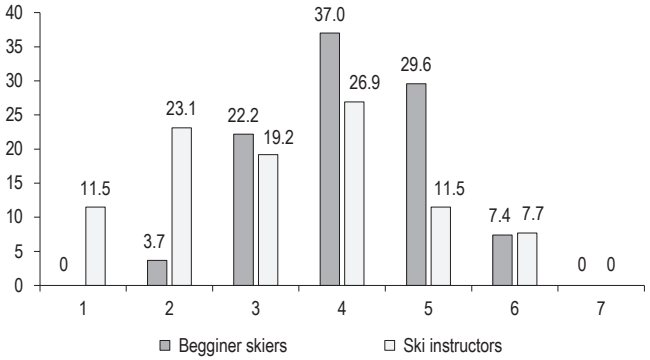

Figure 2. The percentage distribution of the assessment of risk of accident in regards to the respondents

The percentage distribution of the responses to fear of an accident directly involving them is presented in Figure 3, where the largest percentage of expert skiers (42.3%) indicated a response of 2. Among the beginners, this was assessed as 4 by 25.9% of the group.

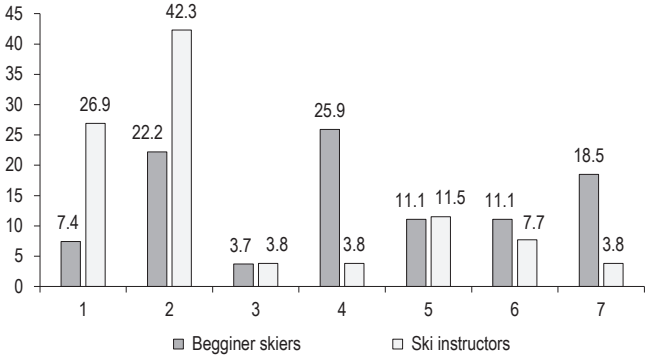

Figure 3. The percentage distribution of the responses regarding fear of accident

The ability to gauge what consequences may arise after a skiing accident (probability of a specific injury) was evaluated by the respondents in reference to the average skier and themselves, i.e. what injuries they felt they were likely to suffer. The beginner group assessed the risk of injury higher than the expert skiers, with the largest difference between the two groups in assessing those injuries that may affect the average skier, with beginners obtaining a mean score of 10.41 and experts 7.72. When assessing the risk of personal injury, beginners scored 8.20 and the instructors 7.77 (Figure 4).

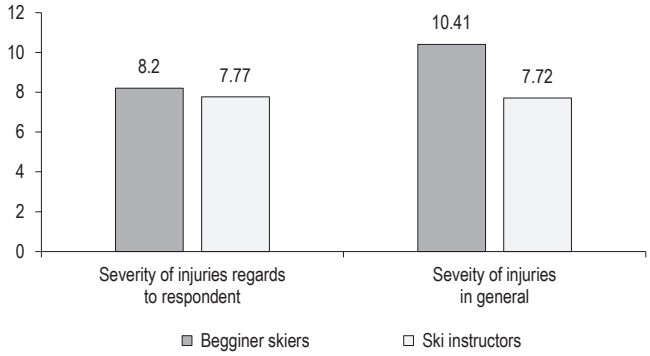

Figure 4. Severity of injuries assessed by respondents

The overall score of assessing risk for beginners was 9.53 and 7.36 for experts, with the difference between the two at the limit of statistical significance ($p = 0.05$).

The responses on the participants' involvement in a skiing accident was then compared with their estimate of the number of people involved in an accident when skiing. Here, 73.1% of the expert skiers had witnessed an accident and 50% had been involved in one. Among the beginners, 77.8% reported they had witnessed an accident, but only 25.9% had been involved in one. However, beginner skiers assessed the percentage of average skiers who had been in an accident to be 34.3%, while the expert group assessed this to be 24% of all skiers (Table 2).

Table 2. The percentage of skiers involved in accidents estimated by respondents and experiences of them

	Ski instructors	Beginner skiers
The percentage of skiers involved in accident estimated by respondents	24.0	34.3
The percentage of accidents' witnesses	73.1	77.8
The percentage of respondents involved in accidents	50.0	25.9

Discussion

Risk is present in every physical activity, subject to a wide gamut of factors. However, the complexity of assessing risk makes it a very difficult concept to define. Nonetheless, further understanding of the perception and internal mechanisms of risk is particularly important due to the growing popularity of recreational sports, as many participants do not only lack general knowledge about the sport they are practicing, but have little methodological-technical understanding or interaction with professional advice and coaching (Gracz, Sankowski, 2001; Merski, Warecka, 2001).

Research on people's personal experience and observations and the assessments they make on the likelihood of risks found that both the experiences that affect us directly and the observations we make of a situation that poses a risk to other individuals all have an impact on our cognitive schemas. This in particular involves the schema associated with anticipating a future threat that may endanger our safety. In this way does experience with

threats influences our assessment of risk. In contrast, whether a person will protect themselves against a threat is determined by whether they perceive the threat as one that can endanger them personally. However, experience based on previous encounters or observations of risky situations increases the likelihood of determining a future threat, which can be considered to be a form of preventive action.

A similar effect on risk assessment was found in the case of personal contact or observation of a dangerous situation involving other individuals (Gasparski, 2004). Such a correlation was observed when comparing the subjective assessment of risk by recreational downhill and cross-country skiers. In this study, the cross-country skiers had been involved in more accidents and, at the same time, estimated that a higher percentage of people suffer from an accident while skiing in open mountainous country (Pawelec, 2014). However, the results of the present study do not allow for the conclusion that personal experience with an accident is associated with a higher level of subjectively assessed risk. In the group of expert skiers, of whom half had been involved in an accident, the estimated percentage of skiers involved in an accident was lower than that reported by the beginner group, whom had less individuals involved in an accident (Table 2).

Conclusions

Beginner skiers believed there to be a higher level of risk in skiing than ski instructors, especially among aspects that assessed their perception of risk that concerned themselves. Previous experience was found to affect the subjective perception of risk only in some of the analyzed dimensions. Beginner skiers clearly assessed the risk of downhill skiing higher when it concerned their own welfare and declared higher levels of fear of being involved in an accident.

Bearing in mind that skiers themselves and their behavior are largely responsible for their own personal safety when skiing, further research should aim to clarify the relationship between objective risk and the subjective aspects surrounding risk assessment. A feature undoubtedly of importance would be the dependencies between individuals involved in various recreational activities and their propensity to engage in risky behavior. This would involve analyzing the determinants of their assessment of risk including factors such as previous experience, age, or knowledge of a particular risk.

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