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Contents

DOMS MANAGEMENT – THE STATE OF ART

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Abstract Delayed Onset Muscle Soreness (DOMS), is a phenomenon that has long been associated with an increased physical exertion. This is typically experienced by all individuals regardless of their fitness level, and it's a physiological response to greater efforts or to unusual physical activities. Loss of strength, pain, muscle weakness, stiffness and swelling are symptoms often associated with DOMS and there are many theories that try to explain these different pathways. Furthermore, more and more DOMS management methods are widespread among athletes and trainers, like stretching, supplements, NSAIDs, special training programs and cryotherapy. However, mechanisms underlying DOMS and their limitation and management are still not well understood; there are conflicting results for some of the therapy considered in this review, as well as encouraging results for some supplements or special foods, though literature concerning DOMS management is still emerging.

Key words DOMS, DOMS management

Introduction

It is commonly accepted that the delayed onset muscle soreness (DOMS) occurs with repeated exposure to eccentric muscle contractions or an unaccustomed exercise (Jooyoung, Joohyung, 2014; Suzuki et al., 1999); generally, it continues to increase after exercise with peaks between 24 and 48 hours after exercise. Although the exact etiology of DOMS remains unclear, several studies have suggested that it is triggered by a variety of biochemical changes and inflammatory responses after muscle damage, rather than from a single harmful event (Connolly, Sayers, McHugh, 2003; Kanda et al., 2013). DOMS is the main cause of reduction of physical performance including muscle strength and range of motion both for athletes and non-athletes, and often this also brings a psychological distress.

For many years the DOMS phenomenon has been erroneously attributed to the accumulation of lactate in muscles after an intense workout, bringing this baseless theory to be widely spread among athletes and amateurs. However, this hypothesis has been demonstrated inconsistent. The pain that comes from an intense eccentric

exercise and its perception, are not at all related to lactate accumulation (Gleeson, Blannin, Walsh, Field, Pritchard, 1998).

Indeed, blood and muscle lactate levels rise significantly during intense eccentric exercise and concentric anaerobic, but return to normal levels within shorter range of time than DOMS, that increase in the first 24 hours following the exercise and peak between 24 and 48 hours, when blood lactate levels are already largely returned to normal (Szymanski, 2001; Menzies et al., 2010).

Theory of Doms

Although several factors have been suggested as possible causes of DOMS, nowadays there is not yet any clear explanation. Causes of DOMS are currently unknown, and are generally described as a consequence of mechanical and metabolic stress induced by physical activity (Kanda et al., 2013; Pyne, 1994); muscle soreness is often associated with muscle microtrauma, but it seems a quite vague definition. Although it seems likely that intense exercise can cause microtrauma, evidence does not strongly support this idea, and some studies seem to contradict (Malm et al., 2004, Yu, Carlsson, Thornell, 2004).

In the past, some researchers have suggested that DOMS-related factors presumably resulted in large part from tearing of connective tissue of muscle and its tendon insertion. They noted that the urinary excretion of hydroxyproline amino acid, a specific product of the connective tissue catabolism, was higher in subjects who had felt muscle soreness than those who had not. Because a significant increase in urinary hydroxyproline levels indicates both an increased degradation of collagen synthesis, they concluded that an intense workout damages the connective tissue, which increases the degradation of collagen, creating an imbalance in its metabolism (Abraham, 1977). Other researchers have supported this theory, claiming that occurs breakage in non-contractile elements of sarcomeres (such as the sarcoplasmic reticulum) and connective tissue that surrounds muscle proteins (sarcolemma) as a result of an irreversible deformation during an eccentric contraction, which destroys components of the sarcomere and can lead to an apoptotic response (McHugh, Connolly, Eston, Gleim, 1999; Park, Lee, 2015).

On the basis of an extensive review, Armstrong in 1984 proposed his own theory on DOMS development, according to which the sarcolemma's structural damage resulted from the exercise, alters the permeability of cell membranes, allowing an influx of calcium into the interstitial site. High levels of calcium into the cell, activate a calcium-dependent proteolytic enzyme that degrades Z lines, troponin, and tropomyosin. This gradual destruction of sarcolemma in post-workout allows intracellular components to diffuse into the interstitial space and plasma, attracting lymphocytes in the damaged area, causing accumulation of substances such as histamine, quinine and potassium, which could stimulate nociceptors (Armstrong, 1984).

In 1991, Smith suggested that the acute inflammation in response to muscle and connective tissue damage caused by eccentric exercise is the main mechanism involved in DOMS development, since many symptoms of acute inflammation such as pain, swelling, and loss of functionality, occur concurrently with DOMS (Smith, 1991); however, recently Mizumura and collegues have found that muscle fiber damage is not essential, although it is sufficient, for induction of DOMS, instead, nerve growth factor (NGF) and glial cell line-derived neurotrophic factor (GDNF) produced by muscle fibers/satellite cells play crucial roles in DOMS. They observed in rats that two pathways are involved in inducing mechanical hyperalgesia after eccentric contraction: activation of the B2 bradykinin receptor-NGF pathway and activation of the COX-2-GDNF pathway (Mizumura, Taguchi, 2015).

Another less popular theory is the "metabolic stress", which argues that muscle cells produce some substances during their intensive activities, to which have not had a chance to adapt. However, this concept is still difficult to define. Researchers have identified several molecules produced by the cells during exercise, but do not have the certainty of the molecules-metabolic stress link. No study has been able to find a link between DOMS and any biological marker (Malm et al., 2004).

Studies have also focused on the production of free radicals: these highly reactive molecules are an inevitable by-product of cellular metabolism. There are increasing evidences that detect the involvement of reactive oxygen species (ROS), that is a form of free radicals, with the DOMS beginning. However, there is no correlation between the peak of free radicals concentration and the peak of DOMS. On the contrary, the increase in free radicals occurred after the peak and decline of muscle activity and DOMS (Close, Ashton, Cable, Doran, MacLaren, 2003). In other words, they may be involved but the relationship is indirect and unclear.

More recently, a new theory on DOMS has emerged; this phenomenon would be associated with the mechanism of "coupling excitation/contraction" of the myosin bridges attached to actin (Proske, Allen, 2005).

Lamb (2009) explains that the release of calcium ions (from the sarcoplasmic reticulum), which initiates the "power stroke movement" (that is, the actin sliding on myosin), can be stretched more significantly with eccentric contractions than concentric. According to the researcher, this mechanism of "coupling excitation/contraction", followed by the substantial release of calcium ions, causes a rupture of the sensors regulators in sarcomeres (concerning the neural input into the muscle), which also contributes to the DOMS formation after eccentric exercise.

Moreover, recent evidence shows that the DOMS phenomenon can actually spread, likely through a neurological mechanism to adjacent muscle groups even if they are not trained, and this creates an additional question on the causes and mechanisms involved in this reaction (Ayles, Graven-Nielsen, Gibson, 2011).

Types of Contraction

It is well documented that the eccentric contraction produces more muscle damage and deficits than concentric or isometric contractions, like running downhill, plyometric exercises and the traditional resistance training (McHugh et al., 1999).

The harm itself is the result of eccentric exercise, which causes muscle cell damage, and triggers an inflammatory response. This damage is noticeable with the breaking of the alignment bands or with the complete interruption of the sarcomere's Z lines. This damage causes the release of enzymes including creatine kinase (CK), constantly on the increase within 1–3 days of eccentric exercise, contributing to the strength deficit, typical of DOMS (Connolly et al., 2003).

It was observed in the eccentric muscle contraction, from 24/48 up to 72 h, swelling due to the production of prostaglandin E2. The prostaglandin E2 also sensitizes the afferent fibers of type IV muscle, responsible of the dull pain transmission to the central nervous system (Sellwood, Brukner, Williams, Nicol, Hinman, 2007).

Symptoms and Training

Typical symptoms often associated with DOMS include loss of strength, pain, muscle weakness, stiffness and swelling. It feels a loss of power that typically reaches a peak in the first 48 hours following exercise, and full recovery can extend up to 5 days. The pain peaks within 1–3 days after exercise and generally regresses within

a maximum of 7 days. Stiffness and swelling may rise after 3–4 days of exercise and usually resolve within 10 days. It is important to note that these symptoms are not dependent on each other, and do not always occur together (Connolly et al., 2003; Szymanski, 2001). Although the onset of DOMS was in the past associated with muscle swelling (temporary hypertrophy) (Balnave, Thompson, 1985), more recent research has belied this connection (Yu et al., 2013).

Since DOMS is a symptom that indicates the tearing of muscle fibers as a result of an eccentric muscle work, some coaches might advise against exercise until the pain is completely gone; this is because under the assumption that a new eccentric training during DOMS would exacerbate muscle damage and have a negative impact on recovery and supercompensation. Actually some studies have disproved these theories, confirming instead that training with the DOMS is possible without worsening muscle damage (Nosaka, Newton, Sacco, 2002). Even more so the intensity of the perception of DOMS is not proportional to muscle damage (Nosaka et al., 2002). Indeed, one study found that nearly one third of subjects undergoing maximum eccentric contractions did not report a significant muscle soreness (Sayers, Clarkson, 2001).

Because DOMS may be erroneously interpreted as a signal recovery need, it could be assumed even a strength decrease on the affected muscle as long as it is perceived. Actually it has been shown that DOMS affects expression of muscle strength for up to 24 hours after exercise, even by altering the activity of the antagonist muscle through the reduction of motor units discharge rate.

This response could be attributed to a self-protection mechanism to prevent further injuries, because DOMS has also been shown to alter the walking and running biomechanics (Paschalis et al., 2006). These directions may be correct only if it could stimulate the same muscles the next day, a strategy not practiced because of recovery need of at least 48 hours. Respecting however a muscle rest day stressed, DOMS does not increase perceived exertion (Haddad et al., 2013).

Doms Treatment

DOMS prevention and treatment are remarkably interesting for coaches, instructors and therapists because of pain and discomfort, which may affect physical training and performance.

Even if a significant amount of research on the DOMS treatment has been initiated, so far few people have shown a predominant treatment that can prevent or treat it.

Stretching

For several years in the past, static stretching was recommended as a way to warm up muscle groups at the beginning of a resistance training since it was believed that this kind of stretching could prevent the delayed onset muscle soreness.

However, some scientific evidence has univocally denied the effectiveness of this practice to prevent it (Pope, Herbert, Kirwan, Graham, 2000; McGrath, Whitehead, Caine, 2014). Contrary to other methods, which can be relatively useful to contain DOMS development, it has been shown that stretching has no beneficial effect to stop this physiological reaction, either before, during or after the physical training (Herbert, de Noronha, 2007; Herbert, Gabriel, 2002).

Supplements intake

Supplements have emerged as one of the methods for DOMS treatment; supporting endogenous defense systems with additional oral doses of antioxidants has received much attention as a non-invasive strategy to prevent or reduce oxidative stress, reduce muscle damage and improve athletic performance. For DOMS treatment coenzyme Q and L-carnitine were examined, however no supplement has been shown to be able to effectively treat this reaction, showing the possibility to cause adverse effects (Connolly et al., 2003).

Some studies have shown negative effects of antioxidant supplementation on health and exercise performance. Indeed, although ROS are associated with harmful biological events, they are essential for cell development and function (Ristow, Schmeisser, 2011; Peternelj Coombes, 2011). There are also some evidence that confirm DOMS attenuation following the use of some antioxidants such as epigallocatechin gallate (in green tea) and N-acetyl-cysteine (Kerksick, Kreider, Willoughby, 2010).

Jackman, Witard, Jeukendrup, Tipton (2010) have reported a reduction in DOMS after branched-chain amino acids (BCAA) intake: it was found that BCAA intake in strategic phases throughout the day reduces DOMS caused by the eccentric high intensity. It was also found a decrease of muscle soreness by 64% up to 72 hours following the exercise intaking BCAAs compared to placebo.

Another research studied the intake of 5g of BCAAs taken before a high volume squat session, finding that DOMS levels were significantly reduced and power had been maintained at 48 hours after exercise compared to an isocaloric placebo (Shimomura et al., 2006). The same researchers confirmed the BCAA benefits on DOMS, testing an exercise consisting of squats (7 sets of 20 repetitions with 3 minutes rest): a placebo or 100 mg/kg of BCAAs (about 9 g for a person of 90 kg) was administered to subjects. The group that had taken BCAAs had felt a DOMS reduction at 48 and 72 hours post-exercise (Shimomura et al., 2010).

More recent evidence has shown that also taurine, citrulline malate, N-acetyl-cysteine and glutamine intake have positive effects to reduce DOMS (Ra et al., 2010; Pérez-Guisado, Jakeman, 2010; Rahmani, Farzaneh, Damirchi, Shamsi Majlan, 2013; Kerksick et al., 2010).

Dietary intake

Some studies have shown that consumption of milk or protein/carbohydrate-based supplements with milk immediately following the exercise is able to limit DOMS perception from 24 to 48 hours later (Cockburn, Robson-Ansley, Hayes, Stevenson, 2012).

Another recent study showed that chocolate milk is capable of bringing to reduce DOMS more than an isocaloric drink based on carbohydrates (Gilson et al., 2010), as well as watermelon juice consumption, probably thanks to the citrulline naturally contained in it (Tarazona-Díaz, Alacid, Carrasco, Martínez, Aguayo, 2013).

Recently, also curcumin showed similar properties, reducing inflammatory cytokines and increasing muscle regeneration in mice (Nicol, Rowlands, Fazakerly, Kellett, 2015).

Furthermore it has been noted by many studies that caffeine can lead to DOMS reduction. Taking caffeine within 24–48 hours after an eccentric activity (approximately two cups of coffee) can produce a significant reduction in pain up to 48% (Maridakis, O'Connor, Dudley, G. McCully, 2007). Hurley, Hatfield, Riebe (2013) have shown that consuming 5 mg/kg of caffeine (about three cups of coffee) one hour before resistance training could possibly reduce DOMS.

NSAIDs

Nonsteroidal anti-inflammatory drugs (NSAIDs) have a strong effect to counteract inflammation and swelling that occur with muscle damage. Despite this theory, researches on the effectiveness of NSAIDs have produced conflicting results. Because of the inconsistencies of various studies between types, doses, and hiring of several NSAIDs, as well as the negative effects associated including gastrointestinal pain and hypertension, NSAIDs do not seem to be an optimal choice for DOMS treatment (Connolly et al., 2003).

Rather, it has been found that these drugs can compromise the hypertrophic response (Markworth, Vella, Figueiredo, Cameron-Smith, 2014; Schoenfeld, 2012), with the inhibition of the pathway by which nitric oxide (ON) and hepatocyte growth factor (HGF) activate satellite cells in the early stages of recovery process, that seems to be partially regulated by the enzyme cyclooxygenase-2 (COX-2), which releases various prostaglandins known to stimulate satellite cells (Bondesen, Mills, Kegley, Pavlath, 2004; Mikkelsen et al., 2009).

Cryotherapy and cold water immersion

Since a few years the use of unconventional cryotherapy has been proposed (extreme cold air exposure) (Costello et al., 2016) or methods commonly used to relieve inflammation due to injuries to treat DOMS; however, scientific studies have not been able to concretely demonstrate a significant difference in its treatment.

The protocol of ice-water immersion used by Sellwood and collegues (2007) was ineffectual in minimizing DOMS markers in untrained individuals, but results are still conflicting.

A study has compared DOMS treatment with cold water (20°C) or hot water (38°C) for 30 minutes, and it was found that hot water could be reduced DOMS most efficiently (Hassan, 2011).

Hohenauer, Taeymans, Baeyens, Clarys, Clijsen, (2015) data from 27 articles revealed, that cooling and especially cold water immersions affected the symptoms of DOMS significantly, compared to the control conditions after 24 hrs. recovery, and also Machado et al. (2016) claim that cold water immersion can be slightly better than passive recovery in the management of muscle soreness with an immersion time of 11–15 minutes.

Concurrent training

Aerobic exercise may be a recommended practice following eccentric exercise as a method to mitigate DOMS; when resistance training and aerobics are performed in succession within a single session you talk about concurrent training.

Tufano et al. (2012) tested the effect of 20 minutes of low and moderate intensity aerobic activity or complete rest following an exercise with overloads consists of 60 eccentric repetitions considering the subsequent manifestation of DOMS and the exercise at moderate intensity has been shown to lead to a DOMS reduction compared to low intensity or complete rest.

Repeated bound effect

The “Repeated bout effect” (RBE) is the muscle’s ability to adapt, reducing DOMS response to mechanical stimuli caused by muscle contraction. In other words, the RBE indicates that repeating a workout with weights, right from the next session, DOMS response and therefore the perceived pain, is weaker than the first (Pettitt, Symons, Eisenman, Taylor, White, 2005).

It seems that one of the ways to prevent or reduce the typical DOMS pain (or to accelerate the recovery), is to stimulate muscles with lower volume eccentric exercises about a week or more, before the high volume eccentric training session (Flann, LaStayo, McClain, Hazel, Lindstedt, 2011; Burt, Lamb, Nicholas, Twist, 2015).

The mechanisms underlying the RBE are not understood, though Deyhle et al. (2016) have recently demonstrated that inflammation is not attenuated following a repeated bout of lengthening contraction.

Conclusions

The current literature concerning DOMS management is still emerging. The results of this systematic review indicate that mechanisms underlying DOMS are still not well understood, as well as pathways of their limitation and management. There are conflicting results for almost any therapy considered in this review, especially cryotherapy, NSAIDs and antioxidants assumption.

Instead, encouraging results come from the study of other supplements or special foods, as well as from the different kinds of training, before or after the onset of muscle soreness.

The existing literature provides some evidence for utility of methods in DOMS management, but the limitations should be considered prior to integrating such methods.

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INTEGRATED DYNAMOMETRIC, KINEMATIC AND ELECTROMYOGRAPHIC CHARACTERISATION OF A SWIMMING TRACK START BLOCK PHASE – A PILOT STUDY

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Abstract This study presents a complete biomechanical analysis of the block phase of a swimming modified track start. Kinetic, kinematic and electromyography (EMG) data were collected. The forces produced by the swimmer on the block, the EMG of eight muscles and the kinematics of the centre of mass (CM) were recorded. A national-level swimmer performed three repetitions of a track start in a dynamometric starting block. Temporal instants 'reaction time', 'hands take-off', 'rear foot take-off' and 'front foot take-off' were identified. Results show the peak forces (Fmax) produced by the most dynamic limb in each sub-phase delimited by mentioned instants (right hand take-off: $Fmax_{vertical}$ = 103 N; rear foot take-off: $Fmax_{antero\text{-}posterior}$ = 524 N; front foot take-off: $Fmax_{vertical}$ = 634 N). The CM revealed a descendent vertical trajectory along the block phase. Mean resultant speed at front foot take-off was 4.092m/s. The muscles with highest values of integral EMG (iEMG) were the tibialis anterior during hands take-off, Biceps Femoris and Gluteus Maximus during rear foot take-off, respectively 41.17%, 52.96% and 36.37% of the maximum isometric voluntary contraction (%MIVC). The study demonstrates an effective characterisation of the block phase in swimming starts with potential to evaluate the swimmers performance in the track start, using different back plate positioning.

Key words: Biomechanics, Dynamometry, Kinematics, Electromyography, Swimming

Introduction

In competitive swimming the start is determinant, especially in short distance events (Lyttle, Benjanuvatra, 2005). In the last decade the track start has become one of the most used start techniques by elite swimmers

(Garcia-Hermoso et al., 2013). According to the preferences of each swimmer (forward or backward positioning of the CM and rear foot placement on the starting block) there are some variations in the way track start is performed. Parameters like the reaction time (temporal delay from the start signal until the first mechanical expression) and the impulse on the block (integral of force in order to time) seem to assume relevance in the production of an effective start (Vantorre, Seifert, Fernandes, Vilas-Boas, Chollet, 2010). There are some biomechanical studies that focus on the start as a whole: block phase, flight, entry in water, underwater glide, leg kicking and swimming phase (Vantorre et al., 2010; Seifert et al., 2010; Vilas-Boas, Fernandes, 2003), but few did an exhaustive analysis of the block phase (Honda, Sinclair, Mason, Pease, 2012; Kibele, Biel, Fischer, 2013), defined by the time between the start signal and the instant the swimmer loses the contact of his feet with the block (Vantorre et al., 2010).

In 2008, the *Fédération Internationale de Natation* (FINA) authorized the inclusion of a back plate on the starting block for rear foot support (FR 2.7, 2009 2017). The placement of this back plate is adjustable and swimmers can choose one of the five possible positions to optimize their feet positioning on the block. With this improvement, the modified track start became the most used technique by elite swimmers (Kibele et al., 2013). However, the amount of research available about how the back plate influences the start is still scarce. The purpose of this study is to analyse the coherence of the kinematic, kinetic and electromyographic parameters involved in the block phase of the modified track start and their potential to characterise this event. Based on the findings of previous studies (de Jesus et al., 2011a, 2011b), it was hypothesised that it would be possible to develop a biomechanical method to characterise the block phase of the modified track start, using EMG, force plates and a motion capture system as main tools.

Methods

Participants

A female swimmer, proficient in the modified track start technique (age: 24 years; body weight: 62 kg; height: 1.64 m), performed three trials of this starting technique, with 10 minutes rest between repetitions. The Ethics Committee of Faculty of Sport from the University of Porto approved the research in accordance with the guidelines set by the World Medical Association Declaration of Helsinki (2013). The participant provided informed consent before data collection.

Experimental Procedure

The swimmer executed the established number of repetitions of the modified track start. For the present study the repetition whose data from the three domains of analysis presented the highest quality was selected. +65 this decision was made because two of the three systems used were products in development; the EMG was a non-commercial cable device, custom made, operating in the hostile aquatic environment and the dynamometric starting block was not fully water-resistant. These aspects, combined with the difficulty for the motion capture system to identify the 48 markers on the swimmer's body when she was positioned on the starting block, justify our option to select just one repetition of the track start to analyze, that in which the quality of data from the three devices was the highest.

Active pre-amplified bipolar surface electrodes were used to collect EMG data. The amplifier common rejection ratio was 110 dB and the total gain was set to 1100x. The muscle fibres orientation was respected and the

electrodes were placed in the centre of the muscle belly during a concentric contraction. The reference electrode (ground) was positioned in the *olecranon*. These cable electrodes were placed over eight muscles from the right side of the swimmer body (the front foot side) – *triceps brachii, deltoideus anterior, biceps brachii, tibialis anterior, biceps femoris, gastrocnemius medialis, rectus femoris, gluteus maximus* (Figure 1). For the placement of the surface active electrodes the recommendations from the project Surface Electromyography for the *Non-Invasive Assessment of Muscles* (SENIAM) were respected.

The eight cables were grouped in the lower back region of the swimmer and conducted through a specific hole in the swimming body suit. These cables drove the EMG signal to a data acquisition system composed by an analogue-to-digital converter (A/D) (BIOPAC Systems, Inc., USA), with a sampling rate of 1000 Hz. To normalize the signal, data from the maximum voluntary isometric contraction (MVIC) of the evaluated muscles was also collected. Three MVIC were performed per muscle (5 seconds of duration with 5 minutes of rest between contractions) and the contraction with the highest voltage value was chosen as reference (Figueiredo, Rouard, Vilas-Boas, Fernandes, 2013). Thereafter, using the Matlab® software (The MathWorks, Inc., USA) the raw EMG signals were processed using a digital pass-band Hamming window (35–450 Hz), followed by full wave rectification and smoothing with a low pass filter of 10Hz. The procedures of isolation, cables fixation and signals normalization were done according to previous studies (Figueiredo et al., 2013; de Jesus et al., 2011b).

Figure 1. Electrodes positioning for EMG

To ensure the electrodes protection and to guarantee the correct marking of the 48 anatomical points of interest for the kinematical evaluation, a complete fastskin™ suit (Speedo®, USA) filled with retro-reflective quasi-spherical elements in specific locations was used. Twelve infrared cameras (Qualisys AB, Sweden), with a sampling frequency of 100 Hz, allowed registering kinematic parameters (position, time and derived quantities) of the marked

anatomical points of the participant. This way the principal instants or phases of relevance for the swimming start characterisation were obtained (Ribeiro et al., 2014). The previous system calibration has ensured the coverage of the entire volume of performance of the swimmer allowing the motion capture of the anatomical points identified with reflective markers. The markers setup (Figure 2) chosen was based on the anatomical anthropometric model of the *Istituto Ortopedico Rizzoli* (IOR Gait Full-Body Model) which enabled the creation of a 3D kinematical model on Visual3D software (C-Motion, USA).

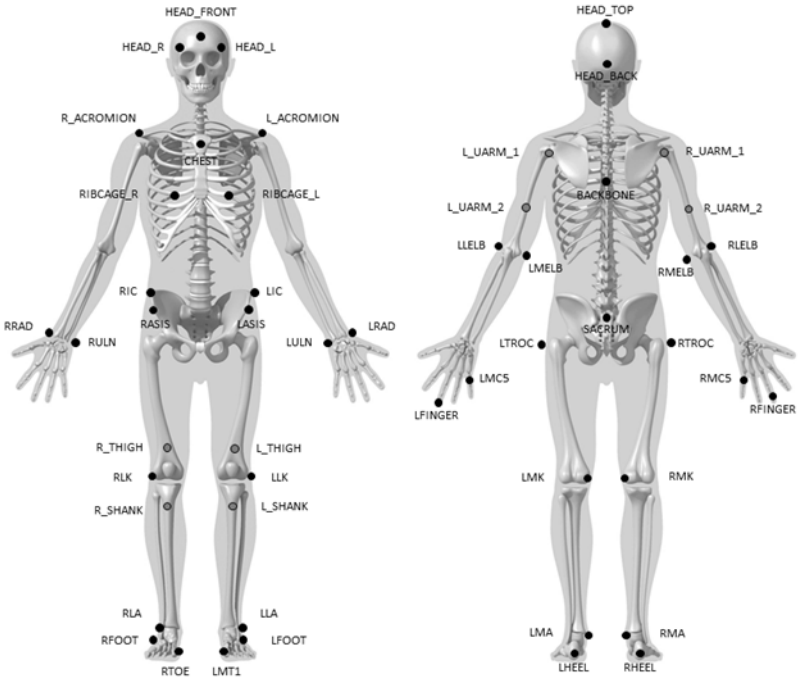

Figure 2. Marks setup of relevant anatomical spots

For the dynamometric analysis of the swimming start, an instrumented starting block was used. This was built with several extensiometric triaxial force plates (Figure 3) for full contact force assessment. The force plates with a natural frequency of 60 Hz operate with 2 N sensitivity, error <1% and a sampling rate of 2000 Hz (de Jesus et al., 2011a). The dynamometric system was picked as reference to define the initial and final temporal instants of each sub-phase of the block phase. This choice was due to the fact that this system can measure, in an independent and direct way, the block reaction forces (BRF) produced by each upper and lower limbs of the swimmer, at any instant.

The temporal synchronization of the three systems was performed with a trigger (TTL wave, 0–5V). This device was coupled to a starter (Pro Start, USA) that emitted simultaneously the starting signal and the electrical pulse to trigger the acquisition system.

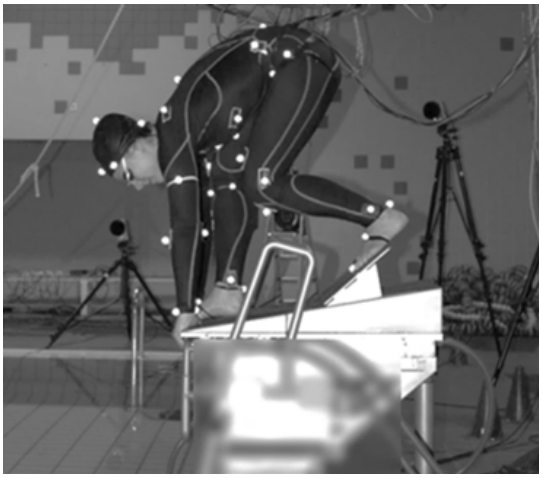

Figure 3. Starting block and markers setup

Measurements

The electromyographic integral (iEMG) was obtained from the collected EMG data to evaluate the electrical activity of each muscle. To calculate the iEMG, signals were normalized to the MVIC, integrated in order to time duration of each sub-phase and then normalized to the same temporal interval. This procedure was done in order to discard the phase duration effect (Figueiredo, Sanders, Gorski, 2012). In the *Results* the values of iEMG will be presented in the form of percentages. The kinematical parameters obtained through the optical motion capture system Qualisys™ were: (i) displacement and average speed of the CM from the instant of the starting signal to the first mechanical reaction of the swimmer; (ii) from this instant to the loss of contact of the hands with the block; (iii) from this moment to the rear foot take-off and (iv) from this instant to the loss of contact of the front foot with the starting block. The vertical, antero-posterior and medium-lateral components of the reaction forces, produced on the block by the action of each of the swimmer lower and upper limbs during the block phase, were registered.

Results

The kinematics results, presented in Table 1, were determined for the sequence of time intervals described in the previous section. The selected parameters were: the time duration and percentage of total time spent in each sub-phase of the block phase; the displacement of the CM in the sagittal plane (antero-posterior – Δx – and vertical – Δz) and the average resultant speed of the CM in the sagittal plane, for each sub-phase.

The values of BRF as function of time, produced by the action of the swimmer upper and lower limbs are presented in Figure 4. Graphic A shows the components of BRF resulting from the action of the right hand and the graphics B and C present the components of BRF of the rear foot and front foot, respectively. In panel D the graphic shows the superimposed curves of the BRF components produced by the action of upper and lower limbs. Analysing the force curves it is possible to see that the vertical and antero-posterior components are those with bigger contribution for the propulsive action on the block, for both upper and lower limbs.

Table 1. Kinematical variables studied in each sub-phase of the block phase for the modified track start

	Reaction time	Hands take-off	Rear foot take-off	Front foot take-off
Time (s)	[0.00–0.13]	[0.13–0.50]	[0.50–0.77]	[0.77–0.90]
Time (%)*	14.45	41.10	30.00	14.45
Δx (m)	0.021	0.492	0.895	0.487
Δz (m)	0.001	–0.059	–0.197	–0.187
V_{avg} (m/s)	0.159	0.974	2.808	4.092

* % of total time on the block; Δx – antero-posterior displacement; Δz – vertical displacement; v_{avg} – average speed.

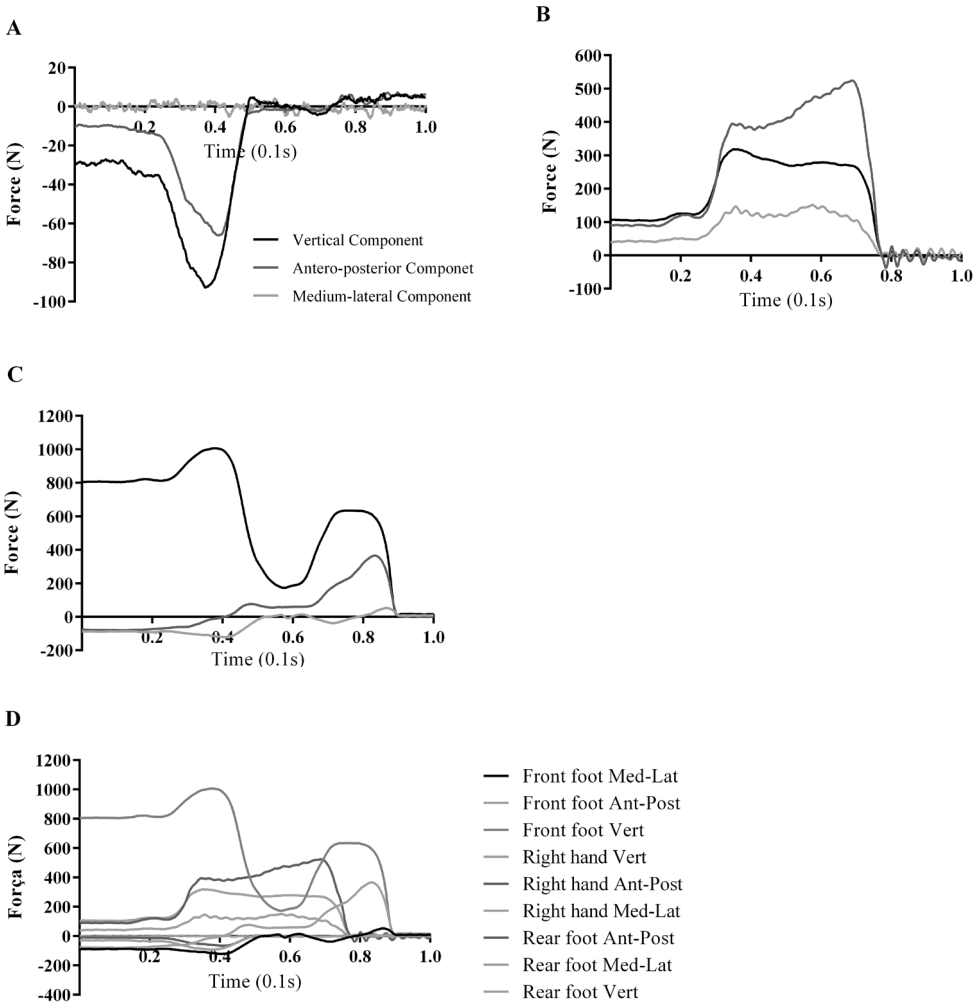

Figure 4. Block reaction forces vs. time from right hand (A), rear foot (B), front foot (C), upper and lower limbs superimposed (D)

Table 2 presents the peak absolute values of the forces produced by the right upper limb and the two lower limbs in the sub-phase where their action is the most characteristic a. The values of the left upper limb are not showed because its behaviour is identical to the right limb, so the information would be redundant.

Table 2. Absolute values of peak forces of the most characteristic limb during the last three sub-phase of the block phase

	Hands take-off	Rear foot take-off	Front foot take-off
F_{max}	Right hand	Rear foot	Front foot
$F_{vertical}$ (N)	103	279	634
$F_{antero\text{-}posterior}$ (N)	66	524	366

In both hands take-off and front foot take-off sub-phases the vertical component of the force produced the highest peak value, respectively 103 N and 634 N. In contrast, the rear-foot take-off sub-phase is the only one where the force antero-posterior component has the highest value, 524 N (Table 2).

Table 3. shows the iEMG values in percentage of maximal mioelectric activation from each of the eight muscles studied, during each sub-phase of the block phase.

Table 3. Values of EMG integral of the muscles studied, in each sub-phase of the block phase (%)

	Reaction time	Hands take-off	Rear foot take-off	Front foot take-off
iEMG BB	1.88	6.58	11.81	5.76
iEMG BF	0.79	13.76	52.96	32.16
iEMG DA	0.41	0.26	4.07	5.76
iEMG GM	0.86	3.24	7.46	22.77
iEMG GL	5.00	15.36	36.37	26.50
iEMG RF	0.00	0.00	1.70	0.82
iEMG TA	2.20	41.17	6.69	2.20
iEMG TB	0.00	5.34	4.39	3.77

Note: BB – bíceps brachii; BF – biceps femoris; DA – deltoideus anterior; GM – gastrocnemius medialis; GL – gluteus maximus; RF – rectus femoris; TA – tibialis anterior; TB, triceps brachii.

Relatively to the EMG data it can be noticed in Table 3 and Figure 5 that the muscles which present highest electrical activity in the reaction phase were the *Gluteus Maximus*, the *Tibialis Anterior* and the *Biceps Brachii*. From the subsequent instants to the hands take-off, the *Tibialis Anterior*, the *Gluteus Maximus* and the *Biceps Femoris* presented the most expressive signal and the *Tibialis Anterior* showed its highest activation levels of the whole block phase. After the hands take-off till the rear foot take-off, the *Biceps Femoris*, the *Gluteus Maximus* and the *Biceps Brachii* were the muscles most recruited and, together with the *Rectus Femoris*, they all present in this sub-phase their activation peak considering the whole block phase. In the front foot take-off sub-phase, the three most active muscles were the *Biceps Femoris*, the *Gluteo Maximus* and the *Gastrocnemius Medialis*.

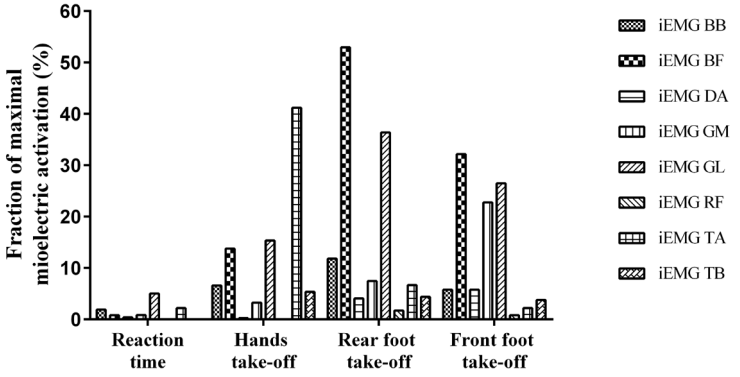

Figure 5. Graphical representation of iEMG data

Discussion

As it was hypothesised, the method developed to characterise the block phase of the modified track start revealed capability to describe the behaviour of important biomechanics parameters related with kinetics, kinematics and muscular electrical activity of a swimmer, during the first determinant part of a swimming competition, the block start.

The processed data from dynamometry, kinematics and EMG revealed coherency in the different sub-phases of the swimming start block phase. Once temporal synchronization was ensured from the beginning, it was possible to get complementary information from the three techniques used to describe the swimmer behaviour on the starting block. Crossing the signals of dynamometry with kinematics, it could be seen that the instants delimiting each of the sub-phases of the block phase where observed either by the inflections of the force curves, or by visual inspection of the 3D model created by Qualisys Track Manager® software.

The sub-phase with greater temporal duration was that between the swimmer reaction time to the starting signal until the hands take-off. This was the period in which the horizontal displacement truly began. Although the calculation of impulse has not been performed in this study probably its value would reach the maximum at this sub-phase, considering the time duration of force application and the high magnitude of its vertical component. The prevalence of this component up to the moment of hands take-off is also a reflex of the swimmer weight.

Considering the iEMG data, it was seen that the sub-phase which lasted from the hands take-off until the rear foot take-off was the one where a greater number of the analysed muscles reached its myoelectric activation peak. In this sub-phase, comparing to all the others, there was also a greater increase of the resultant average speed of the CM and, consequently, the greater acceleration throughout the whole block phase. The speed kept increasing considerably until the moment when the front foot (and the whole body) lost contact with the block, allowing the swimmer to leave the starting block with maximum speed.

In what concerns to the sequence of phases analysed it is, as predicted, accordant with literature (Honda et al., 2012; Kibele et al., 2013) but the magnitude of forces, the displacements of the CM and the muscular activation pattern still need confirmation since this is a pilot study which results refer to a single trial. Aspects like the

competitive level, laterality, gender and age surely have an influence on the measured parameters and will probably condition the results observed if this characterisation procedure is applied to other swimmers with different profiles.

In future studies, a wider sample of participants and a strict inclusion criteria should be considered to make the statistical analysis and interpretation of the results possible. It would also be interesting to have the EMG data of muscles from the left side of the body to understand their relative contribution to the swimmer movement on the starting block.

On a more conceptual level, it should be considered the possibility that within a little time a more extensive practical approach of the referred method would be plausible: from the calculation of the impulse produced by the application of forces on the block over time, knowing the angular momentum of the swimmer body and the behaviour of the CM from the take-off instant until the water entry, it might be possible to predict the take-off angle and take-off velocity. With this information, the flight trajectory and the entry angle of the swimmer can be assessed. These parameters will be valuable for researchers and swimming coaches in the sense they can give feedback to the swimmers immediately after the execution of a start, and contribute objectively to the starting technique optimization.

Conclusions

The adopted method revealed potential to produce an exhaustive biomechanical characterisation of the swimming track start block phase and it could be extended to other starting techniques, with the necessary adaptations.

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THE BIOLOGICAL PROPERTIES OF LACTOFERRIN

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Abstract Lactoferrin (LF) is an iron-binding glycoprotein from the transferrin family, which has been identified in most biological fluids as secretions from exocrine glands and the content of specific granules of neutrophils. It has been reported to have numerous functions. Due to antimicrobial and anti-inflammatory activity, the lactoferrin plays significant role in host defense against infection and extreme inflammation. Recent studies have also demonstrated that LF can protect against cancer in experimental animals and has anticarcinogenic activity in many human tumors. At the cellular level, LF modulates the proliferation, differentiation, maturation, activation, migration and function of immune cells. This review presents the multifunctional roles and specific beneficial properties of lactoferrin.

Key words lactoferrin, antimicrobial activity, immunomodulatory effect

Introduction

Lactoferrin (LF) is a non-heme iron-binding protein of the transferrin family with a high affinity for iron, even a 2-fold higher than transferrin (Ward et al., 1999; Ward, Paz, Conneely, 2005; Adlerova, Bartoskova, Faldyna, 2008).

Lactoferrin was first isolated from cow's milk in 1939 (Sorensen, Sorensen, 1939), and the its presence in human milk was determined in 1960 by three independent research centers (Groves, 1960; Johanson, 1960; Montreuil, Tonnelat, Mullet, 1960). Further studies aimed at determining the sites of lactoferrin synthesis in the body. LF expression has been shown in the cells of the preimplantation mouse embryo at the stage of 2 to 4 cells, persisting until the blastocyst stage. It appears again in the second half of pregnancy, where it is expressed in neutrophils and epithelial cells of the developing gastrointestinal and respiratory systems (Ward et al., 1999). In an adult organism,

lactoferrin is synthesized by glandular epithelial cells and is released into the mucosal fluids that bathe the surface of organs. Its maximum concentrations are found in colostrum and milk, and lower levels in secretory fluids such as tears, saliva, nasal and bronchial secretions, and in the exocrine secretions of pancreas, gastrointestinal tract, and the genital system (Adlerova et al., 2008; Ward, Uribe-Luna, Conneely, 2002). Its presence has been confirmed in the specific granules of neutrophils (Ward et al., 2002) and lactoferrin synthesis takes place during granulopoiesis at the myelocyte stage.

Structure and function of lactoferrin

Human lactoferrin is a positively charged protein composed of a single polypeptide chain comprising 703 amino acids, folded into two symmetrical globular lobes - N and C lobes. Each lobe is organized into two domains (N: N1 and N2; C: C1 and C2 domains) connected by a hinge region containing a three-turn α-helix (Figure 1). Both lobes show 33–41% homology in structure. Each lobe has one binding site for iron ions (Fe^{+2} or Fe^{+3}), and one or more potential glycosylation sites, depending on the species from which LF is isolated. Depending on its form, the molecular weight of LF varies between 76 and 80 kD (Levay, Viljoen, 1995; Siqueiros-Cendón et al., 2014). The degree of iron saturation determines the spatial structure of LF, which occurs in two forms: apolactoferrin (apo-LF), with low iron saturation, and iron-rich hololactoferrin (holo-LF) (Baker, Baker, 2005).

Figure 1. Structure of lactoferrin (According to Berlutti et al., 2011)

The commercially available bioactive recombinant human lactoferrin (rhLF) has three different forms with different levels of iron saturation; apo-rhLF (iron-free <10%), pis-rhLF (partially iron-saturated, at ~50%) and holo-rhLF (>90% saturation) (Nandi et al., 2002; Nandi et al., 2005; Amini, Nair, 2013). The lactoferrin affinity for iron depends on pH and increases when pH becomes slightly acidic (Kanwar et al., 2015). Partial iron saturation of lactoferrin (at 15–20%) occurs naturally in the body. LF shows high structural homology irrespective of the mammalian species from which it was isolated (Małaczewska, Rotkiewicz, 2007).

Lactoferrin has been extracted from human colostrum (human lactoferrin, hLF); goat (goat lactoferrin, gLF) with high homology with hLF; camel (camel lactofferin, cLF) and cow (bovine lactoferrin, bLF) (Kanwar et al., 2015). Researchers have established the functions of lactoferrin originating from various sources (Table 1), with many recent studies bringing new discoveries about its role. LF has a wide range of-physiological properties, showing immunomodulatory, anti-inflammatory, antibacterial, antiviral, antifungal, antiparasitic, anticancer activities,

outstanding osteogenic activity and promoting formation of new blood vessels (Figure 2). Associated with the mucosal tissue, LF is an important component of the innate immune system. It exhibits bacteriostatic and bactericidal properties against Gram-positive (+) and Gram-negative (-) bacteria. One of its basic and well-known functions is iron transport. Produced by specialized cells, e.g. in kidneys, LF exhibits both antibacterial and antioxidant effects, protecting against urinary tract infections. Here, the mechanism of action consists in controlling and reducing the concentration of free iron available to bacteria in the urinary system (Małaczewska, Rotkiewicz, 2007).

Table 1. Lactoferrin: various sources, functions and roles (According to Kanwar et al., 2015)

Lactoferrin Source	Action	Functional Role
Human Lactoferrin	Anti-microbial	Effective against *Streptococcus*, *Salmonella*, *Shigella*, *Staphylococcus* and *Enterobacter*. Enhances the host immune system.
	Anti-cancer	Diagnostic marker.
Goat Lactoferrin	Ongoing research	Still novel and further studies need to be conducted.
Camel Lactoferrin	Anti-viral	Inhibits infection by Hepatitis C and B virus. It has hepatoprotective effect.
	Anti-diabetic	Potential therapeutic molecule in targeting both type 1 and type 2 diabetes. More work needs to be done.
Bovine Lactoferrin	Anti-cancer	Anticancer activity against colorectal cancer and lung cancer.
	Anti-microbial	Effective against oral candidiasis, influenza virus pneumonia and skin infections due to herpes virus. Enhances host immune response. Anti-inflammatory.

The regulation of LF concentration involves macrophages and monocytes with high-affinity receptors for LF, enabling them to quickly remove excess LF from the circulation. The receptors bind iron, transforming it into ferritin, while the LF molecule is degraded.

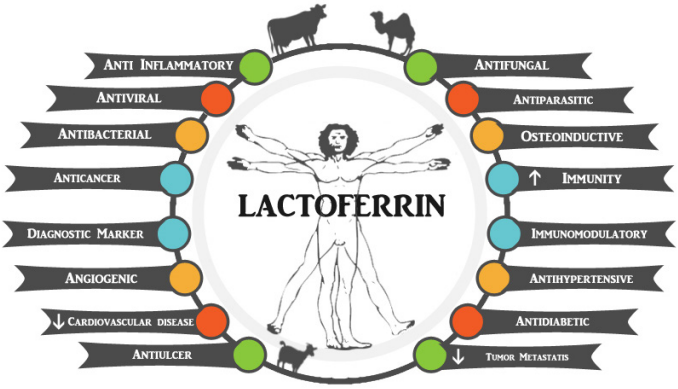

Figure 2. Lactoferrin and its functions

The antimicrobial properties of lactoferrin

The bactericidal effect is a very important property of LF, making it an interesting alternative in antibiotic resistance. It has been shown that lactoferrin is an effective antimicrobial agent (Li, Tan, Vlassara, 1995; Artym, 2010).

The lactoferrin's antibacterial activity is attributed to its ability to sequester iron, an element necessary for the growth and proliferation of microorganisms in body fluids (Artym, 2010). Inhibition of bacterial proliferation by lactoferrin via free iron chelation is one of its earliest discovered functions. Its antibacterial activity was determined by *in vitro* studies in which 0.5% solution of the purified lactoferrin obtained from human milk, free of immunoglobulin, lysozyme and transferrin, were placed on the surface of gel with two species of bacteria, *Staphylococcus albus* and *Staphylococcus aureus*. LF was shown to inhibit the growth of *S. albus*, and introduction of ionized iron to the solution of lactoferrin neutralized that effect (Masson, Heremans, Prignot, Wauters, 1966).

Lactoferrin also has a bactericidal effect not related to the binding of iron. It has an ability to influence bacteria directly, thanks to its specific structure with a highly positively charged N-terminal region (Redwan, Uversky, El-Fakharany, Al-Mehdar, 2014). Acting on the cell walls of Gram positive bacteria, LF is capable of disintegrating them, increasing their permeability, and in consequence inducing cell-death. LF binds to lipopolysaccharide (LPS), an integral part of the walls of Gram-negative bacteria, which leads to their disintegration. Experimental studies have demonstrated that the LF's bacterocidal effect depends on its concentration (Drago-Serrano, Garza-Amaya, Luna, Campos-Rodríguez, 2012). A direct contact of lactoferrin with pepsin in the stomach leads to the digestion or hydrolytic degradation. Thus generated lactoferricin has more potent antibacterial effect and broader spectrum of action than native LF. The inhibitory effect on micro-organisms is obtained at a low dose (0.5–500 mg/mL) (Małaczewska, Rotkiewicz, 2007). LF also shows a synergistic effect in combination with antibiotics. The mechanism consisting in increasing the cell wall permeability facilitates the penetration of the antibiotic into the cytoplasm of the target cell. This results in a faster and more effective chemotherapeutic action (Farnaud, Evans, 2003).

Lactoferrin is also used in the treatment of periodontal disease, thanks to its bacteriostatic action against plaque-forming bacteria, such as *Streptococcus mitis*, *Streptococcus gordoni*, *Streptococcus salivarius* and *Streptococcus mutans* (Kanwar et al., 2015).

Lactoferrin is one of the proteins present in saliva, at 1.23 mg/L of gingival crevicular fluids (GCF) and 8.96 mg/L in unstimulated and 7.11 mg/l in the stimulated saliva. LF concentration in the gingival crevicular fluid depends on the volume of secreted saliva, but also upon the pathological condition in the oral cavity. It has been shown in the locally collected samples from the oral cavity of patients with gum disease, concentration of LF is increased to 63 ng/site, while in those with periodontal disease it increased to 90 ng/site, compared to the levels in healthy subjects (36 ng/site/site) (Wei et al., 2004; Berlutti et al., 2011). The significance of LF in periodontal diseases is emphasized by experimental studies. In tests on mice with lactoferrin knockout ($LFKO^{-/-}$) and alloxan-induced diabetes, the animals were more susceptible to periodontitis induced by *Aggregatibacter actinomycetemcomitans* (Alabdulmohsen, Rozario, Markowitz, Fine, Velliyagounder, 2015).

Periodontal diseases are associated with inflammation in tissue surrounding the tooth, due to the accumulation of subgingival plaque formed mainly by Gram-negative bacteria (Wakabayashi et al., 2010; Berlutti et al., 2011). A new method of treating periodontal disease uses bovine LF (1) inhibiting the inflammatory process by binding free iron ions, (2) binding to the surface of the bacteria (Berlutti et al., 2010; Wakabayashi et al., 2010; Latorre, Berlutti, Valenti, Gessani, Puddu, 2012), and (3) inhibiting the growth of biofilm (Chen, Wen, 2011).

Bacteriostatic properties of LF are confirmed by clinical trials. The frequent problem of halitosis (oral malodor) caused by bacterial metabolism (e.g. inhabiting the oral cavity) is found in approximately 50% of patients in the world, and in 90% the etiology is related to processes in the oral cavity (Armstrong, Sensat, Stoltenberg, 2010). It is accompanied by the presence of plaque and tartar, periodontal diseases, such as periodontitis, and infections involving dentures, tooth decay, mouth ulcers and ulceration (Chomyszyn-Gajewska, Skrzypek, 2013). In randomized trials, patients with halitosis were given single oral dose of a commercial drug (*Morinaga Orabarrier, Morinaga Milk Industry Co., Ltd.,* Tokyo, Japan), a tablet containing 20 mg of lactoferrin, 2.6 mg lactoperoxidase, and 2.6 mg of glucose oxidase. As early as 30 minutes after administration of the tablet the malodour was inhibited (Nakano, Shimizu, Wakabayashi, Yamauchi, Abe, 2016).

Antiviral properties of lactoferrin

The antiviral effect of LF consists in inhibiting the replication of viral DNA and RNA. One of the mechanisms of action, confirmed in experimental models, is its protective effect against virus-free cells. LF has also been observed to bind directly to molecules in the structures of viruses such as HSV, HIV and HCV (Välimaa, Tenovuo, Waris, Hukkanen, 2009; Berlutti et al., 2011). Another mechanism of the antiviral action of LF is its ability to block the host's cell surface receptors. The LF's affinity for glycosaminoglycans results in blocking the virus binding sites in the initial phase of infection (Redwan et al., 2014). This prevents the use of surface molecules as specific receptors or co-receptors for the different types of viruses and prevents viral fusion. This mechanism has been described, inter alia, in HBV, HPV, HSV, and HIV (Berlutti et al., 2011; Wakabayashi, Oda, Yamauchi, Abe, 2014). It has also been shown that the effect of iron-free apolactoferrin on some viruses was greater than that of holo-lactoferrin (Małaczewska, Rotkiewicz, 2007).

Antifungal properties of lactoferrin

Antifungal properties of LF are related to its ability to damage fungal cell membranes and alter their permeability, and also to iron chelation (Wakabayashi et al., 2000). These effects have been confirmed *in vivo* in mice, in which hLF effectively protected against experimental oral infection with *C. albicans* (Velliyagounder, Alsaedi, Alabdulmohsen, Markowitz, Fine, 2015).The native human lactoferrin showed a higher activity against *Candida*, as measured by the minimum inhibitory concentration (MIC), than the form with high iron-saturation (Grammatikova et al., 2010).

Antiparasitic properties of lactoferrin

Lactoferrin also exhibits a beneficial effect in parasitoses. Although it does not inhibit the entry of parasites into the body, it does inhibit their growth (Cintra, Silva-Filho, De Souza, 1986). The ability of iron chelation blocks the ion uptake by parasites, the main mechanism directed against *Pneumocystis carinii*. It has been observed that LF preincubated with the sporozoites of *Toxoplasma gondii* greatly reduces their infection ability. The mechanisms of the protective effect of LF have not been fully explained. It is believed that the observed antiparasitic effects are associated with the activation of macrophages, as well as with the direct effect on membrane integrity of the parasites and positive interactions with host tissues (Farnaud, Evans, 2003; Małaczewska, Rotkiewicz, 2007).

Anti-inflammatory properties

A multifunctional protein, lactoferrin also exhibits the ability to modulate the body's inflammatory response, affecting the immune system in different ways. LF enhances proliferation, differentiation, and causes the activation of immune cells. It affects the mechanisms of the innate response, by influencing the activation of the complement system, an increase in NK cell activity, increase in the phagocytic ability of monocytes and their enhanced cytotoxicity (Legrand, Mazurier, 2010). LF also reduces the amount of produced proinflammatory cytokines (TNFalpha) and interleukins IL-1 and IL-6 (Haversen et al., 2002). It affects hemostasis by reducing the time of clot formation, and prevents platelet aggregation (Brock, 2002). Its anti-inflammatory properties are also linked to the ability to bind components of bacterial cell walls (LPS) as well as the specific receptors (Morgenthau, Beddek, Schryvers, 2014). Lipopolysaccharides, potent mediators of the inflammatory response, cause the activation of leukocytes which results in the hyperproduction of free radicals. Iron is a catalyst for these reactions (Actor, Hwang, Kruzel, 2009). Thanks to its chelating properties, LF can reduce the indirect effects of reactive oxygen species at inflammation sites and thus protects the tissue against damage (Ward et al., 2005). Infection results in neutrophil degranulation, and LF released from their specific granules has the ability to quickly inactivate LPS, thereby protecting the tissue against damage (Baveye, Elass, Mazurier, Legrand, 2000; Ammons, Copié, 2013). Anti-inflammatory properties of LF have also been confirmed by *in vivo* tests in animal models. Oral administration of LF resulted in reducing the symptoms of inflammation in mice and the subsequent occurrence inflammation in experimentally induced colitis (Haversen, Baltzer, Dolphin, Hanson, Mattsby-Baltzer, 2003).

Anticancer properties

Lactoferrin prevents from developing chemically-induced tumors. This effect has been confirmed in studies conducted on laboratory rodents (Tsuda, Sekine, Fujita, Ligo, 2002). LF decreases the incidence of metastases in experimental mice diagnosed with the disease (Wolf, Li, Taylor, O'Malley, 2003). Fujita suggests that the inhibition of tumor growth may be associated with tumor cell apoptosis via the activation of the Fas pathway (Fujita, Matsuda, Sekine, ligo, Tsuda, 2004). Studies on human and mouse cell lines have shown that the administration of recombinant human lactoferrin can inhibit the growth of head and neck squamous cell carcinoma (HNSCC), via a direct impact on the development of cells, and also through systemic immunomodulation (Wolf et al., 2007). A similar effect has been observed in the case of glioblastoma. Furthermore, the combined administration of lactoferrin and temozolomide enhances the effect of chemotherapy both in vitro and in vivo (Arcella et al., 2015).

Lactoferrin and immunity

As mentioned above, lactoferrin is present in all body fluids, and its iron-free form is stored in specific granules of neutrophils. During inflammation, LF is released from the granules, which increases its concentrations at the inflammation site from 0.4–2.0 μg/mL to 200 μg/mL, playing a central role in response to inflammation (Farnaud, Evans, 2003). Its expression at the RNA and protein levels has also been demonstrated in cells of the distal collecting ducts of the medulla. LF mRNA was detected along a relatively large portion of the tubuli, whereas LF antigen was found mainly in the very distal regions of the same tubuli. This indicates that LF is released by large regions of the tubuli and possibly reabsorbed in the most distal parts renal tubules. Nonetheless, it is suggested that LF may support the immune system via the reduction of free iron in the urine (Abrink, Larsson, Gobl, Hellman, 2000).

The immunomodulatory function of lactoferrin is well known. It interacts with specific receptors of the target cells (either epithelial cells and cells of the immune system), and also thanks to its ability to bind to bacterial wall LPS (Na et al., 2004). Acting via two mechanisms of intracellular signal transduction, i.e. *nuclear factor kappa B* and MAP kinase, LF modulates differentiation, maturation, activation, migration, proliferation and function of immune cells, T and B cells, neutrophils, monocytes/macrophages and dendritic cells belonging to the antigen-presenting cells (APC) (Gahr, Speer, Damerau, Sawatzki, 1991; Krzyżowska, Świątek, Fijałkowska, Niemiałtowski, Schollenberger, 2009; Siqueiros-Cendón et al., 2014) (Figure 3).

Macrophages are antigen presenting cells and their role in innate immune response is based on inducing the phagocytosis of foreign particles and subsequently releasing pro-inflammatory mediators. They also participate in adaptive immune system by stimulating specific T cells after antigen presentation. *In vitro* studies have shown that both human and bovine macrophages contain surface receptors for LF (Birgens, Hansen, Karle, Kristensen, 1983; Roseanu, Chelu, Trif, Motaş, Brock, 2000; Siqueiros-Cendón et al., 2014). LF is also involved in the suppression of proinflammatory cytokines and induction of interferon α/β (IFN/β), and affects the ability of macrophages to present antigens to $CD4^+$ T cells in the adaptive resistance (Latorre, Puddu, Valenti, Gessani, 2010; Siqueiros-Cendón et al., 2014). The major cytokine produced by macrophages is IL-12, acting as a stimulator of INFα secretion by differentiated Th1 and T cells of the immunological memory (Gately et al., 1998). LF also enhances the expression of adhesion molecules on endothelial cells, resulting in leukocyte infiltration at the inflammation site (Kim, Lee, Park, Choi, Kim, 2012).

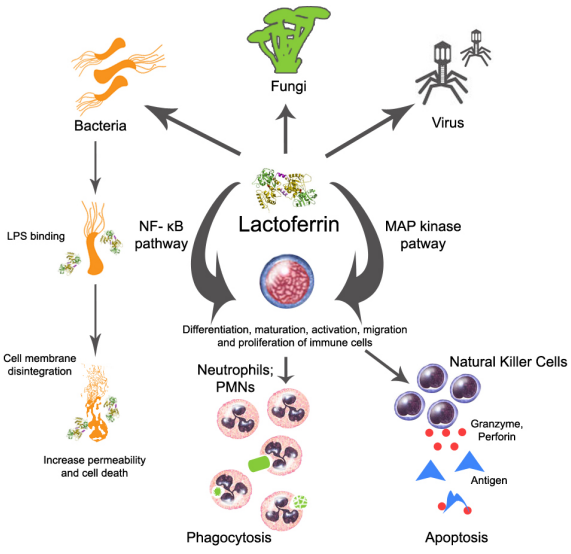

Figure 3. Role of lactoferrin in the activation of immune cells

Dendritic cells also exhibit phagocytic properties, participate in the differentiation of T cells, and regulate the functions of memory T cells (Siqueiros-Cendón et al., 2014). They also play an important role in the stimulation of

Th1 cells, resulting in cytokine secretion (Moser, Murphy, 2000). Similar to macrophages, dendritic cells are capable of binding hLF and bLF (Saidi et al., 2006). LF stimulates the function of dendritic cells, but also acts as alarming to promote the recruitment and activation of APCs and antigen-specific immune response (Yang, Rosa, Tewary, Oppenheim, 2009; Siqueiros-Cendón et al., 2014).

LF is involved in the regulation of B-cell functions and the subpopulation of T cells which express LF receptors (Legrand et al., 1997; Kawasaki, Sato, Shinmoto, Dosako, 2000). Oral administration of LF stimulates the secretion of IgG and IgA in the intestinal mucosa of mice (Sfeir, Dubarry, Boyaka, Rautureau, Tomé, 2004; Siqueiros-Cendón et al., 2014). LF reduces the inflammation response in allergic rhinitis, by inhibiting the activity of Th2, Th17 and regulatory T cells. It can promote Th1 responses, while inhibiting Th2 responses, and it causes T-cell receptor cross-linking, which leads to the inhibition of T-cell activation, reduces the release of inflammatory mediators, such as IL-5 and IL-17, and alleviates the degree of inflammation (Siqueiros-Cendón et al., 2014; Wang et al., 2013). Thanks to its ability to bind to cell surface receptors, LF has an ability to modulate the function of T cells and natural killer cells (Kanwar et al., 2015; Siqueiros-Cendón et al., 2014).

Conclusions

Lactoferrin, a multifunctional glycoprotein naturally occurring in mammals, influences a number of physiological and pathological processes. It participates in morphogenesis, iron homeostasis in the body, and thanks to its antimicrobial function and the ability to modulate the function of the cells of the immune system it can be described as the first line of defense in mammals. Therefore, researchers are trying to find the therapeutic application of LF in the prevention and/or treatment of cancer, bacterial diseases and inflammation. The use of LF is also recommended in dentistry, to reduce the risk of infections associated with dentures or implants.

Abbreviations

LF (Lactoferrin)
hLF (human lactoferrin)
rhLF (recombinant human lactoferrin)
gLF (goat lactoferrin)
cLF (camel lactoferrin)
bLF (bovine lactoferrin)
HBV (hepatitis B virus)
HCV (hepatitis C virus)
HIV (human immunodeficiency virus)
HPV (human papilloma virus)
HSV (herpes simplex virus)
HNSCC (head and neck squamous cell carcinoma)
Ig (immunoglobulin)
IL (interleukin)
INF (interferon)
LPS (lipopolysaccharide)
MAP kinase (mitogen-activated protein kinase)
TNF (tumor necrosis factor)

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INJURIES IN THAI BOXING

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Abstract As with many other combat sports, Thai boxing requires high levels of exertion which may result in various injuries. Their types and extent determine the nature of help required during rehabilitation. The aim of the study was to assess the risk of injury and indicate factors causing injury in Thai boxing. To this end, we conducted a survey among the members of the Nauk Muay Association of Physical Culture in Szczecin. Our respondents reported inappropriate technique as the most common cause of injuries. The second leading cause of injuries was an excessively ambitious approach in training. Injuries – most frequently bruises in lower extremities – were most often sustained during sparring. The incidence of injury was statistically significantly related to male gender and sporting experience; men were also most likely to sustain bruises from all types of trauma.

Key worlds tai boxing, injures, muay-tai

Introduction

The popularity of martial arts and combat sports can be partly attributed to the natural human needs for physical activity and competition. Although initially conceived as a form of physical and mental development, many martial arts have transformed into combat sports with a focus on typical sport competition. Regardless of these ideological differences, both forms of activity are based on direct contact with another person.

Muay Thai or Thai boxing, popular in Southeast Asia, is one of those martial arts which have been transformed into a combat sport. Although the Thai word “muay” means “boxing”, it denotes an entire combat system based on fast punches and clinch fighting (Roza, 2013). Consisting of direct-combat using fists, feet, knees, and elbows, it is also used in mixed martial arts (MMA), which is the basis of strike training (Hill, 2008).

Mobilization of osteoarticular and muscular systems in the body during heavy physical exertion, or the direct mechanical force of strikes and kicks, can lead to injuries, i.e. damage to tissues in any area of the body (Gawroński, 1998). Athletes, in their desire to achieve the best possible results and maximize exercise abilities, often neglect minor injuries and tend to cut recovery time short. Usually, traumas are caused by inappropriate warm-up, excessive

training load, incorrect technique, direct combat contact, the poor state of a sports facility, and too early resumption of training following injury. The degree and complexity of injuries determine the form of specialized assistance and rehabilitation.

There are relatively few papers on injuries in Muay Thai. Kordi (2009) reported that in amateur Thai boxers and kick-boxers aged 16–26, head injuries were most frequent at 13% of all injuries in that study. Incidence increased with the level of advancement, and was greater in the full contact formula than in light contact. An increasing degree of contact in training was positively correlated with the incidence of injuries.

Another study on injury rates in combat sports showed that Muay Thai does not differ in this regard from karate, taekwondo, kickboxing, and related sports (Evans, 2006). The surveyed annual percentage of injuries was 2.43 per 1000 amateurs and 2.79 per 1000 professionals. In addition to bruises to the head, concussion was the most frequent head trauma. However, no information exists in literature about injuries of the osteoarticular or muscular systems in this sport. The aim of the study was therefore to assess the risk of injury and identify factors responsible for injury in Thai boxing training.

Materials and methods

The material consisted of data obtained from respondents from the Nak Muay Association of Physical Culture in Szczecin. The study was conducted in accordance with the guidelines set out in the ethics policy at the University of Szczecin (Sieńko-Awierianów, Eider, 2014). The research group was represented by 40 people: 35 men (87.5%) and 5 women (12.5%), diverse in terms of expertise. The respondents included those training for pleasure and those actively taking part in local, national, and international competitions. For the purpose of this study, we selected a diagnostic survey method described by Pilch, Bauman (2010). A questionnaire of our own design consisted of 25 questions about gender, age, place of residence, level of training, injuries related to Thai boxing, and the resumption of training following injury. The collected data were analyzed statistically using Spearman's rank correlation (Statistica 9.0) (Cięszczyk, Boichanka 2008).

Results

In the study, there were no women aged <18 or >40 years. All were in the groups aged 19–25 years (80%) or 26–41 years (20%). Men were mostly aged 19–25 or 26–41 years (37% each). Men under 18 years of age comprised 20% of the studied male population, while only 6% were aged 40–65 years (Figure 1).

The group was dominated by individuals with secondary education (42.5%), followed by university (40%), primary (12.5%), and vocational education 5% (Figure 2).

The motivation of 41% of respondents to train in Thai boxing was the need for self-realization, followed by health benefits (39.3%), better figure (18%), and suggestions from friends (1.6%). None of the students started training Thai boxing out of fashion or to socialize with others (Figure 3).

As many as 35% of respondents trained 5 times a week, 30% 3 times a week, 17.5% every day, 10% 2 times a week, and 7.5% 4 or 6 times a week (Figure 4).

Other forms of physical activity than the classes in Thai boxing were declared by 75% (regularly), and 20% (occasionally) of respondents, while only 5% did not take any part in any other forms of exercise.

According to the subjective opinion of the respondents on their advancement in Thai boxing, 35% described themselves as intermediate, 27.5% as advanced, 22.5% upper-intermediate, and 15% at a basic level (Figure 5).

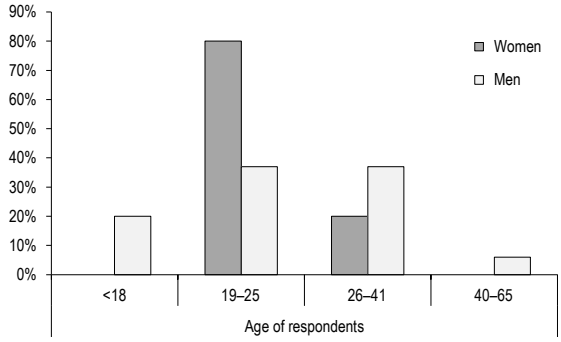

Figure 1. Age of respondents in the study group

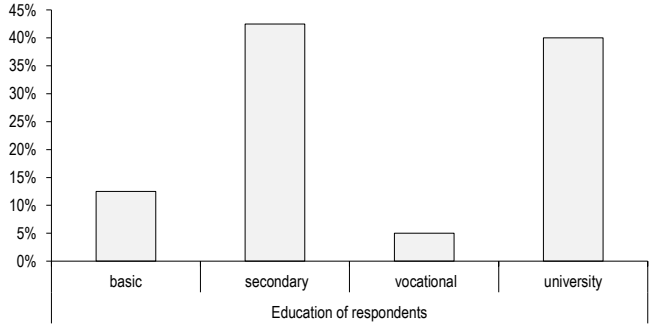

Figure 2. Education levels in the study group

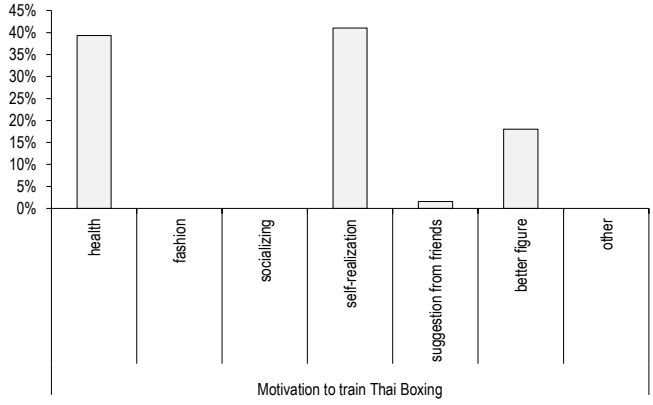

Figure 3. Motivation of the respondents to train Thai boxing

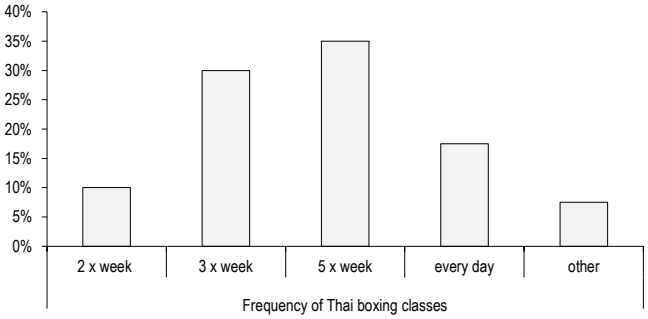

Figure 4. Weekly frequency of training sessions among the respondents

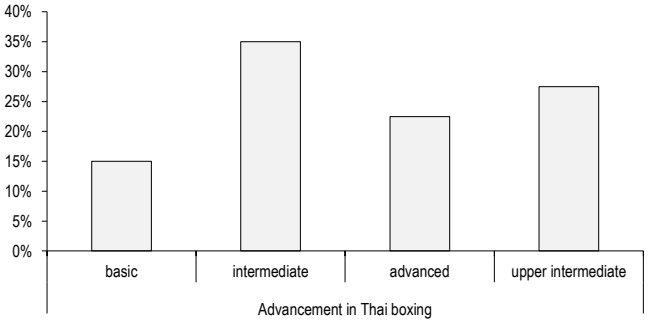

Figure 5. Self-declared advancement of the respondents training Thai boxing

The most of respondent – 52.5% did not take part in any competitions, while 47.5% competed on a regular basis (mainly Polish Muay Thai championships, Polish K-1 championship, and Muay Thai league). Injuries during the Thai boxing classes were sustained by 55% respondents, and as many as 72.5% knew someone who had suffered injury during Thai boxing classes or competitions.

Most often, injuries occurred during sparring (69.2%). Occasionally, injuries occurred during a clinch fight (13.5%) and the training proper (9.6%). Injuries were least frequent during learning Thai boxing techniques (5.8%) and weight training (1.9%). According to the respondents, injuries did not occur during warm-up, endurance training, or post-workout relaxation (Figure 6).

The areas of the body most exposed to injury were the lower extremities, i.e. thighs and legs (19.3%), knee joints (18.1%), and the head (13.3%). The areas of the body less prone to injury included the ankle (9%), elbow and rib (7.8% each), neck (7.2%), and upper extremities, i.e. arms and forearms (6.6%), with the wrist and shoulder (4.2%) and hip joints (2.4%) the least frequently injured (Figure 7).

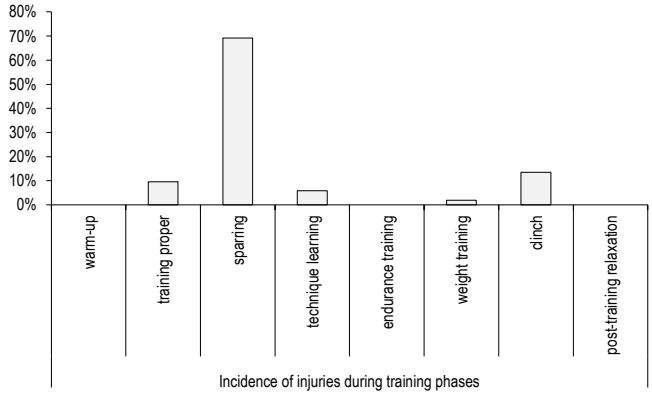

Figure 6. Frequency of injuries depending on the stage of training

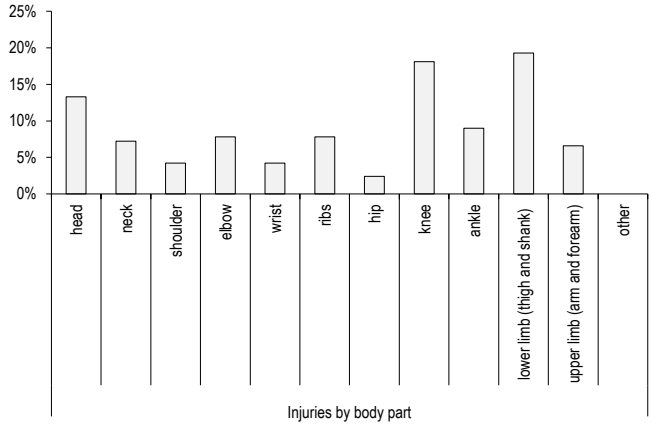

Figure 7. Body parts reported by respondents to be most exposed to injury in Thai boxing

The reported injuries sustained during Thai boxing classes were mostly bruises (53%), followed by sprains and dislocations (18.2%), and damage to the ligaments (15.2%). Fractures constituted 7.6% of total injuries. Other injuries (meniscal tear, cuts) comprised 6% of all injuries (Figure 8).

As many as 72.5% of respondents believed that it was possible to avoid injury during the classes. Other respondents stated that the accident could not have been foreseen.

The respondents differed in their subjective explanation of injury causes. According to 22.5% the injury was caused by incorrect technique, 20.2% indicated an overly ambitious training regimen, 19.1% recklessness, 13.5% ignoring the coach's instructions, 11.2% insufficient concentration, 5.6% inadequate rest, 4.5% neglecting the first signs of injury, while 3.4% indicated insufficient engagement in warm-up (Figure 9).

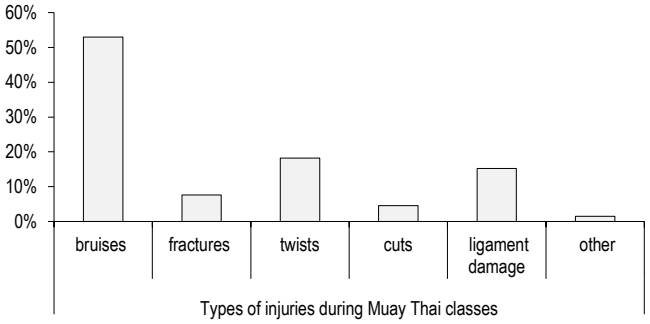

Figure 8. Reported types of injuries during Thai boxing classes

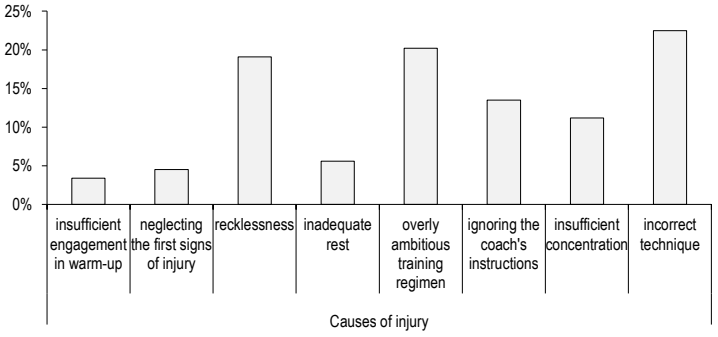

Figure 9. The causes of injury reported by the respondents

Among the respondents who were injured during the Muay Thai classes, 41% needed specialized medical care, while the majority (59%) only needed to cease training for some time. Those respondents who needed specialized medical treatment were diagnosed with the use of ultrasound (26.9%), X-ray (26.9%), magnetic resonance imaging (9.6%), and arthroscopy (3.8%). 32.7% required only basic medical examination (Figure 10).

The most of injured respondents (46.2%) required rehabilitation. The reported periods of rehabilitation were: 2 weeks (35.5%), about a month (29%), 3 months (22.6%), and more than 3 months (12.9%) (Figure 11).

An injury was accompanied by a fear of performing certain training activities in 28.2% of respondents, and no such effect was reported by the remainder of the respondents (71.8%).

The most common physical therapies following injury included physical treatment and specialist massaging (33.3% each), and rehabilitation exercises (18.2%). Less frequent were physiotherapy and kinesiology taping (6.1% each).

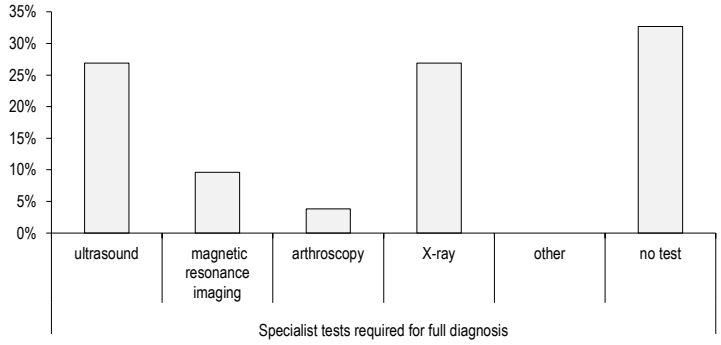

Figure 10. Diagnostic tests used in injured respondents

Figure 11. The duration of rehabilitation following injury

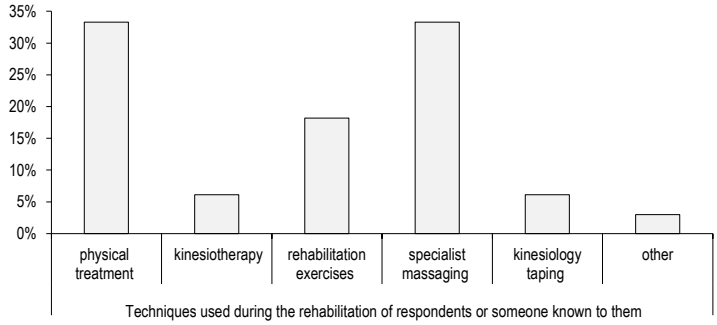

Figure 12. Types of rehabilitation after injuries

Spearman rank correlation coefficients were calculated to establish potential correlations between the incidence of injury sustained during Thai boxing classes, the training phase, type of injury, and: age, gender, attendance at classes, and degree of advancement. Statistically significant correlations (at $\alpha \leq 0.05$) were found only between injury incidence and gender ($r_s = 0.52$), injury incidence and the degree of advancement ($r_s = 0.45$) (with injuries more frequent among men and more experienced fighters), and the type of injury and gender (with men receiving more bruises) ($r_s = 0.45$). In other cases, correlations were statistically insignificant.

Discussion

Although Thai boxing is popular enough for the general public to be aware of the existence of this sport, it still remains relatively unpopular and as such is rarely examined by researchers. A few available studies on this subject, e.g. by Delph (2005) or Evans (2006), indicate a lower level of trauma in people practicing the discipline than in our study.

According to our results, Muay Thai may be considered a sport with a high rate of injuries, as more than half of respondents had been injured, and nearly three-quarters of them knew someone who had suffered from injury. Evans (2006) showed that male Thai boxers who took part in competitions had more head and neck injuries (21.42/1000) than women (16.91/1000). In addition to bruises, concussion was the most frequent head trauma. The results obtained in our work partially overlap with the results of Evans, as bruises were the most common injuries among the respondents (53%). This high number results from defenses against kicks, with legs against low- and middle-kicks, and poorly aimed kicks. e.g. shank hitting the elbow or knee. It is also worth noting that an increasing severity of fighting in Thai boxing is associated with less protective equipment.

According to our respondents, injuries most often occurred in the lower limbs, i.e. in thighs and shanks (19.3% respondents). According to Widuchowski (1998), knee injuries constituted 15–30% of all damage to the human body in sports. Our respondents also reported a relatively high incidence of knee injuries 18.1%. Three Muay Thai basic kicks: low-kick, middle-kick, and high-kick require the rotation of the knee and hip, while the weight is transferred to the support leg; this causes excessive load of the knee. In addition, low kicks, with a primary goal to disable the locomotive ability of the opponent, are aimed at the inner and outer thigh, and are able to damage the joints of the opponent.

Sparring proved to be the most risky part of Muay Thai training, i.e. the simulation of real combat. Respondents most frequently ascribed the injury to incorrect technique (22.5%) and excessive ambition (20.2%). Inappropriate technique is often an underrated problem in combat sports; it includes both the technique of keeping guard, footwork, punches, and kicks. Inadequate aspirations during training often involve the excessive use of force in relation to the sparring partner.

Conclusions

1. The surveyed combat sportsmen from the Nak Muay association were mostly men aged 19–41 years, with secondary and higher education, living in large urban areas, representing mainly the intermediate and upper-intermediate levels of advancement in Muay Thai.

2. The most common motivations of the respondents in training this sport were the need for self-fulfillment and health benefits.

3. More than half of the respondents sustained an injury during Thai boxing classes, most commonly bruises to the lower limbs (legs and thighs).

4. Sparring proved to be the most injury-prone part of Muay Thai training, usually due to incorrect technique and a lack of imagination while exercising.

5. Rehabilitation was used by 53.8% of the injured respondents, with the recovery time after injury lasting most often two weeks. The most common therapy was based on specialized massage and physical treatment.

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SEX DIFFERENCES IN SHOCK ATTENUATION DURING RUNNING

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Abstract The current investigation was conducted to determine whether sex differences in skeletal accelerations and shock attenuation were evident during running. Twelve male and twelve female recreational runners ran at 4.0 $m.s^{-1}$. Axial accelerations were measured at 1,000 Hz using accelerometers mounted at the tibia and sacrum. Peak tibial and sacrum axial accelerations were obtained and utilized to calculate the extent of shock attenuation. The results showed that peak sacrum accelerations were significantly larger in female runners (5.16 ±0.64 g) compared to males (4.37 ±0.75 g). It was also shown that shock attenuation (31.90 ±19.85%) was significantly lower in female runners in relation to males (47.89 ±11.46%). The findings from the current investigation indicate that female runners experience greater skeletal accelerations which may place greater stress on the musculoskeletal structures required attenuate transients forces which can be detrimental to passive tissues.

Key words running, gender, shock attenuation

Introduction

Both recreational and competitive distance runners are renowned for their susceptibly to chronic injuries (Taunton et al., 2002), with as many as 80% experiencing an injury each year (van Gent et al., 2007). The aetiology of chronic running injuries is extremely complex and the factors linked to the development of injuries are often poorly understood. However, it is generally considered that running related pathologies relate to repetitive loading of the lower extremities (Robbins, Hanna, 1987; Whittle, 1999). Female runners have been identified as being at increased risk from chronic running injuries in relation to age matched males (Taunton et al., 2002).

It is postulated that sex differences in chronic injury susceptibility relates to the distinct kinetic and kinematic parameters exhibited by female runners (Sinclair, Greenhalgh, Edmundson, Brooks, Hobbs, 2012). Although females are regarded as being at increased risk from running injuries the specific aetiological contributors are not well understood. Thus, there are requirements for further examination into the biomechanical mechanisms that may

be associated with the aetiology of injury in female runners. Only a small number of investigations to date have investigated biomechanical differences between sexes during running.

Malinzak, Colby, Kirkendall, Yu, Garrett (2001) investigated gender differences in coronal and sagittal plane knee motion. It was demonstrated that the whilst the coronal plane knee excursion was similar between genders, women were found to exhibit less peak knee flexion and a lower range of motion in the knee compared to men. Ferber, Davis, Williams (2003) examined the gender differences in 3-D kinematics of the hip and knee. Female runners exhibited greater peak hip adduction, hip internal rotation and knee abduction compared to men. Sinclair et al. (2012) examined the kinetics and 3-D kinematics of running, their findings showed that whilst no differences in kinetics were evident, female runners exhibited an increased knee abduction and internal rotation. Sinclair, Selfe (2015) investigated sex differences in patellofemoral loading during the stance phase of running. They found that females were associated with significantly greater patellofemoral loads than male runners.

Each foot contact during running causes a transient impulse propagates through the musculoskeletal system (Whittle, 1999). The impact transient generated as a function of footstrike is attenuated by the musculoskeletal structures in order to abate accelerations at the skull, which would otherwise lead to disorders of the vestibular and visual systems (Hamill, Derrick, Holt, 1995). Shock attenuation is therefore an essential parameter when quantifying impact transients during running, as it serves a quantifiable indicator of the extent to which the impact shock wave is reduced (Shorten, Winslow, 1992). The mechanical process by which shock is attenuated is through the absorption of energy via muscle contraction, lower extremity alignment and deformation of passive musculoskeletal structures (Mercer et al., 2010). It has been shown that can be mediated by a number of different biomechanical/ anthropometrical parameters (Mercer et al., 2010). However there is current no research which has examined sex differences in shock attenuation during running.

Therefore, the aim of the current investigation was to examine sex differences in skeletal accelerations and shock attenuation during running. A study of this nature may provide further insight into the distinct chronic injury profiles of male and female runners.

Methods

Participants

Twelve male and twelve female runners volunteered for this investigation. The mean characteristics of the participants were males; age age 25.1 ±4.0 years, height 1.77 ±0.1 m and body mass 73.2 ±6.5 kg and females; age 24.2 ±4.5 years, height 1.66 ± 0.1 m and body mass 64.3 ± 6.4 kg. Runners were free from musculoskeletal pathology at the time of data collection and gave written informed consent. The procedure utilized for this investigation was approved by a University ethical committee.

Procedure

Participants ran at a velocity of 4.0 $m.s^{-1}$ ±5%, striking an embedded piezoelectric force platform (Kistler, Kistler Instruments Ltd., Alton, Hampshire) with their right (dominant) foot (Sinclair, Hobbs, Taylor, Currigan, Greenhalgh, 2014). Running velocity was quantified using infrared timing gates (Newtest, Oy Koulukatu, Finland). The stance phase was delineated as the duration over which >20 N of vertical force was applied to the force platform (Sinclair, Edmundson, Brooks, Hobbs, 2011). Runners were required to complete five successful trials.

To quantify accelerations at the tibia and sacrum, two accelerometers (Biometrics ACL 300, Gwent United Kingdom) sampling at 1,000 Hz were utilized. The accelerometers were both positioned onto a piece of lightweight carbon-fibre which is the same as the mounting protocol documented by Sinclair, Greenhalgh, Edmundson, Brooks, Hobbs (2013). The tibial accelerometer was attached securely to the anterio-medial aspect of the distal tibia in line with its longitudinal axis 8 cm above the malleolus (Sinclair, Bottoms, Taylor, Greenhalgh, 2010). The sacrum accelerometer was positioned onto the bony prominence of the sacrum and secured using an elastic belt (Mizrahi, Verbitsky, Isakov, Daily, 2000). The sacrum accelerometer was positioned so that its vertical axis aligned with the longitudinal axis of the spine. Ground reaction force and acceleration data were collected synchronously using an analogue to digital interface board.

Processing

The acceleration signals were filtered with a 60 Hz low-pass Butterworth 4th order zero-lag filter. Peak tibial acceleration was defined as the highest positive acceleration peak measured during the first 20% of the stance phase. Peak sacrum acceleration delineated as the highest positive acceleration peak during the first 50% of stance. Acceleration slope at each location was quantified by dividing acceleration peak by the duration over which the acceleration occurred. With the data obtained above shock attenuation was also calculated using the formula outlined below.

$$\text{Shock attenuation \%} = [1 - (\text{peak sacrum acceleration} / \text{peak tibial acceleration}) \times 100].$$

Analysis

Statistical differences in acceleration and attenuation parameters between sexes were explored using independent samples t-tests, with significance accepted at the $P \leq 0.05$ level (Sinclair et al., 2013). All statistical tests were conducted using SPSS v22.0 (SPSS Inc., Chicago, USA).

Results

Table 1 and Figure 1 present sex differences in skeletal acceleration and shock attenuation parameters. The results show statistical differences between sexes for acceleration and attenuation parameters.

Table 1. Sex differences in skeletal accelerations and shock attenuation

	Male		Female	
	Mean	SD	Mean	SD
Peak tibial acceleration (g)	8.94	2.33	8.64	3.49
Peak sacrum acceleration (g)	4.37	0.75	5.16	0.64
Time to peak tibial acceleration (s)	0.05	0.04	0.05	0.03
Time to peak sacrum acceleration (s)	0.07	0.01	0.08	0.01
Tibial acceleration slope (g/s)	309.24	139.98	324.37	182.33
Sacrum acceleration slope (g/s)	67.91	9.62	64.79	6.59
Shock attenuation (%)	47.89	11.46	31.90	19.85

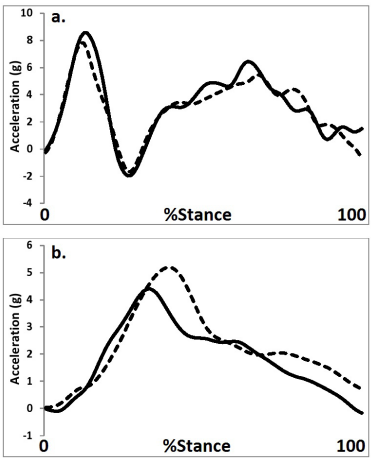

Figure 1. Tibial (a) and sacrum (b) acceleration parameters as a function of sex (black = male & female = dash)

A main effect for peak sacrum acceleration was observed ($t_{(22)} = 2.77$, $P < 0.05$), with females being associated with significantly greater accelerations than males (Table 1; Figure 1b). A main effect was also shown for shock attenuation ($t_{(22)} = 2.42$, $P < 0.05$), with males exhibiting significantly greater shock attenuation compared to females (Table 1). No further significant differences were evident.

Discussion

The aim of the current investigation was to examine sex differences in shock attenuation during running. To the authors knowledge this represents the first comparative investigation of skeletal accelerations and attenuation between sexes. Research of this nature may provide further information regarding aetiological factors that contribute to the distinct chronic injury patterns in males and female runners.

The first key finding from the current investigation is that sacrum accelerations were significantly larger in female runners in comparison to males. This finding may have important implications as clinical research has linked the magnitude of skeletal impact transients to the initiation of lower back pathologies in runners (Voloshin, Wosk, 1992). Aetiological literature has also shown that female runners are more susceptible to stress fractures than age matched males (Miletic et al., 2012). Specifically it has been demonstrated that sacral stress fractures occur more frequently in female runners (Pester, Smith, 1992). The current investigation therefore supports the conjecture that female runners are at increased risk from stress fractures and low back pain and may provide new information regarding the mechanical stimuli that contribute to these pathologies.

Of further importance is the observation that shock attenuation was significantly lower in female runners in comparison to males. Therefore, it can be speculated that greater shock transmission from tibia to sacrum may lead to greater propensity for chronic damage as passive musculoskeletal structures endure increased stress. The findings from this study oppose those from Dufek, Mercer, Griffin (2009) who showed that female runners exhibited greater shock attenuation. It is proposed that this divergence between studies may be due to the reduced

velocities that the participants of Dufek et al., were tested under in relation to the current study. The increased running speed from the current study may have placed increased stress on the musculoskeletal system. Therefore a distinct strategy of attenuating impact accelerations may be evident during higher running speeds (Dufek et al., 2009). Shock attenuation represents the mechanical process by which transient energy diminishes as it propagates through the musculoskeletal system (Valiant, 1990). Shock attenuation is achieved via muscle contraction, lower body alignment and passive musculoskeletal tissue deformation (Mercer et al., 2010). A further discrepancy is that Dufek et al. (2009) quantified transient attenuation from the tibia to the head as opposed to the sacrum. This indicates that females may attenuate transient accelerations to a greater extent from tibia and head but to a reduced degree between tibia to sacrum. This observation may therefore provide further insight into the increased susceptibility of females to lower extremity chronic pathologies (Taunton et al., 2002), although further prospective analyses are required with shock attenuation as a designated risk factor before this can be substantiated clinically.

A potential limitation of the current study is that the potential effects of wobbling mass on skeletal accelerations were not accounted for. Challis, Pain (2008) proposed that tissue artefact can affect skeletal accelerations during dynamic activities. It can thus be speculated that females runners examined as part of the current investigation may have had a higher percentage of adipose tissue, and as such comparative results of shock attenuation between sexes may have be influenced by this (Dufek et al., 2009).

In conclusion, whilst sex differences in running biomechanics have been investigated previously there has yet to be any published work which has examined shock attenuation in between sexes. The current study addresses this by providing a comparative investigation of skeletal accelerations and shock attenuation in male and female runners. The current investigation showed that sacrum accelerations were greater and shock attenuation was significantly lower in female runners. The findings from the current investigation indicate that female runners experience greater skeletal accelerations which may place greater stress on the musculoskeletal structures required attenuate transients forces which can be detrimental to passive tissues.

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THE REPORTING OF THE JOURNALISTS OF "RAZ, DWA, TRZY" AT THE OLYMPIC GAMES IN BERLIN IN 1936

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Abstract The Olympic Games of 1936 in Berlin found sports and Olympic movement in the Second Republic of Poland at a stage of developing and strengthening its organizational structure. The most famous and honored sport newspapers were: "Przegląd Sportowy" from Warsaw and – published by "IKC" concern from Cracow – "Raz, Dwa, Trzy". The circulation of both titles constituted more than 3/4 of the circulation of all the sporting titles in the Second Republic of Poland. In this paper reports of "Raz, Dwa, Trzy" correspondents of the Olympic Games and the capital of Germany were presented.

The analysis of the reporting of the journalists of "Raz, Dwa, Trzy" from the The Games of the XI Olympiad in Berlin allows to conclude that the narration of the reports fully corresponded with the aforementioned Polish-German Press Agreement of the 7th October 1934 and its basic assumptions. At the same time it was in accordance with the appreciation expressed to German organizers by foreign correspondents. The relations of the correspondents from Cracow indicate that Hitler's' regimentation reached its goals also in this environment. Enormous sports and infrastructural investments in the Third Reich, together with incorporating the modern technology, high degree of social discipline and the penchant for order and cleanliness, so typical for Germans, found their expressive reflection in the pages of "Raz, Dwa, Trzy".

Key words Berlin Olympic Games, Polish sport's press, Nazi Sport

The Olympics and the Third Reich

The Games of the XI Olympiad in Berlin occupy special place in the history of the Olympic movement for several reason Firstly, for the first time in history the hosts involved considerable financial means in the organization of the event, supported by modern construction technology and information flow. Secondly, Germany was a totalitarian country, which three years after the Olympics unleashed the World War II and perpetrated terrible crimes, most of all – the Holocaust. German (Alkmeyer, 1996; Eisenberg, 1999; Geyer, 1996, pp. 41–44; Kruger, 1972, pp. 180–181; Peiffer, 2009; Simon, 1964; Teichler, 1976; Wildmann, 1998) and Polish historiography (Falewicz, 2004, pp. 58–61; Jucewicz, 1972, pp. 44–49; Młodzikowski, 1970, 1971, 1984; Olszański, 2000, pp. 24–25; Weiss, 1972) agree that Hitler used the fact that in April 1931 in Lausanne the Weimar Republic was chosen to organize the Olympic Games

in 1936 and prepared a giant political mise-en-scene, both for internal and external use. The "New Germany" was presented as an economic power, the country of technical innovation, inhabited by people (Nation/Volk) united around Führer and fully engaged in the fulfillment of the goals of National Socialism. It cannot be forgotten that Hitler, through his giant propaganda apparatus and declaring his faith to the tradition of ancient Olympics, prepared an efficient show aimed at seducing the world (Harder, 1936). He stole and changed the meaning of traditional Olympic values and symbols. The Nazi filled the Olympic Games of 1936 with military elements, the motives of sacrifice and cult of death. These elements were clearly seen in the artistic performances and monumental sculptures. All those actions were fully accepted by the International Olympic Committee, as well as by P. de Coubertin himself, who eagerly took part in payed guest appearances in German radio (Lipoński, 2012). For German society of that time, independently of the judgements, the Olympic Games of 1936 until the end of the World War II remained the unexampled triumph of German sports, reflected by the top places in medal and scoring tables (Porada, 1980).

The Olympic Games of 1936 and the Second Republic of Poland

The Olympic Games of 1936 in Berlin found sports and Olympic movement in the Second Republic of Poland at a stage of developing and strengthening its organizational structure. These actions, right from the beginning, have been conducted by the elites of revived Poland with enormous determination despite giant material and cultural losses from the World War I. The preparations started under annexations, laying the foundation for the development of physical activity and grassroots sport (Zaborniak, 2009).

The society has been gradually "infected" with the Olympic idea passing down the reports from the first and the following modern Olympic Games (Cybula, 2006; Stępnik, 2010). Polish middle-class movement, immediately after regaining the independence, established its ties with international sports movement by creating PKOl (Polish Olympic Committee) and, afterwards, national sports associations and federations (Gaj, Hądzelek, 1991). Associative movement in Poland, retarded if compared to England, was not much lagging behind compared to other European countries. At the end of the 19th century it gained the ability to join and evolve into higher level organizations (Lipoński, 2012). The most important stimuli in this matter were establishing the Polish Olympic Committee in October 1919 and the will to participate in the first post-war Olympic Games in Antwerp in 1920. These aspirations were accompanied by thorough pioneer actions (Dobrowolski, 1948; Słoniewski, 1986; Wryk, 2012).

Gradual strengthening of the position of Polish Olympic Committee toward International Olympic Committee was a result of the tendency of national Olympic committees to decide about the movement's character and its mission in the world (Młodzikowski, 1984; Wryk, 2012). The consecutive governments of the Second Republic of Poland and the First Marshal of Poland Józef Piłsudski supported sports and Olympic movement at the organizational, scientific and educational level.

The Department of Sports was created at the University of Poznań, and Central Institute of Physical Education (CIWF) was established in 1927 in Warsaw (Gawkowski, 2012; Szymański, 1998; Wieczorek, 2008). Sports and Olympic movement gained an important ally, namely: the sports press and the developing journalistic environment (Kunert, 2008).

Polish athletes that went to Berlin had already had the experience of participation in three former Summer Olympic Games (Paris 1924, Amsterdam 1928 and Los Angeles 1932) and four Winter Olympic Games (Chamonix 1924, Saint Moritz 1928, Lake Placid 1932 and Garmisch-Partenkirchen 1936). Their medal record was rather

good. In 7 events Poles won 3 gold, 8 silver and 9 bronze medals- all of them during Summer Olympic Games (Gaj, Hądzelek, 1991).

Sports press in the Second Republic of Poland

The first stage of the development of Polish sports press in the interwar period finishes in 1926. Until that time all types of sports newspapers had already appeared together with the specialization of sports journalism and the Association of Sports Journalists and Publicists. The relations between the sports press and the government, namely the Department of Physical Education and Basic Training, were mostly correct though cold. Sports press was developing successfully, even in the times of crisis, and before 1939 it achieved a European level. In the times of the Second Republic of Poland 164 sports magazine were being published regularly. The most numerous group of sports magazine were the ones devoted mostly to sports reporting. Their goal was to inform Polish readers about sporting life of the country and the events abroad. The most famous and honoured from this group were two magazines: "Przegląd Sportowy" from Warsaw and – published by "IKC" concern from Cracow – "Raz, Dwa, Trzy". The latter was edited by Adam Obrubański [1892–1940], Włodzimierz Długoszewski [1905–1945], Jerzy Jakub Rochatiner [1904–1979] and Aleksander Szenajch [1904–1987] (Tuszyński, 1997). The existence of "Raz, Dwa, Trzy" is connected to the magazine titled "Ilustrowany Kurier Codzienny" created in 1910 by Marian Dąbrowski, one of the most distinguished organisers and press publishers of the interwar period. Out of a modest local magazine, in a short period of time, he was able to create the biggest and most influential Polish magazine, from the printing, as well as from the popularity, social range, and influence on public opinion point of view. The group of 'IKC" magazines, the so called "Press Palace" in Cracow, became in the period the Second Republic of Poland the main competitor of "Prasa Polska A" concern from Warsaw. Beside "Orędownika" from Poznań or "Express Ilustrowany" from Łódź it was the leader as far as the number of printed issues is concerned. The career of "IKC" was based on a well-organized system of distribution (printing up to 200,000), print and preparation of journalists and editors.

National departments and a dozen or so of foreign correspondents worked for the needs of the publisher (Łojek, Myśliński, Władyka, 1988, pp. 101–111). The weekly sports magazine "Raz Dwa Trzy" belonged to the "IKC" group (Paczkowski, 1971). It was set up in 1931 and published in the "Press Palace" as a large-format, illustrated newspaper. The most compelling were the big opening and closing photographs, as well as so called "Kaleidoscope" in which photos from various sporting events were presented. Large format, typical for all the magazines of M. Dąbrowski, considerable volume (16 columns), relatively low price compared to illustrated magazines (30 gr) – and obviously – the growing popularity of sports, quickly made this weekly magazine from Cracow nation-wide and well recognizable. In its peak period the newspaper circulation was 50,000 copies. Compared to other similar periodicals-excluding the aforementioned "Przegląd Sportowy" – it could be considered the leading one (Paczkowski, 1971).

The circulation of both titles constituted more than ¾ of the circulation of all the sporting titles in the Second Republic of Poland. Apart from these two titles, also "Sport" from Lvov, "Wychowanie Fizyczne" (Poznań–Warszawa), "Stadjon", "Sport Polski" and "Sport Wodny" were noteworthy (Maślanka, 1976). In the 1930's a considerable number of instructional and professional magazines were being published under the auspices of National Institute of Physical Education and Basic Training.

The magazines published by Jewish organizations, i.e. "Makkabi" were of a smaller outreach. Almost all the daily newspapers had their sports columns which often occupied much space. Some editors had their own teams of specialized journalists responsible for sports columns. Polish Association of Sports Journalists and Publicists

was established in 1925 (Dudek, 2001; Paczkowski, 1980; see also: Jakubowska, 1962). 50% of all the journalists worked in the biggest cities of the Second Republic of Poland. The modern and comfortable (at that time) edifice in Marszałkowska Street, where the editorial offices of four daily newspapers and some periodicals belonging to "Dom Prasy" were based, became "the opinion-forming center of Polish journalistic thought" (Nałęcz, 1982). The journalists who worked there were specialized in particular sport disciplines, i.e. Zygmunt Weiss in cycling, Kazimierz Gryżewski in tennis and Zbigniew Lewicki in swimming. This is also where the journalistic talent of Wojciech Trojanowski, the leading athlete and Olympian from 1928 matured (Tuszyński, 1997). In "Raz, Dwa, Trzy" Władysław Długoszewski, Jerzy Rocha and Aleksander Szejnach were the leading admires of Olympic preparations of the Second Republic of Poland and the Third Reich. They belonged to the group of the leading, professional sports journalists who were able to speak foreign languages and were by no means anonymous abroad. They were people in the limelight of the authorities who used to organize different meetings in order to get them closer. For instance, the local authorities of Warsaw regularly wined and dined the journalistic elite during dinners. On the other hand, important representatives of the government, church, local authorities, the world of culture and scence, as well as the employees of foreign diplomatic posts often participated in the journalist deliberations (Nałęcz, 1982).

All the cultural and social processes encompassed also the editorial offices and journalists of the biggest sports magazines which, like in the case of "Przegląd Sportowy", remained under the direct influence of the government.

The departure of Polish Olympic team and a large group of Polish journalists to Berlin took place, as mentioned, in the conditions of Polish-German rapprochement also in this area. Special entities popularizing sporting achievements of both countries were established in Warsaw and in Berlin, and the rapprochement had its origins back in the Weimar Republic.

Polish Committee of Sporting Evets was set up in Berlin and led, consecutively, by: Wojciech Gawroński, and next Andrzej Kruczkiewicz (Gąsiorowski, 1982). It is worth remembering that Poland had its "contribution" in the fact that the International Olympic Committee awarded the 1936 Summer Olympics to Berlin. During the International Olympic Committee's meeting in Lausanne in May 1931 Polish delegates Ignacy Matuszewski and Stanisław Roupert voted for the German capital city (Karl Lennartz, 1994). As one of the coryphaei of post-war sports journalism said, Germans tried to maintain good and warm relations with Polish sport (Gryżewski, 1968). We should add that it was reciprocal.

The Olympics and the relations between Poland and Germany

At the beginning it is worth mentioning that in the reports coming from berlin by the correspondents of "Raz, Dwa, Trzy" the Olympic Games and the capital of Germany were presented in a good light (Stępiński, 2008). G. Walters claimed that for many people visiting Berlin what was striking were not only the omnipresent swastikas and Olympic rings, but also the pervasive militarism (Walters, 2008). W. Lipoński wrote about the propaganda present in every corner of the city and the Olympic village (Lipoński, 2012). The opinions differed. The reporting of Polish journalists should be seen in the context of sports contacts between the Second Republic of Poland and the Third Reich intensified after 1934 and resulting from, inter alia, Polish-German agreements (German–Polish Non-Aggression Pact and Press Agreement from 1934) aimed at supporting peaceful and good-neighbourly relations (Fischer, 1992). Moreover, those relations were much more intensive that in the times of Weimar Republic. Polish representatives were always received hospitably and with all the honours (Gąsiorowski, 2008). When assessing

those relations one has to bear in mind that the enthusiasm of Polish journalists for the Olympic facilities was present in the whole world at that time. The guests leaving Berlin in 1936 were impressed by the extraordinariness of the event, the inhabitants of the city and the city itself. Polish people were prepossessed by the propaganda posters in Polish, which could be seen in Berlin (Rurup, 1996), as well as the participation in International Camps for Youth and Students organized in Germany before the Olympics. Young, foreign visitors could participate in the Olympics for free and their stay was full of cultural and tourist events (Suchorzewski, 1936). Also the world of Polish authorities from the field of sport sciences (anthropologists, doctors, pedagogues and physiologists) cooperated with the most important German research centers (Cejlar, 1936).

The Olympic Games of 1936 in the pages of „Raz, Dwa, Trzy"

One of the first articles expressing the appreciation for the Games of the XI Olympiad in Berlin was published in "Raz, Dwa, Trzy" on the 7th of April 1936. The author was relieved because the opponents of the Olympics in Berlin were defeated. He claimed that Germany had to win over the enormous campaign started by the opponents of the Olympics. For a moment it seemed that they were going to succeed, however the Olympic idea triumphed. Germans included Jews – Rudi Hall and Helene Meyer – in their national team, and therefore they refuted the arguments of the "enemies of the Olympics of Berlin" (Raz, Dwa, Trzy [futher: RDT], 1936, 14). The editors of RDT rushed to inform that even though that for a moment the Olympics were threatened by the "little Austria" whose government was afraid of the Nazi propaganda, finally it withdrew form this strict standpoint and sent Austrian athletes to Berlin. Not even residual reports concerning the boycott of the Games of the XI Olympiad in the USA can be found in RDT. Instead, under a big heading saying "Pre-Olympic fever in the USA" one could find an extensive report on the preparations of the Olympians in the USA supported by numerous illustrations. The enthusiasm of the newspaper from the 7th of April found its continuation on the 9th of April – below the title it was written that "it turned out that the whole hate-campaign against the organization of the Olympic Games in Berlin ended up without any results, and the number of 53 countries reported to the Olympics is a record, never present in any former Olympic Games". Later, the author informed about the hidden purpose of the event in Berlin, unfortunately not the one we would have expected:" We will be the witnesses of the impressive championships of the amateur world with which no other event in the world can compete. To start with, there will be everybody who has anything to say in any of the sports disciplines. We are therefore witnessing a great victory of the idea of the brotherhood of nations over the more mundane trends, the use of a great sports event for political purposes and to set prominent nations of the world against each other" (RDT, 1936, 23).

This line of the newspaper, emphasizing the loyalty of the host country for the Olympic idea, was maintained throughout, far beyond the period of preparation and duration of the Olympic Games. It was expressed both in the content, as well as in the illustrations suggestively affecting the reader's imagination.

The correspondents from the weekly magazine from Cracow were impressed by the incredible scale of the preparations of Berlin to the Games of the XI Olympiad, which increased the international status of the Third Reich's capital city. The reader could learn that it became the capital city of the world for the time of the Olympics. Ehlert, the editor, in positive terms reported on the city which appareled an "Olympic gown". At that time he was not bothered by the omnipresent flags with swastikas. In his opinion Berlin, just like ancient Olympia, was well-prepared for the organization of the Olympic Games and the arrival of 50,000 visitors: "The participants will find everything ready, starting from the smallest details. If someone has ever visited Berlin he can be sure not to recognize the city, it has

changed so much. Berlin is not only decorated with the Olympic emblems, but also the people and daily habits have changed. Everything was marked by the Olympic Games" (RDT, 1936, 30a).

RDT, together with the others, shared the enthusiasm of the of Carl Diem's supporters' idea of the Olympic Torch travelling from ancient Olympia to Berlin. The Nazi press devoted a lot of space to this journey, treating it – unfortunately rightly – as an original contribution of Nazi Germany to the modern Olympic Games. The way the fire travelled from Greece to Germany was being reported both by the OLYMPIA-ZEITUNG and the film crew of L. Riefenstahl. The originality of the idea and its pioneering nature were emphasized (RDT, 1936, 30b).

Zbigniew Grabowski passed to Cracow a cycle of "Olympic letters", which constituted a series of Olympic reporting from the capital of the Third Reich. He emphasized that the Winter Olympics in Ga-Pa was both a sporting and political phenomenon. Grabowski wrote:

"The Olympic Games of Berlin are a political issue and in principle they were meant to be such an issue. From the beginning they belonged to the politics and were a perfect instrument of what is called propaganda. Their aim is to show the new Third Reich in a positive light and, in the second place – equally important – to refute the arguments of all those who were hostile to the *new Germany*. The aim is to discredit them and show that their allegations are completely unfounded. Germany has to appear as a country of prosperity, peace and incredible hospitality. This hospitality is underpinned by a great organization thanks to the "helpful", omnipresent uniformed services, i.e. the police, SA, or HJ, as well as well-developed network of public transport in Berlin."

The arrival to the capital of the Third Reich was purposely facilitated for numerous visitors. Access roads, the airport and the train stations were all extended and one could feel the smell of fresh paint, they welcomed the guests with the signs in many foreign languages, including Polish. Z. Grabowski was impressed by the new face of Berlin's train stations Berlin Fredrichstrasse and Berlin Zoogarten. The latter gained a new setting of glass. Besides the refurbished means of public transport many small information desks appeared in the city. The waiters and waitresses from numerous Berlin cafes and restaurants were dressed in new uniforms with Olympic rings. Other Olympic symbols were exhibited in the shop windows. The press did not lag behind. Even before the start of the Olympic Games special Olympic issues, such as the aforementioned "Olympia Zeitung" appeared in the newsagents' (RDT, 1936, 31a, see also: Stępiński 2010).

The author also expressed his appreciation for the tremendous panache of sports infrastructure and propaganda setting of the Olympic Games. The Olympic Stadium itself was described by Grabowski as an "impressive 100-thousander." He also liked the newly built swimming pool and large gyms (e.g. Deutschlandhalle) and the events accompanying competitions, such as the "Deutschland" exhibition and the exhibition of Hellenic art opened on July 29th.

According to Grabowski the primary objective of the giant efforts was to display the implicit appreciation of Germany for the tradition of ancient Olympism and the attempt to transfer it to modern times: "Olympics is a period of stopping all the struggles, a general pacification, it is also a demonstration of the fact that Reich, is and wants to be, peaceful. If we put all these qualities together, we have to admit that one could not imagine a better propaganda opportunity than the Olympics to show the world the achievements of the Third Reich. ... The Olympics can and must be used to reveal what you've done ... This is why the German propaganda can rightly say: If there were no Olympic Games, they would have to be created." (RDT, 1936, 31a).

The aforementioned uniqueness of the Games of the XI Olympiad, and to some extent the impression of acceptance for the Third Reich by the Olympic community, were supported by pictures showing the opening

ceremony of the Olympic Congress in the auditorium of the University in Berlin. In the pictures one can see the dignitaries of IOC and notables of the Third Reich, with H. Baillet-Latour and Rudolf Hess in the forefront.

The joy of the opening of the Olympics in Berlin was expressed in the joyous title on the cover of that issue. Against the background of clouds the great banner of the Olympic was flapping in the wind and below one could see the Olympic Stadium. Inside the newspaper, under the title "Welcome of the Polish Olympians in Berlin" there was a large photograph of the welcome of the Polish delegation at the station Berlin-Friedrichstrasse by the Chairman of the Organizing Committee and German officers with hands raised in the "German greeting."

The Cracovian newspaper with satisfaction reported on numberless crowd and perfect weather conditions, and the news about the appearing of the Chancellor Hitler as an acquiescent host who, from his loge, compliments the contestants on winnings was printed in bold.

The information that also Maria Kwaśniewska, a Polish athlete who together with two German sportswomen won the first Olympic medal, had such an honuor was not omitted.

Also the information that on the 2nd of August German athletes won four medals – two gold, one silver and one bronze was bold faced (Volkischer Beobachter, 1936, 49; RDT, 1936, 31b).

After the first day of the Olympic Games also Owens was described as he fastest man in the world who believed that the Olympic Stadium in Berlin was the greatest Arena of the world.

In that issue, although in a different article, the newspaper came back to the topic of the presence of M. Kwaśniewska at the Olympic Stadium. Aleksander Szejnach described the competition in javelin throw and the bronze medal won by the Polish athlete.

The article was meant to flatter Polish national pride and to make Polish javelin thrower another, after Stanisława Walasiewiczówna, star of the Polish Olympic Team. The description of the medal ceremony clashed with the aforementioned post-war way of interpretation of the Games of the XI Olympiad and is an example of normality(or correctness) of the relations between Poland and Germany.

It can be seen not only in the tone of the description itself, but also in the way Kwaśniewska was treated by Hitler. This episode, emphasized in 1936 by the *Sanation* sports press was condemned for total oblivion during the successive 50 post-war years: (RDT, 1936, 31c) "…Both of the German contestants, as well as Kwaśniewska, stand in the middle of the stadium, two German flags and one Polish white and red flag rise up on the mast next to the scoreboard. After the medal ceremony three triumphators of javelin throw were invited to the loge of Chancellor Hitler who talked to them for a while. We had the opportunity to have a closer look at the conversation. Smiling Hitler was talking not only to the Germans, but also to Kwaśniewska who replied very pluckily. It could be seen that the Chancellor was impressed by her and he saw her off even more kindly than he did with the German athletes".

Another expression of full acceptance for the Olympics in Berlin together with its particular competitions was the information about Polish victories in the Olympic Art Competitions in Berlin (Hądzelek, Zuchora, 2012), in which we had great traditions (Lipoński, 1974). German Olympic propaganda appreciated Polish artists. The piece of art called "The ball" by Józef Klukowski was awarded with a Silver Relief (Lorenz, 1936).

Other compliments for the hosts came from Grabowski's article dated August 11th, titled "The Olympic Carnival".

The author stated that besides the rally of the NSDAP in Nuremberg, where it was possible to achieve "memorable mass effects," there have never been such a directing with participation of hundreds of thousands of people in Germany. Grabowski relied on a certain English journalist, who aptly stated that Germans were patterning

themselves on the American Hollywood. Usually "rigid" Berlin was transformed. Colorfully adorned, "packed" with the Olympics it looked like a giant film decoration and was experiencing its carnival.

Grabowski highly praised the working conditions of journalists in Berlin. He himself felt very privileged, surrounded by the extraordinary care and treated seriously by the Organizing Committee and the authorities of the Reich. He stressed with great satisfaction that his Olympic Identity Card ["Olympia-Ausweiss"] allowed him to use all means of communication for free. He was also impressed by organization of work in the press offices, messaging systems and excellent conditions, created by the hosts for the media, including Polish journalists.

In the further period of functioning of the Olympic post the author raised the issue of the contribution of one of the Nazi organizations NSKK (The National Socialist Motor Corps) which left at the disposal of the organizers of the Olympic Games 5,000 motorcycles and the members helped in mail distribution from the morning till the evening.

The author – as a professional – was particularly interested in radio reporting. In his short description of German broadcasting station he gave his excellent opinion about it. He was similarly impressed by the opening ceremony, its deeply Olympic character and unmitigated admiration for the Chancellor of the Reich. The author admired the organization not only of the ceremony itself but also of the entrance and exit of such a mass of people.

To emphasize the range of the event he gave the accurate numbers of the people being transported in Berlin. He got aware of the greatness of the event and the accompanying load of emotions only 48 hours after the end of the opening ceremony: "This colossal stadium reminds me now of some surreal transatlantic liner with numerous stairs and gangways. Up on the captain's bridge there's the press and the radio…the Chancellor, together with the Olympic Committee, went to the entrance which resembles the opening of the Roman Colosseum… the yell "Heil" crushes the stadium…the stadium is alive and beautiful" (RDT, 1936, 32).

At the end of his article the correspondent from Cracow positively referred to the official reception organized by the hosts for the Olympic guests on the 31st of August 1936. He mentioned Joseph Goebbels as an authority figure who reassured the people that the Olympic of Berlin had peaceful and apolitical nature.

The newspaper through the selection of the titles, texts and illustrations strengthened the image of a truly Olympic newspaper and carefree atmosphere of the Berlin Olympics, this "Olympic Carnival." The section called "The Olympic Kaleidoscope" was dominated by pictures showing rows of smiling faces, the representatives of all nations and races, athletes of many countries during the competitions, medal ceremonies, listening to the national anthems or participating in sport competitions. The choice was objective. Next to the photo of Tilly Fleischer from Germany, there was a a photo of an American champion in discus throw – Carpentier. There was also enough space for the world of media and politics. The following pictures showed Leni Riefenstahl filming the stadium and the Chancellor of the Third Reich surrounded by party dignitaries and guests of the IOC in the "Loge of the Führer."

Cracow newspaper correspondents were impressed by the sporting successes of the greatest sports powers of the Games of the XI Olympiad, namely Germany and the USA. In his correspondence dated the 18th of August the correspondent of RDT reported, using headings in capitals, that Germans – motivated by the fighting spirit and cheering crowd – won 5 five gold medals in the sailing regatta finals.

This search for sources of the triumph of the Germans in Grünau indicates a certain, clear boundary that was not crossed by the editors of RDT. The correspondents did not mention the cult of the Führer as a source of motivation for German athletes. In fact, the presence of Hitler at the Olympic Stadium constituted great source of motivation for young German Olympians. They wanted to honour their "beloved" Führer by their sporting successes, as well as express their love and devotion.

The admiration for the triumph of Nazi sport clearly contrasted with boundless sadness because of the weak, as shown, performance of Polish representation at the Games of the XI Olympiad in Berlin. The vastness of sadness, disappointment and frustration did not prevent Polish correspondents from recognizing the triumph of German sport. Two days after closing of the Olympics a great heading "Under the sign of German victory" the admiration for athletic performance of German athletes was expressed. It was stated there that the organizational success was to be expected, however the sporting victory of Germans who with their 33 gold medals beat the Americans (so far regarded the unrivaled sporting nation) was a surprise.

It was described this way: "Germany has shown that the incredible diligence and accuracy can fill in any gaps and shortcomings. Germany won the Olympics in sports and organization and there is no doubt that all the goals of organizers from Berlin have been fully accomplished" (RDT, 1936, 33).

Grabowski, summing up the Olympics, expressed his criticism towards the performance of Polish athletes, justifying them by the greatness of the event, its length and panache, which overwhelmed them and "tied their legs". Later in his text, he emphasized great energy with which the authorities of the Reich began to take advantage of the success of the Olympic Games. Before every film in Germany the "Olympic Review" and the trailer of L. Riefenstahl's film were shown. Grabowski used to call it "the longest film of the world", edited using hundreds of thousands meters of the filmstrip. It was to be shown in 2 parts in every corner of Europe. The author appreciated also the educational value of the film "…This film will be the real school for the athletes from all over the world. They will be able to observe the secrets of Owen's and Lovelock's step, the swing of Jaervinem and the artistry of American divers" (RDT, 1936, 34).

Following the journalistic reports before and after the Olympic Games it can be stated that the journalists themselves were overwhelmed by the greatness of the event. Even before the Olympic torch was lit they used to write that the Olympics was going to be an endless 'Olympic Carnival", however at the end of August they claimed, with a certain relief, that it was good that the "Olympic avalanche was over". Those discrepancies were influenced by the fact that in the summer of 1936 they were not able to write anything about gold medals for Polish athletes. It might have been also a result of the load of work they had to do during the Olympic days.

However, in the end the comments of RDT regarding the Olympic Games were rather enthusiastic, almost in line with the interpretation dominating in the propaganda of the Third Reich.

Their enthusiasm expressed strong support for the segment of propaganda and information policy of J. Goebbels, who, after August 16th expressed his deep and undisguised satisfaction of the authorities of the Third Reich with the triumph of the Olympics and the moral and political defeat of supporters of the boycott. On September 1st 1936 W. Długoszewski with passion rejected the accusations of the enemies of the Reich (RDT, 1936, 35).

"One of the biggest accusations brought against the organizers of the Games of the XI Olympiad was the question of supposed German intolerance of other nations. The anti-German agitation pointed to the fact of relegating the Jews from Germany and was proving that there was no guarantee for the peaceful course of the Olympics in Berlin. In practice, such an argumentation was ungrounded. There were hundreds of representatives of other races at the Olympics and I have not heard of any race-based intolerance. Quite the opposite. I have had a lot of evidence how kind and hospitable the Germans were for the "colored" races.

Later in his text, Długoszewski claimed that the Olympics proceeded in a pleasant atmosphere of trust and omnipresent brotherhood. He also gave numerous examples of positive behaviours, i.e.: "Negroes, hated in America, saved the honour of Americans in athletics. Without them, the Americans would not have played any

role… When Owens won, no one at the Stadium asked about his race. The crowd of one thousand people was cheering the black runner."

According to the author, other foreigners such as the Japanese, the Indians, the Egyptians or the Chinese, were also kindly welcomed. The inhabitants of German towns eagerly listened to the Brazilian folk songs in the evenings and "didn't think about finding a stick for them".

There was a clear message coming from the author's relation aimed at showing the Germans as people by all means tolerant. One would think that the author might not have seen some blatant behaviours. Just the opposite, he was outraged by the posed photographs in which the amateurs of originality purposely collated the representatives of various races, especially Negros and Asians.

In his opinion, it would paint the whole white race in a bad light. In the end he rushed to explain that "those amateurs of originality were not Germans."

In the summary, the author manifested his love to the Olympics that had just finished. The best evidence are his words:

"This was the Olympics of records and the record of the Olympics – a record which will never be repeated… When the bell tolled for the last time and the Olympic flame went off one could feel the regret, the regret that the spectacle was over and will never repeat again… Nowhere else one could better feel that the Olympic sport has reached the level that cannot be better… The Games of the XI Olympiad were a powerful anthem in honour of the Olympic idea and every race. The anthem sounded with a great power and there is no hope for it to be repeated ever again."

Summary

The analysis of the reporting of the journalists of "Raz, Dwa, Trzy" from the The Games of the XI Olympic allows to formulate some judgements. It can be concluded that the narration of the reports fully corresponded with the aforementioned Polish-German Press Agreement of the 7th October 1934 and its basic assumptions. At the same time it was in accordance with the appreciation expressed to German organisers by foreign correspondents. The relations of the correspondents from Cracow indicate that Hitler's' regimentation reached its goals also in this environment. Enormous sports and infrastructural investments in the Third Reich, together with incorporating the modern technology, high degree of social discipline and the penchant for order and cleanliness, so typical for Germans, found their expressive reflection in the pages of "Raz, Dwa, Trzy". Moreover, the triumph of monumental architecture and modern technical civilization was observed from the perspective of a country, which after times of slavery and terrible damage of World War I, could only dream of such infrastructure and organization. It remains an open question to what extent this positive, sometimes enthusiastic picture of Germany as a host of the Olympic Games in Berlin was influenced by the triumph of German sports and rich symbolic and aesthetic sphere.

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FLEXIBILITY PROGRAM AMONG LOWER SECONDARY SCHOOL STUDENTS AND PHYSICAL FITNESS INDICATORS ASSESSED IN THE CONVENTION OF HEALTH-RELATED FITNESS (H-RF)

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Abstract Flexibility is one of the elements – components which support physical fitness and health as well (Howley, Franks, 1997; Bouchard, Shephard, 1994; Skinner, Oja, 1994). The purpose of this paper was to assess the impact of additional flexibility exercises on physical fitness in lower secondary school students, evaluated by means of IPFT (the International Physical Fitness Test). The study was conducted in two experimental groups, where extra flexibility exercises were added to all obligatory PE lessons, and one control group.

1. The decreased standard deviation observed in particular IPFT attempts in the experimental class is the correct tendency showing the favorable influence of flexibility exercises on students' physical fitness and health.
2. An improvement and considerably better, though statistically insignificant, results were obtained by the students involved in the additional exercises, in all assessed motor skills (strength, speed, endurance and flexibility) and in the scoring reflecting the level of physical fitness.
3. After one year of exercises the control group had worse average results in two attempts – 50 m run (to assess speed) and standing forward bend (to measure flexibility). This trend indicates the importance of flexibility exercises as regards speed and agility.

Key words flexibility, physical fitness, health, IPFT (the International Physical Fitness Test), students

Introduction

Physical fitness is one of the main health indicators and belongs to the characteristics which are frequently assessed by specialists from different fields. Over the past few years physical fitness has been contrasted with motor performance or skill-related components – or rather distinguished from them (Osiński, 2009). Howley, Franks (1997) present physical fitness as the purpose of positive health „which determines the low risk of health problems".

As Osiński reports (2003) the assessment of track record in sport used to be the aim of testing the level of physical fitness, yet only in the 1980s there were introduced "the elements of physical fitness characteristics intended to (…) provide information on health". The author emphasizes that physical fitness testing facilitates the identification of one's own body needs and the development of health and care for one's own body. According to the health-related fitness (H-RF), the testing of physical fitness is mainly expected to serve for the purposes of diagnosis and a wide-range support to health patterns and not to refer to the actual level of motor performance (Osiński, 2003; 2009). Health-related fitness consists of such components as body composition, cardiovascular endurance, muscular endurance and muscular strength as well as flexibility (Bouchard, Shephard, 1994; Howley, Franks, 1997; Skinner, Oja, 1994; Osiński, 2009). Flexibility is essential for maintaining a good body posture, a certain level of fitness particularly during old age (Osiński, 2009). Well-developed flexibility ensures that an individual can make a movement in a fast, economic and technically proper way; what is more, it can be developed by every man at every moment of life to achieve a high level indeed. Nevertheless, the best time to shape flexibility is childhood because just then the body becomes most susceptible to stimulation of flexibility development (Marciniak, 1998). The available literature provides a large number of references with strong indications of the links between physical activity, fitness, efficiency and health. Yet, these indicators, defined as the so called positive health measurements, are not used in medical diagnostics (Drabik, 2006).

Aiming at their improvement is becoming the subject of research (Bendikovà, Šmída, Rozim, 2014; Łubkowska, Troszczyński, 2011; Kostencka, et al., 2004; Przewęda, Dobosz, 2003) and a strategy of numerous countries (Bendikovà et al., 2014; Bendikova, Uvinha, Pines, Kanásová, Šmída, 2015; Bendíková, Kostencka, 2013; Rado, Dervišević, Kovač, Ćirić, 2015).

The purpose of this study was to determine the influence of the flexibility program on physical fitness in boys at lower secondary school age.

Material and methods

The study was carried out in five stages:

- the first stage included the choice of a lower secondary school and the classes at the same education level, taught by the same teacher of physical education. Then two groups were selected from among the classes – the experimental group and the control one,
- the second stage involved the somatic development assessment based on the measurement of body height and weight, as well as the body mass index,
- the third stage was the assessment of the physical fitness level on the basis of the IPFT (Drabik, 2006),
- the flexibility program was introduced during the fourth stage,
- the reassessment of the physical fitness level took place in the fifth stage.

The study was conducted in the Lower Secondary School No. 1 in Tuchola and the experimental group (class 1B) and the control group (class 1D) were selected as a result of random sampling. The study group consisted of boys with the same conditions to take up compulsory physical activity – physical education lessons. Both classes attended four lessons under the core physical education curriculum on a weekly basis and the lessons were given by the same teacher.

Then the somatic development assessment was performed to verify if this development was at the similar level (if there were any significant differences in body height, weight and body mass index) (Table 1). The following

step was the physical fitness assessment based on the IPFT followed by introducing the additional 15-minute flexibility program to compulsory physical education lessons in the experimental group. Finally, physical fitness was reassessed in order to determine the impact of the extra flexibility program on the results achieved in subsequent physical fitness attempts. Each stage of physical fitness testing was conducted in accordance with the methodology (Drabik, 2006).

The experimental group (class 1B) consisted of 15 boys whereas the control group (class 1D) of 18 individuals.

The fitness attempts were performed in the gymnasium, at the Orlik pitch and sports stadium. The students involved in the study performed the fitness test in sportswear after a warm-up.

The physical fitness test was made up of 8 attempts: 50 m run (to measure speed), standing long jump (to measure the jumping ability/ explosive power of the lower limbs), 1000 m run (to measure endurance), handgrip test (to measure hand strength)[1], flexed arm hang (to measure relative strength), 4 × 10 m shuttle running test (to assess agility), 30 s sit-and-reach (to measure abdominal muscle strength), trunk flexion (to measure flexibility) (Drabik, 2006).

Flexibility exercise program

The flexibility program was based on ''The battery of correctional and flexibility exercises" by J. Marciniak (1998, pp. 66–94) and included the set of the exercises mentioned below.

1. The upper limb and pelvic girdle exercises:
   a) starting position: standing with legs spread apart. Step aside with your right leg and simultaneously swing your arms in opposite directions. After 10 swinging exercises change your leg and perform the same battery with your left leg;
   b) starting position: standing with legs spread far apart. Arm rotation forwards for 10 seconds, then backwards for another 10 seconds;
   c) starting position: stand with arms straight forward, then rest your right wrist on the left elbow and pull behind your head, next return to the starting position and repeat with the other arm. Do this exercise 5 times on each side.
2. Lower limb exercises:
   a) starting position: standing with your legs slightly spread apart and your knees bent, make the swinging movement to the left and then to the right; exercise for 10 seconds to each direction;
   b) starting position: standing. Swing your right leg forward and up to your left arm straight ahead and repeat the exercise with the other leg. Do this exercises 10 times on each leg;
   c) lie back, keep your arms straight along your trunk, knees bent at ca. 90 degrees. Swing your legs alternately forward up and down. Swing each leg up 10 times.
3. Trunk exercises:
   a) starting position: standing position with your legs together and arms at side. Lean forward and simultaneously swing your arms backward, return to the starting position Leanie backward. Repeat the exercise 10 times;
   b) stand with your legs apart, raise your arms and grip your elbows. Keeping this position lean forward and return to the starting position. Do this exercise 10 times;

c) lie on your stomach. Pull your trunk maximally backward with your shoulders and simultaneously pull your head back.

Compilation of statistical material

The collected material was subject to the statistical analysis using the basic methods of descriptive statistics (arithmetic mean, standard deviation). The formulated hypotheses about the significance of differences in average deviations for particular tests were verified by means of statistical tests: for two average values (Student's t-test for independent variables), Student's t-test for differences between the correlated pairs of measurements. The analysis of the correlations between the measurements was carried out using the Pearson's linear correlation coefficient.

Results

Below there is presented the evaluation of the significance of differences and the comparison of the average results achieved by the subjects: between the experimental group (1b) and the control group (1d) in the study conducted in autumn and spring (Table 1), between the results produced by the individual groups in the study in autumn and spring – the experimental group (class 1b) Table 2, the control group (class 1d) Table 3.

Table 1. Statistical characteristics of the significance of differences, the results achieved in the particular IPFT tests, between the experimental group (1b) and the control group (1d) in the study conducted in autumn and spring

IPFT	Analyzed groups		T	p	1 b	1 d
	1 b	1 d				
	$\bar{X}$	$\bar{X}$			SD	SD
50 m run – autumn	8.2867	8.2833	0.01111	0.991209	0.95608	0.76869
50 m run – spring	8.2733	8.6111	–1.16925	0.251217	0.71261	0.90936
Standing long jump – autumn	158.2667	170.8333	–1.33628	0.191184	29.10196	24.94052
Standing long jump – spring	163.6000	175.6111	–1.18346	0.245623	27.22079	30.44018
1000 m run – autumn	313.6000	302.2778	0.61900	0.540437	57.68114	47.45128
1000 m run – spring	297.5333	287.6667	0.53970	0.593261	58.83739	46.21306
Hand strength – autumn	13.0667	12.4444	0.46335	0.646347	3.99046	3.71360
Hand strength – spring	14.4000	13.8333	0.39802	0.693340	3.75690	4.31482
Flexed arm hang – autumn	16.0340	10.6500	1.22825	0.228597	15.11431	9.92734
Flexed arm hang – spring	21.1800	12.9944	1.55434	0.130255	18.31862	11.72285
4 × 10 m shuttle running test – autumn	12.5000	12.1778	1.01126	0.319720	1.11484	0.70089
4 × 10 m shuttle running test – spring	11.7400	11.3778	1.31972	0.196591	0.88221	0.69499
Sit-and-reach – autumn	21.0000	25.0556	–3.30922	0.002379	3.33809	3.63759
Sit-and-reach – spring	22.2667	25.7778	–2.37135	0.024118	3.36933	4.83316
Trunk flexion – autumn	–0.9333	2.0000	–0.96679	0.341134	11.16414	5.89117
Trunk flexion – spring	2.0667	1.4444	0.20427	0.839477	10.84611	6.44636
Physical fitness level (score) – autumn	328.1333	341.8333	–0.56983	0.572898	83.43335	53.77103
Physical fitness level (score) – spring	341.6000	351.6111	–0.39900	0.692630	82.10168	61.97926

When analyzing the results achieved in the particular IPFT attempts by the experimental group (1b) and the control group (1d), some slight differences can be observed in the average results revealed in the tests between

both groups in autumn and spring alike. The only significant difference between both groups was reported in the sit-and-reach test. Significantly better results were produced by the students from the control group (1d) in autumn and spring as well.

Table 2 outlines the differences in the average results achieved in the individual physical fitness tests by the experimental group (1b) at the onset of the experiment (autumn) and the end (spring).

Table 2. Statistical characteristics of the significance of differences concerning the results achieved in the individual IPFT attempts in the experimental group (1b) at the onset of the experiment (autumn) and at the end (spring)

Class 1b				
IPFT	Period of test		t	p
	autumn	spring		
50 m run	8.286667	8.273333	0.043306	0.965765
Standing long jump	158.266700	163.600000	0.518362	0.608278
1000 m run	313.600000	297.533300	0.755214	0.456427
Hand strength	13.066670	14.400000	0.942211	0.354144
Flexed arm hang	16.034000	21.180000	0.839210	0.408460
4 × 10 m shuttle running test	12.500000	11.740000	2.070431	0.047747
Sit-and-reach	21.000000	22.266670	1.034340	0.309829
Trunk flexion	–0.933333	2.066667	0.746469	0.461607
Physical fitness level (score)	328.133300	341.600000	0.445571	0.659333

The analysis of the average results achieved in the particular IPFT attempts at the beginning and the end of the experiment showed some improvement in all results achieved, yet the results turned out to be insignificant. However, a significant improvement was observed in the trunk flexion test.

Table 3 presents the differences in the average results achieved in the physical fitness tests in the control group (1d) at the onset of the experiment (autumn) and at the end (spring).

Table 3. Statistical characteristics of the significance of differences concerning the results achieved in the particular IPFT attempts in the control group (1d) at the onset of the experiment (autumn) and at the end (spring)

Class 1d				
MTSF	Period of test		t	p
	autumn	spring		
50 m run	8.283333	8.611111	**–1.16790**	0.250971
Standing long jump	170.833300	175.611100	0.515096	0.609819
1000 m run	302.277800	287.666700	0.935884	0.355933
Hand strength	12.444440	13.833330	1.03508	0.307937
Flexed arm hang	10.650000	12.994440	0.647502	0.521656
4 × 10 m shuttle running test	12.177780	11.377780	3.438677	0.001563
Sit-and-reach	25.055560	25.777780	0.506544	0.615744
Trunk flexion	2.000000	1.444444	**–0.269905**	0.788865
Physical fitness level (score)	341.833300	351.611100	0.505569	0.616422

The analysis of the average results achieved in the particular IPFT attempts at the beginning and the end of the experiment revealed a slight improvement in six out of eight results achieved. The subjects got worse results in the second session of tests (spring) in two tests, namely, in the 4 × 10 m shuttle running test and the trunk flexion test.

Table 4 shows the difference between the results achieved in autumn and spring, and the difference is presented as the numerical indicator; next, the significance of the average values of the changes in both groups is assessed.

Table 4. The assessment of the statistical significance of the results of the differences between the tests conducted in autumn and spring in the IPFT attempts, between the experimental group (1b) and the control group (1d)

IPFT	GROUP		t	p
	experimental 1b	control 1d		
	difference between the average results (autumn/spring)	difference between the average results (autumn/spring)		
50 m run	0.0133	–0.32778	1.41434	0.167227
Standing long jump	5.3333	4.77778	–0.10036	0.920706
1000 m run	16.0667	14.61111	0.18469	0.854673
Hand strength	1.3333	1.38889	0.06639	0.947494
Flexed arm hang	5.1460	2.34444	–0.94100	0.353981
4 × 10 m shuttle running	0.7600	0.80000	–0.19589	0.845977
Sit-and-reach	1.2667	0.72222	–0.41788	0.678916
Trunk flexion	3.0000	–0.55556	–1.61167	0.117169
Physical fitness level (score)	13.4667	9.77778	–0.35885	0.722141

The analysis of the figures outlined in Table 4 clearly shows that the experimental group (class 1b) had a substantial improvement in most of the IPFT tests assessed, although no significant differences were observed. On the opposite, the control group, not involved in the additional flexibility exercises, was reported to have a slightly improved results in six out of eight tests and even worse results in two tests (trunk flexion and 50 m run). Likewise, the average score determining the physical fitness level of the subjects was better in the case of the experimental group.

Table 5 outlines the difference between two correlation coefficients.

Table 5. The difference between two correlation coefficients in the evaluation of the trunk flexion test performed in autumn and spring

Experimental group 1b (The marked correlation coefficients are significant with $p < 0.05000$)	
	Trunk flexion – spring
Trunk flexion – autumn	0.8066
	p = 0.000
Control group 1d (The marked correlation coefficients are significant with $p < 0.05000$)	
	Trunk flexion – spring
Trunk flexion – autumn	0.4223
	p = 0.081

The difference between two correlation coefficients is statistically significant at the level of $p < 0.0479$. In the experimental group 1b there is a closer correlation between the results of both measurements whereas in the control group this correlation is much weaker (this means that in the experimental group those who are fitter maintain their fitness, but in the control group, more commonly, some individuals considerably improve their results while others get worse results.

Summary

Health is the most important value. When taking physiology into consideration, health also means the efficiency of adaptive mechanisms and adaptability comprises the basis of health (Drabik, 2006). Therefore, physical fitness, activity and efficiency can be considered as the adaptive elements, thus, they are health components (Drabik, 2006). In the light of the above, it is apparent that health does not just mean the absence of disease but it is also wellbeing. Hence, one should not only focus on the fight against disease, but in the first place on aiming at being healthy and maintaining good health. That is why, it is also essential to control the positive health measurements, such as the quality of life, life expectancy, physical activity, physical development and physical fitness (Hyder, Morrow, 2006; Drabik, 2006; Karski, 1997). Controlling physical fitness, including especially the components connected with cardiopulmonary system, motor skills as well as flexibility provide the image of the health of the body (Bouchard, Shephard, 1994; Drabik, 2006), (Howley, Franks, 1997; Osiński, 2003). Thus, flexibility is an important component of physical fitness and of health as well. As Osiński reports (2003), appropriate flexibility may protect from the musculosceletal injuries whereas the absence of proper flexibility may cause diseases and dysfunctions of the motor system.

This study assessed the impact of the additional flexibility program as an important factor determining wellbeing, on physical fitness in the boys. After the experiment was completed, a substantial improvement was achieved in all IPFT attempts and the standard deviation was reduced which shows that regular flexibility exercises positively influence the evaluated components of physical fitness. As Drabik claims (2006), parents should be acquainted with the students' physical fitness level as it is conducive to teaching health-related behavioral patterns and values and developing in parents a conscious attitude to exercise in general. Physical activity is an essential determinant of staying healthy and also serves as a means in the health education of the society (Paczyńska-Jędrycka, Łubkowska, 2014):

1. Introducing the 15-minute flexibility program to physical education lessons is insufficient to achieve significant differences in the physical fitness level.
2. The decreased standard deviation in the individual IPFT attempts in the experimental class, to which the additional flexibility exercises were introduced (as opposed to the control group, where the standard deviation increased after one year of exercises) is a normal tendency and shows a positive influence of the flexibility exercises on physical fitness and so on the health of the students.
3. The students engaged in the additional exercises had an improvement and considerably better, though not statistically significant, results in all assessed motor skills (strength, speed, endurance and flexibility) as well as in the score-based assessment reflecting physical fitness.
4. Following one year of exercises, the students not involved in the extra flexibility exercises got worse average results in two tests – 50 m run (to measure speed) and trunk flexion (to evaluate flexibility). This tendency suggests the special meaning of flexibility exercises for speed and flexibility.

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TIME ANALYSIS OF MUSCLE ACTIVATION DURING BASKETBALL FREE THROWS

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Abstract *Objective of the study:* The study assessed and compared the duration of the muscle activation in a basketball free throw, by players representing a preliminary and specialist stage of training. There was also analysed the accuracy of throws according to the stage of training, and whether individual changes in duration of activation have impact on the accuracy of free throws.
Material and methods: Players from national basketball teams second and third league of the AZS Academic Sports Club of Opole University performed twenty free throws shooting to the basket during the research study. During tests, players were equipped with EMG apparatus, which registered the time of muscle activation, when subsequent free throws were performed. Arm muscle (biceps and triceps) activation time was measured from the beginning of muscle activation to the time of completion of their work, and from muscle activation to the time of reaching the rim.
Results: Players of specialist stage of training, have 0,30 sec shorter average arm muscle time activation, counted from the beginning of activation to obtain the minimum value, from players of the preliminary stage of training. They also gained average 2 points better result in throw accuracy. Variability coefficient of throws duration was higher by 19.56% at players of the specialist stage of training. In the case of unforced extend duration of muscle activation, 80% of specialists and 40% players of preliminary group, don't score the basket.
Conclusions: It was observed that the basketball players of higher training experience, have lower average time of arm muscle activation. It was demonstrated that in players of the specialist stage of training, missed free throws were mostly caused by longer duration from the beginning of muscle activity to the rim, with players of the preliminary stage it was reverse.

Key words throw efficiency, EMG, stage of training

Introduction

The aim of the study was evaluation the level of bioelectrical activity of muscles and its relationship with the efficiency assessment of performing free throws. The authors wanted to show the relationship between muscle time reaction and accuracy of the free throw, in two different stages of training of basketball players.

Free throw shooting, that is individual activity of an individual, is regarded by many authors as crucial activity of a player during basketball matches (Argaj, 2005; Mačura, Potocký, 2009; Tománek, Vencúrik, 2008).

Free throws have particular meaning in basketball game, because if they are successful, they can play important part in victory of the team (Mačura, 2007). This mainly occurs when the last seconds of game decide on the victory and tactics of the losing team is focused at foul play.

A free throw is more effective because it is done without defender, always at the same distance, and player has 5 seconds. These are the activities unchanged during the whole match and for each player, which moreover has a stable position. The effectiveness of free throw is still determined by many factors, such as: technique, the quality of the training process, intensity and complexity of training load, psychological resilience, motivation and environment. (Gablonsky, 2005; Liu, Burton, 1999).

Internal and external factors related to performance of free throw were studied by several authors. The impact of visual acuity was observed by Vickers (1996). Duration of preparation for throwing basketball was measured by Mack (2001), Burton, MacLeod, Sanders, Coleman, (2003) and Zuzik (2011), it was proven that the success of free throws is increased with age.

Miller (2001, 1999) considers that throws in basketball require substantial accuracy. The author also proved that when the throw is off target, there is increased duration of muscular contraction.

Higgins and Späth (1972) reached the conclusion that in order to maximize accuracy, a successful motion pattern should be carefully developed. Similar recommendations for free throws are proposed by Wissel (1994), Kornecki and Lenart (1997) believe that top basketball players perform the throw in a different and individual way, as well as individually repetitive, according to a person. Therefore, it is concluded that coaches should spend more time to build a consistent pattern of motion.

The EMG system measures the bioelectrical activity of muscles, helps us to understand signaling processes in performing better. EMG (electromyography) can be used to determine the condition of muscle training (Konrad, 2007). Well trained muscles have low activation at work, while untrained muscles at the same work have a tendency to higher activation, so EMG plays an important role in study enabling objective evaluation of neuromuscular activation during any kind of activity.

Abe, Nozawa, Kondo (2009) used EMG in testing to measure the assessment of skills acquisition. They proposed a hypothesis, that visualization of EMG signal difference between the expert and beginner, as well as information of error in actual time, speeds up the learning process, especially in the initial phase of training.

The analysis of literature allowed the authors to make hypotheses, that bioelectrical activity of muscles can affect the accuracy of free throws and that motor pattern is changing, when the skills are increasing.

Material and methods

The aim of the study was to assess and compare the duration of free throws performed by basketball players, who are at preliminary and specialist stage of training. Five players of AZS Sports Club of the Opole University of Technology at the preliminary stage were at the average age of 17.6 ±1.67 years and training experience of 1.4 ±0.54 years, while five more advanced players were at the average age of 25.4 ±3.83 years and training experience of 10.2 ±1.48 years. The average height and weight of players of the preliminary stage was 183.6 ±12.52 cm and 73 ±12.55 kg, while in players of the specialist stage it was 190 ±10.49 cm and 86 ±7.03 kg. (Table 1).

Table 1. Data on the examined players depending on the stage of training

	Players of the preliminary stage of training	Players of the specialist stage of training
Age [years]	17.6 ±1.67	25.4 ±3.83
Height [cm]	183.6 ±12.52	190 ±10.49
Weight [kg]	73 ±12.55	86 ±7.03
Training experience [years]	1.4 ±0.54	10.2 ±1.48

Players' task was to perform twenty free throws in standard training conditions. The initial nature of the study and the difficulties in making time-consuming test procedures, have influenced the numbers of studied players. Study tests were conducted at the beginning of the annual microcycle training for both groups in the hours of afternoon training, in the same period. Selected players with declared handedness played in both groups at different positions, from point guard to center, being members of second and third basketball league.

The EMG system of Noraxon Company was applied as research tool, it records muscle activity, so-called dynamic EMG in training conditions with the wired communication between pre-amplifiers and the signal collecting unit. A digital signal recording EMG parameters is sent using telemetric transmission to the computer. Four pairs of electrodes were placed between the motor point and the tendon trailers along the longitudinal axis of the muscle, according to the SENIAM methodology. The duration of arm muscle activation was measured from the beginning of muscle activation to the time of obtaining their minimum activation after the throw, and from muscle activation to the time of reaching the rim by the ball. The time assessment of motion was measured using the EMG, considering the involvement of arm flexor muscles (musculus biceps brachii) and arm extensor muscles (musculus triceps brachii) of the right and left sides of the body. Data analysis was performed using the MyoResearch XP MT 400, after the signal was cleaned and smoothed. The video was recorded with camera, which shoots 60 frames per second.

Data analysis was made using MyoResearch XP MT 400. The sampling rate was 1000 Hz. The root mean square (RMS) values of EMG signals were calculated for consecutive segments of 50 ms. The video was recorded by a camera with 60 frames per second in sync with the record of EMG. Moment of muscle activity was determined using 3SD factor in the MyoResearch XP, MT 400. The combination of EMG recording with video recording allowed reliably to determine the time muscle activation in both groups and enables to accurately recreate studies in the future.

To verify hypothesis, statistical analysis software STATISTICA 12 was used. The structure of the groups was characterized by the arithmetic mean and standard deviation, and in order to determine differences between groups coefficient of variation was calculated and Tukey test was used.

Results

Presentation of the results was started from the average duration of biceps' and triceps' muscle activation, when free throws were performed, from the beginning of activation to the time of obtaining the minimum value after the throw was performed. Among players, who are at the preliminary stage of training, it was 2.31 s; whereas in players at the specialist stage of training, it was at the level of 2.01 s. Average duration of muscle activation among players with lower training experience was in the range of 2.07 to 2.59 s. In the second group, it was more diversified and ranged from 1.28 to 2.93 s; however, in case of three players, this time was less than 2 s. Significant difference

can be seen in the variation in variability of muscle activation among individuals in the subsequent throws. Average coefficient in basketball players with less training experience was 10.86% and in those with longer practice, it was at the level of 30.42% (Table 2).

Table 2. The results of statistical analysis depicting average times of throws, standard deviation and coefficient of variation of the time for individual players, depending on the stage of training

	Players of the preliminary stage of training	Players of the specialist stage of training
Free throws made	13.40	15.40
Average time of free throw from the beginning of muscle activation to the lowest activation value after shot		
Average free throw time [s]	2.31	2.01
Standard deviation	0.25	0.61
Coefficient of variation [%]	10.86	30.42
Average time of free throw from the beginning of muscle activation to time when ball reach the rim		
Average free throw time [s]	2.17	2.04
Standard deviation	0.17	0.32
Coefficient of variation [%]	7.74	15.62

Considering the time that has elapsed since the beginning of muscle activation to the time of reaching the target, in this case – the rim, preliminary stage players obtained longer average duration of the motion by 0.13 s. The coefficient of variation in both groups differed by 7.88% (Table 2).

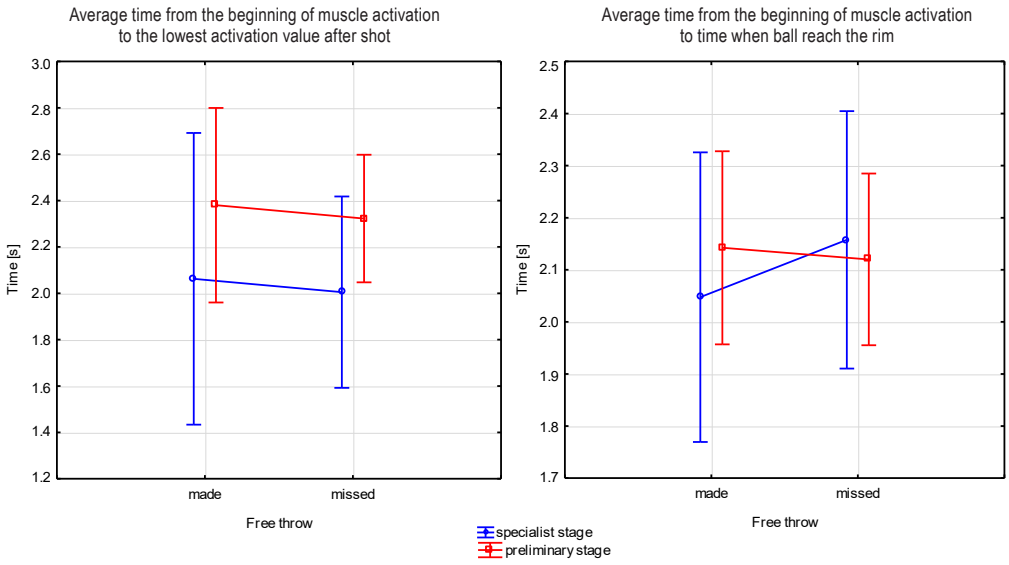

Figure 1. Average time of made and missed free throws depending on the players' stage of training

In three players of specialist stage of training and in only one in the preliminary stage of training, muscle activation ended before ball reached the rim. Four out of five players from specialist stage of training missed their shots, when arm muscle activity was longer. In the group of preliminary stage trend was different. Here, the most of players missed, when the muscle activity was shorter (Figure 1).

By examining the time of free throws, the level of abilities to shoot free throws in groups was also analysed. Players who are in the specialist stage of training on 20 points possible to gain in a trial obtained 15.4 points at average. This result was superior to players in the preliminary stage at 2 points. Furthermore, results in both groups of peripheral players, that is: point guard, shooting guard and small forward were better than under the basket players, that is: power forward and center. In more advanced in training players, they were higher by 2.33 points, and in the second group by 3.17 points (Table 2).

Time of made and missed free throws, when analysed from the beginning of muscle activation to the time of obtaining the minimum value after the throw, significant differences were not at $p \leq 0.05$.(Tukey test). Considering the time that has elapsed since the beginning of muscle activation to the time of reaching the rim, significant differences were shown only in the group of specialized stage, which are at the $p = 0.03177$ (Figure 1).

Discussion

Because of the innovative nature of the research and use of specialized equipment, in the literature there are not many studies on muscle activity during the time free throw. In these studies, "we entered" into the human body, measuring the time activation arm muscles when performing free throws. The study had its limitations, the small number of players dictated by difficulties in the implementation of time-consuming research and analysis, but in total we examined free throws 400 times, in terms of their duration.

The analysis found that basketball players who train more had shorten muscle activation, so they need less time to take free throw. However, it was noticed that more advanced in training players modulate arm muscle activation in a greater extent during performance of throw. The result of this research can expand the opinion stated by Higgins and Späth (1972), as well as Wissel (1994), that with increasing skills, the motor pattern undergoes certain changes. Players with specific stage of training more frequently change their muscle activation time during successively performed throws that those with shorter experience in training. This is probably the result of progressively higher level of kinesthetic differentiation capacity, which increases with the ongoing process of training and acquisition of skills (Zatoń, Zatoń, Zygadło, 2008). Kubaszczyk (2001) argues that this also has a strong relationship with the special efficiency.

Analysing the data, time variation during each of the successive throws of the same player could be seen, with certain regularity. When in more experienced players the average muscle activation time measured from the beginning to the time of reaching the rim was at higher value on average, then most of them performed missed throws. This can corroborate the study by Miller (1999), although in less experienced players a reverse trend was observed, so it may depends on the training experience.

The study confirmed the finding by Burton et al. (2003), Zuzik (2011) and Zwierko, Osiński (2001), because more trained players achieved by 10% better performance during trail, when free throw abilities were measured.

Conclusion

Based on the results, following conclusions were drawn:

1. With the increase of training experience, the time needed for arm muscles to perform free throw, and the time needed to overcome the distance from the initial muscle activation to the time of achieving the target, that is the rim, are reduced.
2. More experienced players possess higher ability to model the muscle activation time needed to shoot free throw, than less experienced players.
3. Missed throws were characterized by longer duration of muscle activation in basketball players with longer experience in training.
4. Basketball players of the specialist stage obtain higher level of abilities to perform free throw than players of the preliminary stage.

The results seem to confirm the hypothesis presented by the authors, that time of muscle activation may affect the accuracy of free throws, and experienced players change motor pattern of muscle activation time during free throw more.

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THE FAN LIFESTYLE ON THE EXAMPLE OF SOCCER FANS

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Abstract The aim of this study was to investigate chosen aspects of the lifestyle of soccer fans. *Methods.* The study was conducted among 200 fans. In the study a diagnostic survey was employed, with the use of the techniques of questionnaire, interview, document analysis and participant observation. In order to draw statistical conclusions, the trait frequency, the independence χ^2 test and multiple correspondence analysis were used. *Results.* The community of active fans is characterized by various kinds of behavior. Fans aged 15–19, for whom important motives for cheering were the opportunity to be with a group and a sense of connectedness, as well as a sense of strength and power, declared consumption of alcoholic beverages before matches. For fans aged 20–24, who more often practiced combat sports and exercised in the gym, an important motive for cheering was the opportunity to meet their friends and let off steam during the match. They regarded devastation of sports facilities and burning scarves as acts of hooliganism. Fans aged 25–29, and 30 or above admitted that they sometimes consumed alcoholic beverages before the game. *Conclusions.* There is a necessity to educate children and youth in sports cheering.

Key words active fan, family's support, combat sports, motives for cheering, hooliganism

Introduction

Sports cheering is generally a positive phenomenon. Some believe true supporters are people who come to the venue only to see the sports event, for others true supporters are those fans who cheer their team. Among fans, just like in any small community, there are diverse behaviors (positive and negative). Soccer fans are most often talked about when negative behaviors take place in or beyond stadiums. The negative image of a soccer fan which dominates the reports is stereotypically transferred to the entire collectivity.

Despite fans also engaging in socially desirable activities, these groups are associated with stadium hooligans. There are few publications describing the positive activity of soccer fans, especially the *ultras* groups and their lifestyle (Karaś, 2010; Pilz, 2009; Sahaj, 2007; Wąsowicz, 2012, 2015).

Far more publications concern stadium hooliganism (Piotrowski, 2000; Kowalski, 2000; Dudała, 2004; Chlebowicz, 2009; Pływaczewski, Wiśniewski (ed.) 2012). Problems emerging in stadiums lead to tensions between

hooligans and the police and the media (Piotrowski, 2012). Causes of disorderly behavior are analyzed in the context of preventive measures (Pałaszewski, 2011; Wądołowska, 2012).

Another perspective in which to view the phenomenon of hooliganism is given by Milcarz (2006), who compares the behavior and values of the members of the *fighting squads* (organized hooligan groups) to the chivalric ethos. A story has been written about everyday life of the supporters of the "Stilon" Gorzów Wielkopolski Sports Club (Korsak, 2012). Rooting for a team is also popular with school youth (Babik, 2010). An indispensable source of knowledge is the periodical "We the fans", which has been issued in Poland by fans every month for more than 15 years. It contains essays written by the supporters themselves which provide insight into the circles of soccer fans.

The structure of the fans' community is subject to evolution (Kowalski, 2000; Piotrowski, 2012). In this paper, an original division of fans into two groups was used: active supporters (stadium hooligans, *ultras*, *scarfers*, *elders*) and passive supporters (*picnics*, *seasoners*, sympathizers, global supporters, connoisseurs of soccer). Ultras could be defined as a supporters' movement aimed at the loudest possible rooting for a team and presenting displays in the stands, consisting of flags, cardboard, balloons and pyrotechnics. One of the common features of the European ultras is deriving pleasure and satisfaction from creative cheering during the match, as well as from pre-match preparations. In contrast to many other supporter activities, you are not an ultra only on the weekend, but for the whole week. Everything is subordinated to soccer and/or to the fan movement (Karaś, 2010).

Although ultras are not hooligans, in the event of spontaneous brawls they also take part in the fight. They do not, however, participate in other forms of hooligan activity. Ultras are considered second category supporters by hooligans, but the members of ultras groups "are content with such "medium" fan mentality, with a penchant for risk and adventure on the one hand, and fascination with the atmosphere of stadium stands on the other" (Jaworski, 2004, p. 15). This work concentrated on the characteristics of active fans (hooligans, ultras and scarfers), as those who are the most recognizable and characteristic of the fan community.

In many interviews with fans of various teams the concept of fan lifestyle appears. This concept is present in songs recorded by soccer fans and can also be found on T-shirts, sweatshirts or fan stickers. Starting from the concept of lifestyle (Siciński, 2002), one can refer it to the community of soccer fans. Fan groups are characterized by a specific system of values, motives, norms and behaviors. They stand out from society. Individuals representing the fan lifestyle attend matches in their location, participate in away games, and take other actions associated with the fan movement (e.g. the creation of graffiti), subordinating their professional and personal plans to the soccer league match schedule.

The aim of the study was to investigate chosen aspects of the lifestyles of soccer fans supporting the "Stilon" Gorzów Wielkopolski Sports Club.

The following hypotheses were formulated:

1. Most soccer fans practice combat sports.
2. Active cheering is supported by most soccer fans' families.
3. Motives for cheering change with respondents' age.
4. Sports fans exhibit positive and negative behaviors.

Research material and methods

Research within the community of soccer fans has been conducted since 2013. A study of 200 fans of the "Stilon" Gorzów Wielkopolski Sports Club, with material gathered during matches in Gorzów Wielkopolski, as well as during away matches, is the basis for the present work. The majority of active fans were males (90%) residents of Gorzów Wielkopolski (79%). The subject were people of different ages (15–50 years old), school and higher education students (46.5%), working (47%). The supporters of the "Stilon" Gorzów Wielkopolski Sports Club create a unique group. Despite the Club announcing its bankruptcy twice in the past several years (which each time resulted in starting the next season in the lowest division), the fans have still stayed with the Club. In 2011, after the second announcement of bankruptcy, the Club's fans became members of the new management to create the team from scratch. The access to the relatively closed environment of fans, who agreed to the study being conducted and consented to participant observation, was possible because one of the authors of this work is an active fan of the "Stilon" Gorzów Wielkopolski Sports Club.

In the study a diagnostic survey was employed, with the use of the following techniques: questionnaire, interview, document analysis and participant observation. Purposeful sampling was used which included only active fans. Uncategorized interviews were conducted with the leaders of the hooligan group and the ultras group. The interviews were not recorded, however, because these people, in order to maintain full anonymity, did not give their consent to it. The study was supplemented with participant observation. The techniques used made it possible to gather detailed information on the phenomena occurring during away matches (especially on trips to the matches), as well as at meetings of members of various fan groups. The contents found on the fan forum and in fan papers were also analyzed.

The qualitative and quantitative analysis was carried out with the employment of standard statistical methods: frequency of characteristics, chi-squared independence test and multiple correspondence analysis (van Bureen, de Leuve, 1992). These analyses are available in the statistical software package Statistica 12 (StatSoft, inc. 2015 Statistica for Windows).

Research results

Social characteristics of the supporters of the "Stilon" Gorzów Wielkopolski Sports Club.

Most supporters attended their first match at a young age (Figure 1).

The subjects most often started their cheering adventure between the ages of 12 and 16. The youngest fan was 7 and the oldest one was 18 years old. The fan community is diverse in terms of age, but it mainly consists of young people (Table 1). The subjects were people aged 15–50. Respondents under 24 years of age accounted for 66.5% of all the subjects, that is 2/3 of the fans. The fan community is formed primarily by men (90%). Female supporters were aged 15–19. After 30 years of age women cease to be active fans. Almost half of the respondents had already started working (47%). A similar number of them continued education. Among the supporters some people were also unemployed (6.5%).

A statistically significant correlation was found between the active rooting and the place of residence and education (in each case: $p \leq 0.05$). The active supporters are mainly residents of Gorzów Wielkopolski, but the 15–19 age group was dominated by residents of neighboring towns and villages. The subjects were characterized

by secondary education. In the 20–24 age group there was the largest number of people with post-secondary education.

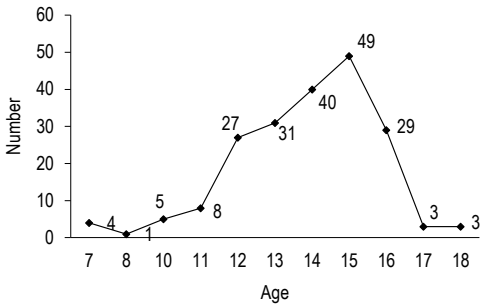


Figure 1. Fan initiation age (n)

Table 1. Social characteristics of the supporters of the "Stilon" Gorzów Wielkopolski Sports Club in relation to age (independence χ^2 test)

Specification	Age (in years)				Total (n = 200)	
	15–19 (n = 48)	20–24 (n = 85)	25–29 (n = 20)	≥30 (n = 47)		
Sex:						
– Male	66.7	96.5	95.0	100.0	180	90.0
– Female	33.3	3.5	5.0	–	20	10.0
Professional work:						
– school student	95.8	1.2	–	–	47	23.5
– higher education student	2.1	52.9	–	–	46	23.0
– working	–	32.9	100.0	97.9	94	47.0
– unemployed	2.1	12.9	–	2.1	13	6.5
Place of residence*:						
– Gorzów Wlkp.	60.4	80.0	85.0	93.6	158	79.0
– Vicinity	39.6	20.0	15.0	6.4	42	21.0
Education*:						
– pre-secondary	31.2	15.3	10.0	6.4	33	16.5
– secondary	66.7	34.1	80.0	78.7	114	57.0
– post-secondary	2.1	50.6	10.0	14.9	53	26.5

* Statistical significance for $p \leq 0.05$.

The largest proportion of the supporters was interested in sport (92.5%) (Table 2). This interest was predominant in all the age categories. The high ranking of sport was strengthened by the subjects' declarations concerning on the one hand practicing extreme sports (22.5%), and on the other health promoting activities (fitness and dance) (14%). Dancing was preferred by the female fans. More than half of the subjects were passionate about music (51%). Many fans were interested in film and the arts (40.5%) as well as history and architecture (29.5%). The automotive industry (37.5%) and computers (29%) were also passions of about 1/3 of the respondents. Among the subjects

aged 15–19 the greatest interest in music was observed (73%) as compared to the other age categories. This correlation was statistically significant ($p \leq 0.05$). The interest in history and architecture distinguished individuals aged 20–24 from the rest (41.2%) ($p \leq 0.05$). The group of 25–29-year-olds was more often interested in motor vehicles (50%) and computers (45%).

Table 2. The supporters' interests in relation to age (independence χ^2 test)

Interests	Subjects' age									
	15–19		20–24		25–29		30 and older		Total	
	n	%	n	%	n	%	n	%	n	%
Sport	43	89.6	79	92.9	18	95.7	45	95.7	185	92.5
Music*	35	73.0	42	49.4	5	25.0	20	42.6	102	51.0
Film, arts	14	29.2	37	43.5	11	55.0	19	40.4	81	40.5
Motor vehicles	15	31.3	32	37.7	10	50.0	18	38.3	75	37.5
History, architecture*	9	18.8	35	41.2	3	15.0	12	25.5	59	29.5
Computers	13	27.1	22	25.9	9	45.0	14	29.8	58	29.0
Extreme sports	11	22.9	19	22.4	3	15.0	12	25.5	45	22.5
Collectables	5	10.4	22	25.9	6	30.0	11	23.4	44	22.0
Books	4	8.3	13	15.3	3	15.0	10	21.3	30	15.0
Tourism	6	12.5	15	17.7	1	5.0	8	17.0	30	15.0
Dance, fitness	12	25.1	10	11.8	3	15.0	3	6.4	28	14.0
Politics	4	8.3	16	18.8	0	–	7	14.9	27	13.5
Other	9	18.8	11	13.0	2	10.0	2	4.2	24	13.5

* Statistical significance for $p \leq 0.05$.

Combat sports and strength training were the most popular among the supporters (Table 3). Almost half of them practiced combat sports. The most frequently chosen disciplines were boxing, kick-boxing and Brazilian ju-jitsu. Several people also trained Mixed Martial Arts (MMA) or karate. Persons between 15 and 24 years of age accounted for almost 70% of those practicing combat sports. A high percentage of those who exercised in the gym (64%) indicates that fans attached great importance to the development of their strength and led an active lifestyle.

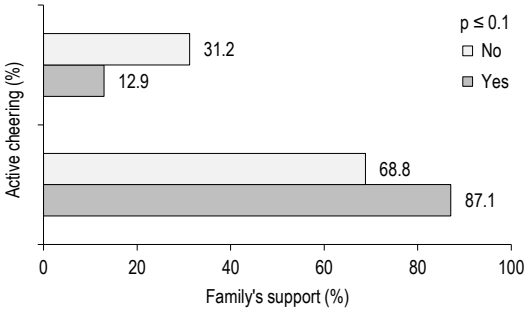
Table 3. Physical activity of soccer fans (%)

Specification	Subjects' age									
	15–19 (48)		20–24 (85)		25–29 (20)		30 and older (47)		Total (200)	
	n	%	n	%	n	%	n	%	n	%
Combat sports*	24	50.0	47	40.0	6	30.0	21	44.4	95	47.5
Exercise in gym	26	54.2	57	67.1	16	80.0	29	61.7	128	64.0

* Combat sports: boxing, kick-boxing, Brazilian ju-jitsu, karate, MMA (Mixed Martial Arts).

Almost 1/3 of the fans had another active supporter in their family (31%). Most frequently the other fans in the family were: brother (48%), cousin (30%), father (7.5%), son (6%) and uncle (4%). Occasionally they were also mother, husband or sister (5% each). A relatively high percentage of respondents who had another soccer fan in

the family, indicates that this passion is transmitted by people in the immediate surroundings. Due to the subjects' financial dependence, with the expenses associated with rooting (the cost of tickets, fares), help is necessary, mostly from the family. A correlation was found between the family's acceptance and family members' active cheering ($p \leq 0.05$) (Figure 2). Most active fans are supported by their families (87.1%). About 13% of the respondents had to face the lack of acceptance of active cheering.



($p \leq 0.05$ for the independence χ^2 test)

Figure 2. Family's support in relations to the family members' participation in cheering

In addition to the support from family members, active cheering requires time planning. 57.5% of the respondents always adjusted their personal and professional plans to the dates of local and away matches, and 33.5% did it frequently. Among active fans, those who did not plan their participation in soccer matches in advance constituted 9%. The majority of fans aged 15–19 and 20–24 subordinated their time to the match schedule (70% and 58% resp.). In the older age categories personal and professional plans were less often adjusted to the dates of matches.

Most of the subjects wanted to help their team to victory with their active rooting (Table 4). It is important for an individual to consolidate friendship and make new acquaintances within their own group. Maintaining ties with supporters of other teams and being together in a group are of sociocentric character. Some groups of fans are linked together (e.g. through *unions* i.e. friendships between fans of different clubs). For the majority of respondents being a fan was an opportunity to root for the team and let off steam. This can be done within one's own group or be a demonstration of dominance over other fans, a display of strength and power before other fan groups.

There was a statistically significant relationship between the subjects' age and their motives for being a fan. Meeting friends was an important motive for supporters aged 20 and above ($p \leq 0.05$). The same age groups were also motivated by the opportunity to let off steam ($p \leq 0.05$). The motives for being a fan for people aged 15–19 were the sense of connectedness ($p \leq 0.05$), the opportunity to be together in a group ($p \leq 0.05$), and the sense of strength and power ($p \leq 0.05$).

Table 4. Motives for being a fan (independence χ^2 test)

Specification	Age (in years)									
	15–19		20–24		25–29		30 and older		Total	
	N	%	N	%	n	%	n	%	n	%
Helping the team	45	93.8	61	71.8	19	95.0	40	85.1	165	82.5
Meeting friends*	27	56.3	69	81.2	17	85.0	39	83.0	152	76.0
Satisfaction	33	68.8	68	80.0	13	65.0	31	65.7	145	72.5
Cheering atmosphere	31	64.6	55	64.7	9	45.0	29	61.7	124	62.0
Opportunity to let off steam*	16	33.3	56	65.9	16	80.0	33	70.2	121	60.5
Sense of connectedness*	36	75.0	44	51.8	4	20.0	11	23.4	95	47.5
Domination over other fans	24	50.0	41	48.2	8	40.0	15	31.9	88	44.0
New acquaintances	24	50.0	27	31.8	9	45.0	5	10.6	65	32.5
Being together in a group*	21	43.8	20	23.4	4	20.0	2	4.3	47	23.5
Entertainment	10	20.8	12	14.1	3	15.0	4	8.5	29	14.5
Sense of strength and power*	16	33.3	18	21.2	2	10.0	1	2.1	37	13.5

* Statistical significance for $p \leq 0.05$.

Misunderstandings between soccer fans and the security forces are often caused by aggressive behavior of those fans who consume alcoholic beverages before matches.

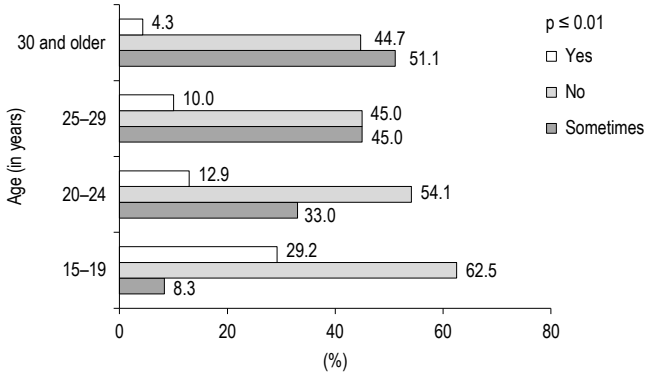


Figure 3. Alcoholic beverages consumption before matches (independence χ^2 test)

Alcoholic beverages were consumed before most matches by 15% and sometimes by 32.5% of the respondents. There was a statistically significant correlation between consumption of alcoholic beverages and the age of the subjects ($p \leq 0.01$) (Figure 3). Drinking alcohol before most matches was the most common phenomenon among the youngest people (15–19 years old) (29.2%). Occasional consumption of alcoholic beverages was declared by fans aged 30 and above (51.1%).

The concept of being a hooligan in view of the fans examined most often had a positive dimension (only 2.5% of them associated it with negative behaviors). Hooligans were associated primarily with *squads' duels* (pre-arranged fights between hostile groups of hooligans, held in secluded places away from stadiums), toward which most of the supporters had a positive attitude. The subjects believed that *squads' duels* were a good way to show which team had better fans and which club dominated. This opinion was expressed by 83.4% of the fans. Only 3.5% of the subjects considered them to be wrong, and 13.1% of the respondents had no opinion.

In the view of the subjects, acts of hooliganism principally included three offenses: devastation of sports facilities, direct aggression (hitting, beating) used toward other fans, and attacking the police and security forces (Table 5). A statistically significant correlation was observed between the age of the fans and recognition of devastation of facilities and burning scarves as acts of hooliganism ($p \leq 0.05$ in each case). The greatest liberalism toward these behaviors was characteristic of young supporters aged 15–19, with short histories of being fans. Firing of pyrotechnics, which are usually used by ultras groups for adding visual effects to their displays at matches, was not an act of hooliganism according to the greatest number of fans.

Table 5. Types of acts of hooliganism in the opinion of the subjects (independence χ^2 test)

Type of act	Age (in years)									
	15–19		20–24		25–29		30 and older		Total	
	N	%	n	%	n	%	n	%	n	%
Devastation of a facility*	33	68.8	73	85.9	19	95.0	47	100.0	172	86.0
Direct aggression	39	81.3	71	83.5	18	90.0	37	78.7	165	82.5
Attacking the police	30	62.5	70	82.4	18	90.0	40	85.1	158	79.0
Burning scarves*	9	18.8	35	41.2	5	25.0	15	31.9	64	32.0
Verbal aggression (toward fans, referee, players)	9	18.8	15	17.6	4	20.0	12	25.5	30	20.0
Firing of pyrotechnics	1	2.1	5	5.9	–	–	2	4.3	8	4.0

* Statistical significance for $p \leq 0.05$.

In performing a graphical analysis of the results of the correspondence analysis in relation to two dimensions in space the four age categories were kept. The first one was comprised of supporters aged 15–19, for whom important motives for cheering were the opportunity to spend time in a group (5a), a sense of connectedness (6a), and a sense of strength and power (10a), and who attached less importance to the opportunity to let off steam (4b). They less frequently perceived devastation of sports facilities as an act of hooliganism (8b). The group of 15–19-year-olds declared consumption of alcoholic beverages before matches (7a).

Fans aged 20–24 practiced combat sports (1a), attended the gym (2a), and were motivated to cheer their team by the possibility of meeting up with friends (3a) and letting off steam during matches (4a). Being together with a group was of less importance (5b), as was the sense of strength and power (10b). They recognized as acts of hooliganism devastation of sports facilities (8a) and burning scarves (9a).

Fans aged 25-29 and 30 and above did not associate being a fan with a sense of connectedness (6b), and admitted (51.1%) that they sometimes consumed alcoholic beverages before matches (7c).

Peripheral position was occupied by supporters who did not drink alcohol before matches (7b) as well as those for whom meeting friends while rooting for their team was less important (3b). In the vicinity of each of the groups were those who did not practice combat sports (1b) or work out in the gym (2b) and did not recognize burning scarves as an act of hooliganism (9b).

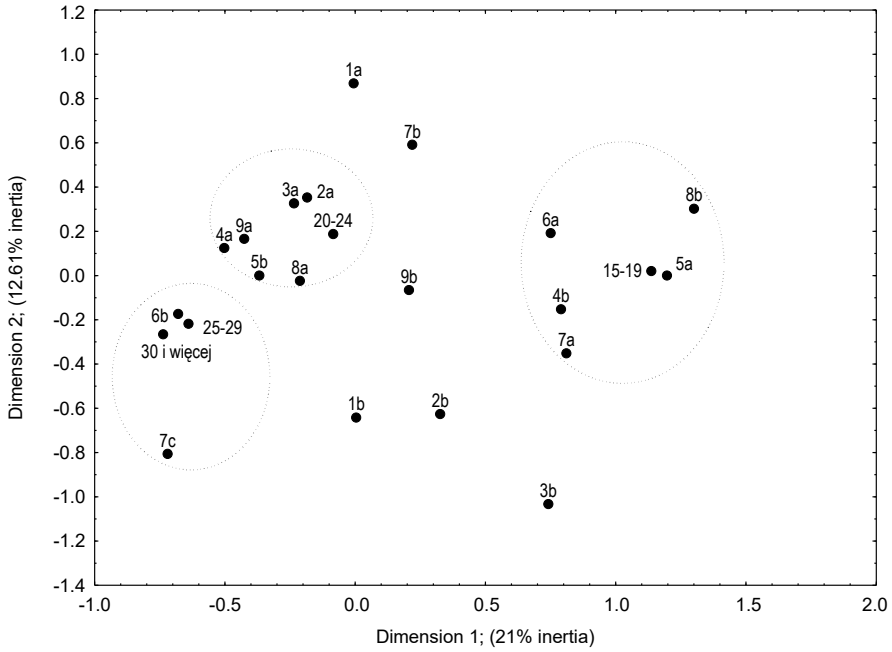


Figure 4. Correlations between the age, education, motives for cheering, practicing sports, alcoholic beverages consumption and recognition of acts of hooliganism by fans (MCA)

Discussion

The community of active soccer fans, namely those who participate actively in rooting for their team at home and go to away matches, is primarily comprised of young people. The results of the present study (interviews with hooligans) and research by D. Cholewa (as quoted in: Babik, 2010, p. 84) have confirmed that people usually join hooligan groups at the age of 16–19. The observations have shown that even young schoolchildren are now involved in cheering. They come to the stadium with their parents or other family members. As the fans say: "It is these children that will be like us in future".

Men constitute the vast majority of the community of fans. In the case of the supporters of the "Stilon" Gorzów Wielkopolski Sports Club, women–mainly young girls aged 15–19—accounted for 10%. In another study, out of 318 fans of Zagłębie Sosnowiec only 9 were female (Dudała, 2004). Favorable changes in the community of supporters may result in an increase in the number of female fans. Stadiums, including "the mills" (the sectors where the most active fans of the home teams are located), have become more friendly, and the fan community less aggressive. Also, women's soccer teams have been established, which can affect the growth of interest in this sports discipline among girls. Over the years, the structure of supporters' education has changed. The percentage of fans who are higher education students has risen considerably. At the beginning of this century it amounted to about 3–4% of the population of fans (Dudała, 2004). In the present research, 21.5% of the supporters were studying. As far as fans of the "Stilton" Sports Club are concerned, 46.5% of them were currently either learning at

schools or studying at higher education institutions, and the proportion of those who were employed was almost the same (47%); the unemployed accounted for 6.5%. The percentage of unemployed fans was lower than half the national average unemployment rate, which amounted to 13.9% (Central Statistical Office, February 2014).

The community of fans of the "Stilon" Sports Club is mainly comprised of residents of Gorzów Wielkopolski (79%). The remaining supporters are inhabitants of villages and nearby towns. As for the whole country, these proportions are different. The best Polish teams, for example "Lech" Poznań, "Legia" Warsaw or "Widzew" Lódź, have so called fan clubs (FCs), i.e. organized groups of supporters coming also from other cities. They usually have their own flag with the emblem of the team they support and the name of the place which they come from. Still another situation can be observed concerning fans in the Upper Silesia: the proximity of the cities makes a lot of fans travel to matches of teams different than those which play in the place of their residence, e.g. "in Gliwice, fans of "Górnik" Zabrze operate vigorously (Kuczyński, 2011) (the so called *Torcida* Gliwice), and the inhabitants of Katowice root for "Ruch" Chorzów (the so called Blue Katowice).

Interest in sport was declared by over 90% of the supporters. They most often practiced combat sports. The skills acquired in combat sports training sessions are used by hooligans during *squads' duels* and other forms of fighting with supporters of opposing teams. It is sometimes the case that new members are recruited for the *fighting squads* from the combat sports clubs. "During the practices, effective combinations of blocks, grips and blows are tested. Hooligans learn to fight in a way which will allow them to rapidly defeat the opponent" (Sahaj, 2007, p. 142) It has been found that people aged 15–24 account for 70% of those practicing combat sports. This is probably connected with the nationwide trend concerning *squads' duels*, in which only people up to 21 years of age are to participate. Individuals who practice combat sports, however, should not be perceived as hooligans. The results of research carried out among athletes with a high sporting level indicate that their motives were different from those of hooligans and that they more often observed the principles of a healthy lifestyle. "Athletes with the highest sporting level (champions) mostly did not smoke (93.3%) and abstained from drinking alcoholic beverages (59.1%)" (Nowak, Umiastowska, Nowak, 2013, p. 41). The hypothesis concerning the preference of combat sports by sports fans was confirmed.

Most hooligans would not like their children to join a group like theirs (Babik, 2010). This demonstrates the hooligans' awareness of the consequences which being in a fighting squad entails. For supporters, especially the minors, it is important that their passion be accepted by their family (also for financial reasons). A large proportion of soccer fans participate in most of the matches of their team, both at home and away. Few fans attend their team's games occasionally. As is apparent from the interviews, this group may be comprised of hooligans, who avoid matches which are less interesting for them. They are present, however, at games at which fans of antagonistic teams are to appear.

Most of the active fans of the "Stilon" Gorzów Wielkpopolski Sports Club adjust their professional and family plans to the match schedule. "For those individuals, work and family take second place; the performance of their favorite team is the most important" (Dudała, 2004, p. 23). N. Hornby (2003, p. 196) wrote in his memoirs: "I'm ready to watch any game, anytime, anywhere, regardless of the weather". Approximately 50% of the subjects went to most or all away matches. These data cannot be referred to all the Polish fan groups in general, because the proportions in bigger clubs are considerably different from those in smaller ones.

This state of affairs is influenced, among other things, by the number of tickets allocated for matches in Ekstraklasa (the top division in Polish soccer) and the costs of travel. Participation in away games, especially by the

younger supporters, would not be possible without the approval and financial support of the family. The hypothesis that most of the active fans receive support from their families was confirmed.

The fans of the "Stilon" Gorzów Wielkopolski Sports Club most often reported that they attended matches because they wanted to help the team with cheering. In the stands, lasting friendships are formed; there is an opportunity for socializing. Cheering is a source of personal satisfaction. In a national magazine about sports fans a fan wrote regarding rooting: "And what's so beautiful about it? Dedication, which each of us puts in to travel with our team. Love – not for money, not for honors. It's for the beautiful moments that can never be forgotten" (Przemek (Lechia Gdańsk), 2011, p. 41). This text perfectly illustrates the motives that attract soccer fans to the stands. The above words were also confirmed by this study, because in both cases the motives are related to helping the team, friendship, and personal satisfaction. At the same time, differences in motives for rooting can be observed with respect to particular age categories. A sense of strength and power over the group of fans of the opposing team and reign over the stadium were mostly motives for participation in cheering for people aged 15–19. These behaviors require targeted pedagogical measures. The hypothesis about the evolution of motives for rooting depending on age was confirmed.

There are both socially acceptable and deviant behaviors among soccer fans. In recent years, supporters of the "Stilon" Gorzów Wielkopolski Sports Club have run several charity campaigns, e.g. they have donated blood and volunteered as potential bone marrow donors. The "Blue and Whites" fan association has organized holiday soccer training for school children, which was conducted by players of the Gorzów Wielkopolski Soccer Club (contemporary name of the "Stilon" Gorzów Wielkopolski Sports Club). During the 2013/2014 season "Stilon" fans ran the "Blue and white Santa Claus" campaign, during which they visited the children's home and gave presents to about 50 wards of this institution. In March of 2014 supporters of the "Stilon" Gorzów Wielkopolski Sports Club organized a collection of food and other necessary articles for the Gorzów Wielkopolski dog shelter. In earlier years, funds for the sick were raised at the stadium. In addition to charity campaigns, the club's supporters help with the work done at the stadium, like renewal of ticket offices or clearing snow from the pitch. They also assisted in the reactivation of the club. Similar behaviors of Polish fans have been described by Prendecki (2012). Most of such activities are not heard of in the media, because the fans are reluctant to provide the television or newspapers with this kind of information (72.5% of them do not trust the media). Following an activity the information appears on the team's website, summarizing the actions taken and encouraging further ones.

In view of the respondents, acts of hooliganism included: devastation of a facility, direct aggression used toward fans of other teams, attacking the police, and burning scarves. The report of the Polish Football Association (PZPN) lists several offenses which did not appear among the responses from fans of the "Stilon" Gorzów Wielkopolski Sports Club. Those are, among others: uncontrolled intrusion on the premises of a facility, throwing objects at members of security forces, putting up flags with illegal content (Report of the PZPN, 2005). According to the data of the Police Headquarters, the number of hooligan excesses decreased tenfold between 1997 and 2010 (Piotrowski 2012, p. 72). However, apart from acts of hooliganism at stadiums and *squads' duels*, a few others can still be distinguished. Kołek and Mikołajczyk (2010) mention the following: an attack on the visiting team's fans during their journey to the game (stopping the train with the emergency brake followed by an attack on the hostile fans) and devastating public transport. The leaders of supporters encourage and even require behavior which is consistent with the accepted social norms. Not everybody observes these requirements, which sometimes leads to damage to public property.

Not infrequently, soccer fans commit acts prohibited by law in and beyond stadiums (Journal of Laws of 2009, No. 62, item 504; Journal of Laws of 2015 item 1707). In most cases, members of hooligan groups are responsible for deviant behavior. Such situations often require intervention by the police, who along with other public order services (e.g. security staff) are viewed negatively in the community of soccer fans (Babik, 2010). "The hatred toward public order services prevailing among hooligans and ultras stems from the unjustified, in their opinion, brutality with which they are treated by law enforcement officers" (Piotrowski, 2012, p. 51). Supporters also protest against the Law on Security of Mass Events (Journal of Laws of 2009 No. 62, item 504; Journal of Laws of 2015 item 1707), under which the courts can impose *stadium bans* on them. In the interviews, fans of the "Stilon" Gorzów Wielkopolski Sports Club stressed that they understood the sanctions imposed for brawls in stadiums, but were opposed to punishing people with stadium bans for e.g. taking a seat other than that which is assigned to the ticket, standing on the stairs between sectors or failure to obey the instructions of public order services. The last mentioned plea, concerning failure to comply with orders of security staff, was deemed unconstitutional by the Constitutional Court in May 2014 (Ref. file No. K 17/13).

Misunderstandings between fans and the security forces are often caused by aggressive behavior of the fans who consume alcoholic beverages before matches. In the case of fans of the "Stilon" Gorzów Wielkopolski Sports Club, alcoholic beverages are regularly drunk before the game by 15% of the respondents, the largest proportion of them being those aged 15–19 (29.2%). The observations confirmed that "(...) the most valiant ones, the true fight pickers, they rather shun alcohol. They prefer to stay sober so they can fight" (Kowalski, 2000, p. 47).

There is a controversy about participation in *squads' duels.* It was not mentioned by fans of the "Stilon" Gorzów Wielkopolski Sports Club among acts of hooliganism. *Squads' duels* are considered a good form of rivalry and confrontation between hooligans. Held outside the stadiums, they do not threaten the safety of other people and do not expose the club to financial responsibility as the brawls that erupt in the stands do. It should be emphasized that nowadays hooligans themselves often provide order in the stands, i.e. they ensure that other fans do not commit offenses. T. Sahaj is of the view that "if hooligans take care of their affairs in this way, they should be left to their fate. If only this does not harm outsiders, let them even physically eliminate each other during such *squads' duels*" (Sahaj, 2007, p. 143), but there are consequences of such acquiescence: people breaking the law and then using public hospitals if injured (Sahaj, 2007).

In our opinion, there is also a risk of the violence used by the participants of *squads' duels* being transferred to everyday life. The hypothesis concerning diverse, positive and negative, behaviors of soccer fans of the "Stilon" Gorzów Wielkopolski Sports Club was confirmed.

Based on research conducted in the community of active supporters, having considered their specific standards of behavior, motives for cheering, preparation of displays for matches (a form of spectacle performed by the ultras), adjustment of their professional and personal plans to the match schedule, and a specific way of dressing, it can be stated that the fans have created a separate sports fan lifestyle, distinguishing them from other social groups (Siciński, 2002). The community of fans use specific linguistic expressions, which can be considered a sports fan jargon. Soccer fans are also distinguished by wearing clothes in the colors of their club, and an active fan's attribute is a club scarf.

Conclusions

1. The community of fans of the "Stilon" Sports Club is mainly comprised of residents of Gorzów Wielkopolski who practice combat sports and exercise in the gym.
2. Active cheering is accepted and supported financially by most soccer fans' families.
3. The main motives for cheering were: helping the team, meeting up with friends, and satisfaction. For the youth aged 15–19 spending time with a group was important, as well as a sense of connectedness and a sense of strength and power. Supporters who were 20 years of age and older appreciated the opportunity to meet up with friends and let off steam during the match.
4. The community of active fans is characterized by various kinds of behavior (positive and negative). Accurate determination of these behaviors is difficult due to controversial provisions relating to cheering.
5. Alcohol consumption before matches concerns nearly half of the supporters surveyed.
6. There is a necessity to educate children and youth in sports cheering.

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AGE DIFFERENCES IN PSYCHOACTIVE SUBSTANCE ABUSE IN POPULATION OF THE REPUBLIC OF BELARUS

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Abstract *Background*. The recent epidemiological studies conducted in Belarus point to a fall in the average age of registered drug abusers and in the age of drug use onset, an increasing proportion of injecting drugs, and addicted persons.
The aim of the study was to evaluate the age differences in the prevalence of psychoactive substance abuse in the Republic of Belarus using the official data of the Ministry of Health.
Material and methods. The data on registered drug abusers, who were recorded in the Narcological Register in health care institutions between 2000 and 2014, were analyzed.
Results. During that period the number of drug abusers under observation increased almost 3 times, and the situation with the spread of psychoactive substances changed towards appearance of synthetic drugs. The spread of particular drugs (opioids, cannabinoides, inhalants, and Spice based designer drugs) was shown to be depended upon the age of registered drug abusers.
Conclusion. The data obtained indicate necessity of the age-related studies on drug abuse prevalence, and might be useful for working up preventive measures to stop the spread of drug addiction.

Key words psychoactive substances, drug abusers, Narcological Register, population, Belarus

Introduction

The prevalence of drugs and drug addiction presents a real problem for many CIS countries including Belarus. A progressive growth of this pathology over the last three decades combined with a number of negative tendencies in drug trafficking are alarming (Koshkina, 2011; Lelevich, Kozlovsky, Vinitskaya, Maksimchuk, 2006; Lelevich, Vinitskaya, Lelevich, 2014; Moskalenko, 2007).

In Belarus, the Narcological Service of the Ministry of Health and the Ministry of Internal Affairs conduct parallel assessments of the spread of psychoactive substances among the population, sharing and coordinating their information (Lelevich et al., 2006). The Narcological Service of Belarus is a network of specialized outpatient

and inpatient clinics within the public health care system that provides treatment and preventive measures to alcohol and drug abusers. The Narcological Service works with law enforcement agencies, other health authorities and various other government ministries, agencies and non-governmental organisations.

The national health care system maintains a **Narcological Register (NR)** of non-anonymous patients who are kept under dispensary observation at local narcological and psychoneurological clinics associated with the use of alcohol and other psychoactive substances. **The Dispensary Register** lists patients diagnosed with psychoactive substance dependence based on the ICD-10 (the 10th revision of the International Classification of Diseases). The casual drug users who have been found with psychoactive substances and their metabolites in their biological liquids but who were not addicted constitute the group on the **Prevention Register**. The observation period for drug abusers on the Dispensary Register is three years, whereas casual drug users are observed over a one-year period. In case of relapses of drug use the observation period for a patient may be extended indefinitely. At the end of the observation period, a patient may be released from the NR on the following reasons: recovery (or prolonged remission); conviction and imprisonment; change of place of residence; transfer to another medical institution (e.g., psychiatric or other clinic resulting from a change of residence); patient's death; transfer from the Prevention to the Dispensary Register (in cases with developed dependency syndrome). Patients' names and addresses are confidential and are not made public. Other information can be used for professional purposes by other medical institutions, mass media, etc. (Lelevich, Vinitskaya, Lelevich, Maksimchuk, Pekarsky, 2008).

The study was aimed to estimate the spread of psychoactive substance use among different age groups of the population in Belarus using the official data on the psychoactive substance abusers, listed in the NR of the Ministry of Health in 2000–2014.

Material Methods

The object of the study were statistical data on the patients either diagnosed as drug dependent (ICD-10: F11.2−F.16.2, F18.2− F19.2), or with harmful use of drugs (ICD-10: F11.1–16.1, F18.1−F19.1), who were listed in the Dispensary and Prevention NR of the Ministry of Health of the Republic of Belarus, in 2000–2014. The full database of all non-anonymous drug abusers in Belarus is maintained in the National Monitoring Centre for Drugs and Drug Addiction (NMC) established at the Grodno State Medical University. Today the NMC is the only institution in Belarus responsible for collecting and analyzing information on the prevalence of drug abuse and illicit drug trafficking in the Belarus (Lelevich, Vinitskaya, Lelevich, Tishchenko, Konorazov, 2015). Information on the patients who seek medical aid at narcological clinics or were withdrawn from the NR due to different reasons is included in the statistical records of the Ministry of Health and delivered quarterly to the NMC in form of completed registration cards. Data from the registration cards were entered into a computer database and analyzed statistically. To calculate the indicator, *"the prevalence of drug use" (the total amount of drug abusers/addicts registered at the end of the year, per 100,000 population)* the information of the National Statistical Committee of the Republic of Belarus on the population of the country has been used.

Results

According to the NMC estimates 16,975 drug abusers were registered on the Narcological Register (NR) by 31st December 2014, including non-addicted persons and drug addicts (Table 1). Out of those registered drug abusers, 8,711 or 51.3% were the patients on the Dispensary Register (i.e. their condition was complying with the

WHO criteria of addiction when they were put on the register). The rest 8,264 casual drug abusers were on the Prevention Register for non-addicted persons who were suspected of using drugs.

In 2014, 3,792 new users of psychoactive substances were added to the NR, 31.6% of whom had been diagnosed with a psychoactive substance dependency. The same year, 3,143 individuals were released from the register, 19.5% of those died. The rest drug abusers were released because of recovery, were sentenced, or removed from the register due to other reasons.

We investigated the prevalence of different drug categories among the Belarusian drug abusers of different ages, who were recorded on the NR by the end of 2014 (Table 1).

As of late 2014, the most common psychoactive substance categories were opioids, cannabinoides, solvents and inhalants, "designer drugs", and to a lesser extent - amphetamine-type stimulants, hallucinogens, sedatives and tranquilizers. The share of drug abusers, who preferred the certain drugs, was following: opioids – 63.5%; cannabinoides – 18%; Spice based designer drugs – 8%; inhalants and solvents – 6.9%; amphetamines – 2.6%; sedatives and tranquilizers – 1.8%; hallucinogens – 0.9% (Table 1).

Table 1. Distribution of drug abusers listed in the Narcological Register of the Ministry of Health of the Republic of Belarus according to age and common psychoactive substances, 2014

Psychoactive substance category	Age groups							
	under 15 years	15–19 years	20–24 years	25–29 years	30–34 years	35–39 years	40 years and older	total
Opioids	0	51	495	2,027	3,099	2,604	2,503	10,779
Extracted opium	0	41	381	1,621	2,341	2,073	2,081	8,538
Heroin	0	2	18	60	187	148	103	518
Illicit Methadone*	0	2	34	104	231	133	120	606
Cannabinoides	19	543	725	932	517	157	161	3,054
Solvents and inhalants	79	343	252	315	88	45	49	1,171
Amphetamine-type stimulants	2	31	85	131	99	42	62	452
Hallucinogens	10	53	35	27	10	10	12	157
Sedatives and tranquillizers	1	8	20	32	47	53	151	312
Designer drugs**	40	723	337	111	94	30	30	1,364
Total for Belarus	133	1,408	1,866	3,610	4,003	2,962	2,993	16,975

Note: * – including the cases of combined use of methadone and other opioids (opium, heroin, etc); ** – including combined use of Spice based designer drugs, injective psychostimulants and other psychoactive substances.

We analyzed the age distribution of men and women, as well as addicted and non-addicted persons, recorded in the Belarusian narcological clinics by the end of 2014 (Figures 1 and 2).

Males constituted the majority of the registered drug abusers in Belarus. By the end 2014, 14,466 men (85.2%) and 2,509 women (14.8%) were registered as psychoactive substance users in Belarusian narcological institutions. The "men to women" ratio was equal 5.7 to 1. The mean age of the male drug abusers, listed in the NR in 2014, was 34.7 8.8 years (mean ± standard deviation), and their ages ranged from 7 to 60. However, the ages of women ranged from 11 to 58, and their mean age was comparatively lower (32.4 ±8.5) (Figure 1).

Males predominated in all age groups of the registered drug abusers. However, the older group of drug abusers was analyzed; there were more women abusing drugs. In 2014, women comprised 12,4% of the drug

abusers aged under 20. However, among the patients aged 45 and above, the proportion of women was 15.5% (Figure 1).

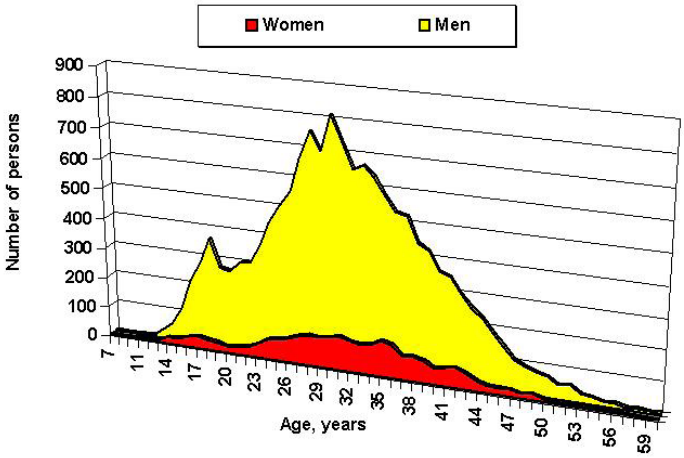

Figure 1. Age distribution of men and women listed in the Narcological Register of the Ministry of Health of the Republic of Belarus, 2014

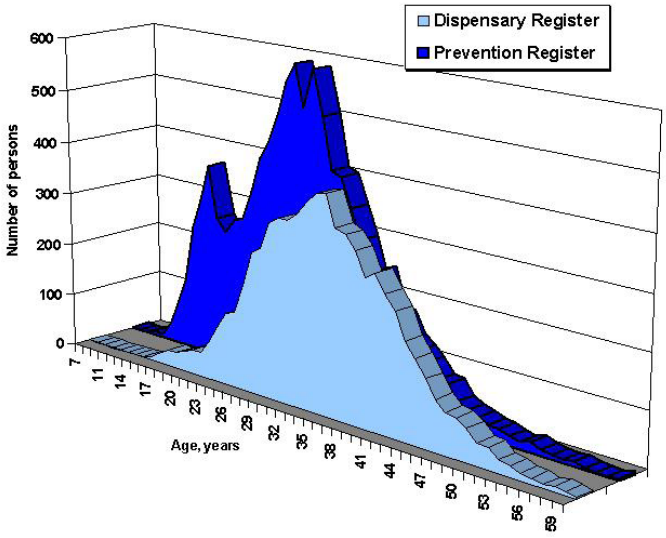

Figure 2. Age distribution of drug abusers, who were recorded on the Prevention and Dispensary Narcological Registers of the Ministry of Health of the Republic of Belarus, 2014

In 2014 the age of the drug abusers, who were under medical surveillance in Belarus, ranged from 7 year-old children abusing solvents to 60 year-old opioid injectors (Table 1; Figure 1). About 80% of all illicit drug abusers were aged 25 and above, and the mean age of these persons was 34.1 ±9.1 years.

In 2014 133 children aged 7 to 14 were under medical surveillance in narcological institutions because of use of different psychoactive substances. Among them there were 101 boys and 32 girls. In 2014, 1408 or 8.3% of drug abusers were aged 15 to 19, and 10% of them were girls (Table 1; Figure 1). Only 102 of these young people were addicted, and placed on the Dispensary NR according to the clinical criteria of ICD-10 (Figure 2).

According to the NMC estimates, 11% of all registered drug abusers were aged 20 to 24, whereas the older drug patients constituted almost 80% of all persons registered on the NR in Belarus. Other age groups constituted, subsequently, 21.3% for drug abusers aged 25 to 29; 23.6% for those aged 30 to 34, 35.1% for those aged 35 years and above (Table 1). It was shown that the ratio of addicted persons was higher among the older drug abusers. In 2014 the share of addicted persons among registered drug abusers constituted even 71.2% among those aged 40 years and more, whereas only 16.6% of the young addicts aged 20 to 24 were registered on the Dispensary Register (Figure 2).

Discussion

According to official statistical data of the Ministry of Health of Belarus at the end of 2014, narcological and psychoneurological dispensaries had registered 188,260 alcoholics and alcoholic psychosis patients, or 1,985.7 per 100,000 of the population (1,426.0 per 100,000 in 2000 (Ministry of Health of the Republic of Belarus 2014). Whereas the number of the persons abusing other psychoactive substances constituted 16,975, including casual users and patients with dependency syndrome (Table 1). A comparison of statistical data on alcoholics and drug addicts shows that alcoholism is much more widespread among the population than drug addiction. However, two factors must be taken into account here: first, there is more latent drug addiction than latent alcoholism and, second, the social risks associated with drug addiction are greater than those associated with alcoholism (Koshkina, 2003).

Over the last 14 years the prevalence of non-prescription use of psychoactive substances has become a pressing issue in Belarus. According to the NMC estimates, the number of drug abusers under observation increased almost 3 times between 2000 and 2014: At the end of 2000 it stood at 6,310 persons throughout Belarus. In 2014 the indicator of *"the prevalence of drug use"* was 179 drug abusers per 100,000 of the country population, whereas in 2000, it was 67.4 per 100,000 of the population.

It has been shown before that drug users living in different regions of Belarus, differed on the number of socio-epidemiological parameters, including sex ratio, age characteristics and preferences of different types of psychoactive substances (Lelevich et al., 2014). In 2014 the city of Minsk and the Gomel region reported the majority of new cases of drug use and had the highest cumulative number of registered drug users per 100,000 of the population (306.3 in Minsk, and 190 in the Gomel region). The Mogilev region had the smallest number of registered drug users per 100,000 (98 in 2014).

National epidemiological studies point to a fall in the average age of registered drug abusers and in the age at which drug use begins, an increasing proportion of hard drugs, and addicted persons (Lelevich et al., 2008, Lelevich et al., 2014). According to the official statistic of the Narcological Service at the end of 2014, 8,711 persons (or 51.3%) were recorded on the Dispensary NR for the patients with diagnosed dependency syndrome. The rest 8,264 casual drug abusers were on the Prevention NR.

Overall, statistics have shown that illicit drug abuse rises with age until it peaks at ages when people begin to inject drugs (Table 1). In 2014 the age of the drug abusers, who were under medical surveillance in Belarus, ranged from 7 years children abusing solvents to 60 years opioid injectors (Table 1; Figure 1).

Epidemiological studies carried out in different countries show that the drug use is considered as a "male phenomenon "(Becker, Hu, 2008, Degenhardt et al., 2008). Animal research and human studies have revealed that males and females may differ in their biological responses to drugs. From the neurobiological point of view, men are more likely than women to abuse drugs that might be explained by hormonally-mediated differences in the neurochemical reactions in response to the drug (Stevens, Andrade, Ruiz, 2009).

Among Belarusian drug patients, men constituted the majority of the registered drug abusers, who were under medical surveillance in 2014. At the end of 2014, male drug abusers comprised 85.2% and women 14.8%. Out data are consistent with the latest data of the UN Office on Drugs and Crime (UNODC). According to the World Drug Report for 2015, women make up one-fifth of all drug users in treatment, whereas their real number may be even one-third (UN World Drug Report 2015). According to the previous observations in Belarus women usually start to use psychoactive substances in older ages compared to men (Razvodovsky, Vinitskaya, Lelevich, 2010; Lelevich et al., 2015). The mean age of women, who were registered on the NR in 2014, was slightly lower than the mean age of men (32.4 ±8.5 years against 34.7 ±8.8). The youngest reported age of a female substance abuser was 11, whereas for the boy this age was 7.

It was found that men predominated in all age groups of the registered drug abusers in Belarus. However, the older group of them was analyzed; there were more women who abuse drugs. In 2014, women comprised 12,4% of the drug abusers under the age of 20. However, among the patients aged 45 and older, the proportion of women was 15.5% (Figure 1).

The structure of the drug market in Belarus reflects changes that have taken place in the structure of global trafficking routes. Belarus finds itself now at the intersection of plant drug routes running in parallel from Southeast Asia and Central Asia to destinations in Western and Northern Europe, while some synthetic drugs and psychotropic substances are trafficked eastward. Due to the "transparency" of its external borders, especially the border with the Russian Federation, the territory of Belarus continues to play a significant role in drug trafficking. At the same time, cases of cultivating drug containing plants with the goal of producing drugs have been registered in country (Lelevich et al., 2008).

Epidemiological studies carried out it Belarus point to the following main categories of psychoactive substances that are spread among registered drug abusers.

Opioids category of drugs includes homemade opium (extracted or acetylated opium made from poppy straw or seeds of the Papaver plants), heroin, and street methadone. There are also cases of misuse of pharmaceutical opioids, such as morphine, codeine, and tramadol.

Cannabinoides group include marijuana (herb) and hashish (resin), and also Spice based smoking mixtures, containing synthetic cannabinoides, (JWH-type, AB-PINACA, etc.).

Amphetamine-type stimulants include amphetamine, methamphetamine, and 'Ecstasy'-type substances (e.g. MDA, MDMA), Other cases include use of ephedron, pyrovalerone, mephedrone, and 'Nasvai' (the mixture with a slightly hallucinogenic properties composed of tobacco dust, glue, lime, water or vegetable oil, rolled into small balls. "Nasvai" is mainly used by teenagers).

Sedatives and tranquilizers include barbiturates, benzodiazepines and other sedatives. There are the cases of misuse of prescribed drugs Xanax, Zopiclone, Afobazol, Somnol, Sonnat. As well as misuse of "Corvalol" and "Valocordin", which are the prescribed medicines, containing low doses of barbiturates.

Hallucinogens category include misuse of some medications such as taren, dicyclomine, cyclodol, dymedrol, and per oral use of atropine-containing seeds and extracts from plants *Racinus communis L., Datura stramonium, Hyoscyanius niger L.*

Designer drugs category includes all recorded cases of the use of smoking mixtures, containing synthetic cannabinoides, as well as injecting of some psychostimulants.

According to the UNODC estimates, opioid drugs are some of the most widely used in European and Asian countries (UN World Drug Report, 2015). Over the last three decades, opioids were the most common drugs in Belarus (Vinitskaya, Lelevich, Razvodovsky, 2012). More than 80% of users of opium-based drugs, who were placed on the NR showed a preference for intravenous injection of extracted or acetylated opium made up from poppy straw or seeds of edible grades of *Papaver somniferum L*. These homemade opioids were used extensively among drug addicts in nearly all regions of the country, as poppies and precursors for making a narcotic extract are readily available (Lelevich et al., 2008).

As of late 2014, 10,779 opioid users were recorded in the Narcological Register, or 63.5% of all registered cases (Table 1). 72% of these cases were listed in the Dispensary NR (ICD-10, F 11.2) and the rest were listed in the Prevention NR with a diagnosis of harmful use of opioids (ICD-10, F 11.1). The overwhelming majority of opioid users (95.3%) were intravenous users.

In 2014, almost half of all recorded drug abusers in Belarus (50.3 %) injected extracted opium, as the most available and cheep drug ("kompot"). Unlike the EU countries, heroin users comprised only 3.1% of all reported drug abusers in Belarus. According to the European Monitoring Centre on Drugs and Drug Addiction, heroin is the most popular opioid in the EU countries, whereas the use of home-made poppy prevails mainly in the Eastern European countries (EMCDDA European Drug Report 2016). Besides, street methadone was used by 3.6% of all registered drug abusers in Belarus (Table 1).

Cannabinoides and inhalant were on the second and third positions in Belarus, and abusing them persons constituted, respectively, 18% and 6.9% of all registered drug abusers in 2014. The use of some amphetamine-type stimulants is spread in Belarus to a lesser extent, although these drugs predominate in Western Europe, as the common drugs for injecting (EMCDDA European Drug Report 2016). The rest registered drug abusers consumed sedatives and tranquillizers (barbiturates, benzodiazepines) (1.8%) and hallucinogens (1%) (Table 1).

In addition to the above-mentioned psychoactive substances, we analyzed the cases of abuse of so-called "designer drugs", compounds with modified chemical formula. According to the Belarusian experts, the most common substances found in these smoking mixtures were JWH-type synthetic cannabinoides (more often JWH-018), AB-PINACA, AB-PINACA-F, AB-PINAC, AB-PINACA CHM, psychostimulants like MDPV, alpha-PVP, and other psychotropic substances (4-MeO-PCP, MBA(N)-018, QCBH-DZ-F, QCBL). There were also cases of injecting use of Psychostimulators, such as MDPV and alpha-PVP.

In Belarus the sudden growth in the number of recorded patients poisoned with Spice based designer drugs is observed since 2013. If in 2010–2012 the number of identified users of these mixtures had ranged from 4 to 7 persons, by the end of 2013, there were 334 officially registered users of designer drugs. The most sudden growth in the number of recorded poisonings with these substances was observed in 2014. As of December 31, 2014, drug

treatment facilities in Belarus recorded 1364 persons, abusing various substances with modified formula (Table 1). Of those persons, 43% were residents of the capital city of Minsk.

The age distribution of the registered substance abusers was highly dependent on their gender and narcological diagnosis (Figures 1 and 2).

In 2014 the youngest drug abusers treated in Belarusian narcological clinics were aged from 7 to 14. They constituted only 0.8% of all registered drug abusers. Only 3 of these children were diagnosed as dependent from solvents and inhalants, according to the clinical criteria of the ICD-10. The rest of the children were placed on the Prevention Narcological Register (Table 1; Figure 2). The vast majority of these children preferred inhalants (volatile solvents, glues) (59.4%) and Spice type smoking mixtures (30%). Other registered young abusers consumed herbal cannabinoides (14.3%) and amphetamine stimulants (ecstasy) (1.5%). Besides, 10 teenagers were hospitalized in 2014 as the result of poisoning with atropine-containing plants, mainly hog bean *(Hyoscyamus L. niger),* jimsonweed *(Datura stramonium L.),* and castor bean *(Ricinus communis L.),* and 1 person was registered after poisoning with barbiturates. In 2014 there were no registered cases of injecting drug use among young people aged under 15 (Table 1).

In 2007 the ESPAD-based regional study on the prevalence of drug use among students aged 15–16 was conducted in the Brest region. The survey demonstrated that 10.5% of boys and 3.5% of girls reported use of psychoactive substances at least once in their life. Among psychoactive substances used the most common were marijuana (6.8% of all respondents), ecstasy (1.3%), LSD (0.9%) and hallucinogenic mushrooms (0.4%). 5.3% of respondents admitted to the use of inhalants during their life and 1.1% said that they had used tranquilizers without a doctor's prescription (Avsievich, Danilova, Krasko, Golovach, Seredich, 2008). Therefore, our data on the registered teenagers treated in narcological clinics are consistent with the data of sociological surveys performed among Belarusian students.

In 2014, 1408 or 8.3% of drug abusers were aged 15 to 19, and 10% of them were girls (Table 1, Figure 1). The vast majority of these young abusers were placed on the Prevention NR mainly due to the information of law enforcement and medical agencies, or educational institutions. Only 102 of them young people were addicted, and placed on the Dispensary NR according to the clinical criteria of ICD-10 (Figure 2). Unlike the youngest group the substance abusers of this age category preferred herbal cannabinoides (38.6%) and Spice based designer drugs (51.3%) compared to the youngest drug abusers. About a quarter of the 15–19 aged patients (24.4%) misused solvents and inhalants that was less then among the youngest group of drug abusers. On the other hand, there were 51 drug abusers aged from 17 to 19 who injected opioids, mainly extracted opium (Table 1). This founding indirectly points to the fact that the young people of these ages begin to experiment with so-called soft drugs, and then gradually move to "hard' injecting opioids. These observations are consistent with our previous studies carried out in 2007 (Razvodovsky et al., 2010).

Our data show that in Belarus the spread of particular drugs among registered drug abusers is highly dependent on their ages. For example among the individuals aged 20 to 24 opioid abusers comprised 26.5%. Among drug abusers older than 25 years the proportion of people who use opioids ranged from 56 % among the drug patients aged 25–29 to 84% among the patients aged 40 years and above (Table 1). The preference for opiate drugs has led to the faster development of the dependency syndrome in the older drug abusers. According to our data, the share of addicted persons constituted even 71.2% among those aged 40 years and above, whereas only 16.6% of the young addicts aged 20 to 24 were registered on the Dispensary NR (Figure 2).

Opioid abusers of different ages show preference to certain types of opioids. Although the vast majority of Belarusian opioid abusers preferred extracted opium made up of poppy straw and seeds, injecting use of heroin and street methadone was noted mainly in the groups of patients aged 20 to 39 (Table 1).

At the same time, the spread of typically recreational drugs like marijuana and Spice based smoking mixtures rather predominated among the younger drug abusers. As for the end of 2014, the share of the cannabinoides abusers varied from 39% among the 20–24 aged persons to 5.4% among to those aged 40 years and above (Table 1). Low recreational doses of spice compounds or bath salts produce the expected desirable effects, but high doses or chronic exposure can lead to dangerous medical consequences including psychosis, violent behaviors, tachycardia, hyperthermia, and even death (Baumann et al., 2014).

According to statistical data of the Ministry of Health of Belarus for 2014 year, amphetamines and different "designer drugs" were mainly distributed among men and the drug abusers in the age groups up to 25 years (Table 1). For example, the proportion of underage persons abusing "designer drugs" (under 18) constituted even 32%. In 2014 the youngest "spice" smoker was 9 years old at the time of his registration in the NR. Cumulatively more then 80 % persons, who were poisoned with the Spice based substances in the reporting year were aged less than 25 years. The older users of designer drugs were polydrug users and combined abuse of smoking mixtures with injecting of opioids, or amphetamine-type stimulants.

In addition, the misuse of legal prescription drugs was also more characteristic for older patients treated in Belarusian narcological clinics. In 2014 more than 58% of the persons listed in the NR because of misuse of barbiturates and benzodiazepines were older than 40 years (Table 1).

Conclusions

1. Analysis of the official data of the Ministry of Health of the Republic of Belarus can give insight of the real situation on the prevalence of psychoactive substance use in Belarus.

2. Over the period from 2000 to 2014 the number of drug abusers recorded in the Narcological Register increased almost 3 times, and the situation with the spread of psychoactive substances is changing towards appearance of synthetic drugs.

3. In 2014 among the registered drug patients in Belarusian narcological clinics the most common drugs were extracted opium, herbal and synthetic cannabinoides, solvents and inhalants.

4. In Belarus, the abuse of psychoactive substances increasingly spread among men compared to women. At the end of 2014 men constituted 85.2% of all drug abusers registered on the NR.

5. In 2014, the age range of the drug patients registered on the NR, varied from 7 to 60 years. However, the vast majority of recorded drug users in Belarus were aged 25 and above, and the mean age of these persons was 34.1 ±9.1 years.

6. It was shown, that drug abusers of different ages preferred certain types of psychoactive substances. Among the drug patients aged fewer than 20 the most common drugs were cannabinoides, inhalants, and Spice type smoking mixtures. Injecting opioids were mainly spread among drug abusers older than 20 years, and the share of these persons increased with the age.

7. The data obtained indicate necessity of the age-related studies on drug abuse prevalence, and might be useful for working up preventive measures to combat the spread of drug addiction

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Guide for Authors

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Contributors are invited to submit their manuscripts electronically to e-mail: joanna.latka@usz.edu.pl. Central European Journal of Sport Sciences and Medicine considers for publication manuscripts in the categories of Original Research, Review Article and Short Communication. The manuscripts should be in one of the following sub-disciplines: exercise physiology and biology, sports nutrition, sports science, biomechanics, coaching and training, sports medicine, sports injury and rehabilitation, physical activity and health, public health, physical education and health promotion as well as methodology of sport and history of physical culture and sport. Manuscripts with an interdisciplinary perspective with specific applications to sport and exercise and its interaction with health will also be considered. Papers are published only in English.

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The manuscript must be word-processed, double-spaced throughout, with a 2.5 cm margin all around, with no 'headers and footers' (other than page numbers), and without footnotes unless these are absolutely necessary. Use Arial, size twelve (12) point font.
All experimental work in which humans are participants must conform to the laws of the country in which the work took place. The manuscript should contain a statement to the effect that the work reported has been approved by a local ethics committee or review board. The statements about ethics approval or sources of data should be made at the beginning of the methods section.
Manuscripts should be compiled in the following order: title page; abstract; keywords; main text; acknowledgments; references; list of table(s) caption(s) and figure(s) legend(s) (on individual page at the end of the manuscript). The table(s) and figure(s) have to be uploaded as separated file(s). The main text can be arranged under headings such as Introduction, Methods, Results, Discussion and Conclusion if this is appropriate. Number the pages consecutively, beginning with the title page as page 1 and ending with the Figure pages. 6,000 word count limit (including title, abstract, acknowledgements, and references).

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Include the following information on the first page of the manuscript: the full title; a running title of no more than 75 characters and spaces. List all authors by first name, all initials and family name. List departmental affiliations of each author affiliated with institutions where the study described was carried out. Connect authors to departments using numbers superscripts. Contributions of the author and each co-author considering the following categories: A – Study Design; B – Data Collection; C – Statistical Analysis; D – Manuscript Preparation; E – Funds Collection. No names of co-authors will be published unless their contributions are indicated. Connect authors to contributions using alphabetic superscripts.
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