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Contents

SOCIAL AND POLITICAL ASPECTS OF THE DEVELOPMENT OF CYCLING IN POMORZE ZACHODNIE (WEST POMERANIA) IN THE YEARS 1945–1950

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Abstract The article presents the determinants of the development of cycling in the areas incorporated by Poland in the first years after the Second World War.

The biggest contribution into this process was made by people from large cities, pre-war enthusiasts and athletes who undertook the hardships of social activity and the engagement of local youth. Sports organizations were controlled, but also supported, by state authorities that used mass events in the propaganda policy and actions aimed at integrating the Northern and Western Lands with the rest of the country. This was an important task due to the difficult living conditions and marauding groups of criminals for whom Pomorze Zachodnie constituted an area of criminal activity, mainly plundering former German property, as well as attacking. Polish settlers. The development of cycling in Szczecin was favored by the German infrastructure, including a concrete track often used in national championships.

At the end of 1949, sport in Poland was reorganized and centralized, making it similar to the Soviet model, where there was no room for social measures. The bourgeoisie clubs had to cease their activities, while the circles and clubs were created at workplaces and trade unions. Sports federations were liquidated and their place was occupied by sports clubs located within the structures of the state administration. The organizational changes were accompanied by the mass popularization of sport and increased financing for competitive sport from the state budget. The goal of such activities was to reach a wide group of young people for the needs of indoctrination, as well as to raise the level of sport to achieve more effective competition with Western countries.

Key words sport history, years 1945–1950, physical culture

Introduction

With the end of the Second World War, the communists took over power in the area of Poland occupied by the Soviet army. They were protected by the former occupant, and later the Allies' supporter, as well as reinforced by the armed units of the Internal Security Corps (ISC) the Office of Public Security (OPS). During the chaos, it was difficult to control society to a full extent and counteract the spontaneous movement of the population. One of the directions of intersecting roads was Pomorze Zachodnie, in the past called Hinterpommern (Farther Pomerania). This was not due to the proper conditions of settlement, but its closeness to Western Europe. There was a transport route stretching from Szczecin to Berlin, and further to the zone of capitalist countries. It was not without reason that all of Pomorze Zachodnie was called “the Wild West”. The plundering of post-German property by Soviet soldiers, but also the Poles themselves, discouraged people from settling. Especially that in the “rage” of the so-called looting, defenseless civilians were often assaulted.

In the atmosphere of post-war demoralization and general vagrancy, sport activists and athletes themselves were a positively distinguished group. Of course, the years of occupation had to affect them negatively, which was also noticeable in brutal and particularly aggressive field behavior. However, when most of the Poles arriving to the Western and Northern Lands were busy with their own problems, i.e. looking for a place to live, food and work, those with passion and commitment started to create sports clubs, organize training and first competitions, especially football matches. Another activity preferred by the settlers was cycling, despite the lack of proper equipment at that time.

So far, there has been no reliable and critical study on cycling in Pomorze Zachodnie after 1945. Therefore, the authors undertook the task of examining the social and political conditions that influenced the development of this sport discipline in the territory incorporated by Poland after the Second World War. This article is also a preliminary study of the formation of cycling in the period of pioneer settlement and the reconstruction of sports activities based on the pre-war model.

The research involved an analysis of archival and press materials as well as literature on the subject applying the inductive method. Furthermore, conclusions were drawn without the possibility of direct access to relevant materials, as well as based on knowledge beyond the source (the method of deduction). Materials collected in the State Archive in Szczecin, the Faculty of Health and Physical Education of University of Szczecin as well as private collections were used.

Results of the research

Although in autumn 1945 cycling competitions had not yet been organized, a group of post-war enthusiasts of this sports discipline already existed in Szczecin. The problem constituted a lack of both active athletes and bicycles, which were considered luxury goods at that time, with every person using such means of transport being exposed to assaults and robberies. In the following years, brutal attacks on officials, teachers or postal workers cycling to work were not uncommon. Nevertheless, a favorable element was the infrastructure: high-class road surfaces, highways, the motorway outside Szczecin, not to mention the concrete cycling track in Szczecin itself.

In the first place, Pomorze Zachodnie was inhabited by people coming from the closest Wielkopolska and the destroyed Warsaw, as well as forced laborers returning to their homeland and prisoners of war. Szczecin welcomed a lot of citizens of Poznań, who were usually sent there by the authorities to organize public administration and municipal services. It was this group coming from metropolitan areas that shaped the development of sport on the so-called “Recovered Territories”, though de facto they were acquired lands. For many settlers-athletes coming to these areas meant new career opportunities. Of course, this was usually associated with the need to join the Polish Workers’ Party (PPR), and from 1948 – the Polish United Workers’ Party (PUWP). However, most activists did not protest against such attitudes. It was possible to treat such behaviors as a kind of camouflage donned every day during German occupation.

The first sports club, which associated mainly employees of the city council, was established in Szczecin on July 20, 1945, and took the name "Odra", referring to the border river flowing through the city. It was a common geographical motif used by sports communities, however in the post-war times, when the border changed, it took on a special propaganda meaning. The association also became the nucleus of the growing cycling culture since the spring of 1946, when a specialized unit was established ("Kurier Szczeciński", 1946, No. 62). It brought together cycling activists and enthusiasts of this discipline: Leon Bestry and Dominik Nadolski, with the latter being an owner of a workshop and bicycle shop. They were supported by Jan Dix, a sports activist, athlete, referee and football coach (the State Archive in Szczecin – APSz, the City Board and National City Council – ZMiMRN in Szczecin, file number 240, "Odra" Sports Club, 1945–1949, p. 27).

The first chance to demonstrate sports activity was a propaganda event organized by the central authorities called "Trzymamy straż nad Odrą" ("We Keep Guard Over the Oder"), as part of the National Youth Meeting (April 12–14, 1946). Among the guests invited to Szczecin there were Bolesław Bierut, Edward Osóbka-Morawski, Michał Żymierski-Rola and Stanisław Mikołajczyk. The program of the ceremony included the Recovered Territories Games with a cycling competition (APSz, ZMiMRN in Szczecin, file number 520, Report on the activities of the City Committee of Physical Education and Military Training in Szczecin, pp. 1–2; "Kurier Szczeciński", 1946, No. 72, 75, 81, 85). Although there were not cyclists from Szczecin, the competition took place with the participation of leading sportsmen from other regions of the country. On April 14, 1946, the first road race along the 60-km long Polish-German border (26 competitors) was organized in Pomorze Zachodnie, and on the following day – the competition on a concrete track with the participation of 21 cyclists took place (Tuszyński, 1986; "Kurier Szczeciński", 1946, No. 85). The above-mentioned event served propaganda to be sure, but at the same time contributed to the popularization of this discipline in Szczecin. Competitions on the cycle track were able to attract from several up to 10,000 spectators. That is why the municipal and voivodeship authorities started supporting the organization of mass events and the renovation of the former German building. However, there was still a lack of appropriate equipment, mainly bikes, which is why only a few people wanted to become a member of the cycling unit during that time. The training itself was usually trips to suburban villages.

Another breakthrough moment in cycling in Zachodniopomorskie voivodeship took place in July 1946, when the Regional Cycling Federation (OZKol.) was established in Szczecin. It was, in fact, created by the same activists from the "Odra" Sports Club, joined by Roman Antowski, who came from Poznań. Leon Bestry was chosen the President of OZKol. The first and at the beginning the only federation member was the "Odry" cycling unit (APSz, PWRN in Szczecin, file number 11477, Minutes of OZKol.'s meetings, 1946–1949, p. 5). The main objective of the activists was the organization of the first local races. However, there was still the problem of the lack of willing and active participants. For these reasons, the event had to be postponed twice. It was possible to carry out 15-km long competitions around Jasne Błonia in Szczecin as late as in August. The race was won by Hieronim Machnik from "Odra" Sports Club, who was rewarded a camera funded by the Governor of Szczecin – Lt. Col. Leonard Borkowicz ("Kurier Szczeciński", 1946, No. 184).

Figure 1. Before the start of the race around Jasne Błonia on August 11, 1946

Source: Collections of the Faculty of Health and Physical Education of University of Szczecin (WKFiZ US).

Nevertheless, the biggest event in Szczecin in 1946 was the September 50th Polish cycling championship at a distance of 50 km won by Jerzy Bek. This event was also included in the policy of integrating Recovered Territories with the rest of the country. According to the official statements of the Polish Cycling Federation (PZKol.), the race was organized to "underline the link with the ancient Piast lands", that is Pomorze Zachodnie ("Kurier Szczeciński", 1946, No. 223). This time two Szczecin cyclists managed to take part, but unfortunately, they did not finish the race. The autumn of 1946 brought about the activation of other communities in Pomorze Zachodnie. In the first poviat sport games in Białogard, apart from other competitions, an 18-km race was organized ("Kurier Szczeciński", 1946, No. 223).

Both establishing contacts with PZKol. and, especially, the appropriate infrastructure, resulted in Szczecin being commissioned to build a central training camp for leading Polish athletes, who were preparing for the 1948 Olympic Games in London. Apart from training, fans in Szczecin could also watch the struggles of cyclists participating in track racing. Another large event commissioned to OZKol. in Szczecin was a long-distance race as part of the Polish championship covering the 200-km long Kołobrzeg–Szczecin route ("Kurier Szczeciński", 1947, No. 175). In 1947, cycling units in other sports clubs were also opened. In July, Militia Sports Club from Łobza was accepted as a member of OZKol., while in August, the "Pionier" Railway Sports Club from Szczecin joined the federation. In the autumn of that year, a cycling unit was organized at the "Drukarz" Union Sports Club in Szczecin (APSz, the Voivodship National Council – PWRN in Szczecin, file number 11477, Minutes of meetings of the Regional Cycling Federation, 1946–1949, p. 17). At that time, the leading cyclist of "Pionier" was Kazimierz Broszczak, a dismissed soldier from the 2nd Polish Corps in the West under the command of General Władysław Anders. Arriving from France to Szczecin, he brought with him three new racing bicycles, which were then the only high-performance bicycles in Pomorze Zachodnie. K. Broszczak also won the first official track cycling championships of Szczecin organized on September 7, 1947. All profit from the event, as in many other cases, was dedicated to the reconstruction of Warsaw ("Głos Szczeciński", 1947, No. 85). It was a kind of levy of former German lands incorporated into Poland, intended for rebuilding the capital of Poland from the rubble. This also meant that the central authorities were not interested in the rapid development of the Western and Northern territories. Unfortunately, the above-mentioned competition became a source of conflict between the management of OZKol. and the top cyclists who demanded a cash equivalent for taking part in the race. As a result of the conflict, L. Bestry resigned from the post of the president but was reinstated after a year.

The above-mentioned K. Broszczak participated in the Tour de Pologne in 1947 and took the 19th place. In March 1948, he was drafted to the central training camp before the Warsaw–Prague–Warsaw Race, later known as Wyścig Pokoju (the Peace Race) ("Głos Szczeciński", 1948, No. 76). However, ultimately, he was not qualified for the international competition. In 1948, another great talent appeared in Szczecin – Zygmunt Przezdomski.

When planning the main cycling event in 1948 – the Tour of Poland, the Zachodniopomorskie unit was not omitted. The fourth stage of this event took place between Słupsk and Szczecin, while the next was organized on the Szczecin–Poznań route. Pre-war cyclist Kazimierz Konopczyński, who lived in Szczecin and wanted to compete wearing the colors of the "Odra" club took part in the race. However, he did not finish it due to the lack of spare inner tubes ("Kurier Szczeciński", 1948, No. 174).

In 1948, local races were more and more often organized both on roads and tracks. However, Szczecin remained the center of the voivodeship thanks to proper infrastructure, and most importantly, passion and engagement shown by a handful of sports activists. Another important factor was the authorities' policies, where sports events were included in the multitude of propaganda actions aimed at integrating the Northern and Western territories with the rest of the country. Unfortunately, the progressing vandalizing of vehicles as well as taxes imposed on the organizers of the competition were not conducive to more frequent contacts with the national leaders. Difficult living conditions in Pomorze Zachodnie and the lack of financial support for outstanding athletes made it impossible for other leading cyclists to move to Szczecin.

The year 1948 brought about organizational dependence of sports communities on state authorities (Pasko, 2012). The seats of regional sports federations were located in the building of the Voivodeship Office for Physical Culture and supervised by the Voivodeship Office of Public Security (APSz, ZMiMRN in Szczecin, file number 246, Regional Cycling Federation in Szczecin, 1948–1951, p. 13). All electoral meetings were overseen by the deputes of the provincial authorities, and at the same time, members of the Polish United Workers' Party (PUWP). Furthermore, the representatives of the communist-dependent organizations were also introduced to individual boards. The situation was similar for the management of the Regional Cycling Federation in Szczecin. Antoni Dałkowski, from the Voivodeship Rural Sport Council, was also included in this body. He was to act as the head of the tourism section in the board of OZKol. (APSz, Provincial Committee – PC PUWP in Szczecin, file number 3466, Resolutions and executive functions of PC PUWP on the Sport, 1949, p. 73). Such enlargement of the OZKol. presidium resulted from the authorities' policy aimed at mass popularization of physical culture, especially in the rural environment. Sports organizations, i.e. the Popular Sports Teams, alongside the corps of the Public Organization of "Service for Poland" ("Służba Polsce") and the circles of the Polish Youth Association, were in fact the stronghold of the authorities that set the stage for the introduction of collectivization of agriculture (socialist economy). As it soon turned out, people from the party did not take part in OZKol.'s work and after some time they were replaced by other activists.

The centralization of sport also had an organizational aspect. Sports federations based on social movements could not simply be registered, and thus were dissolved (Godlewski, 2002). To survive, they joined new units applying the new structure of sport (APSz, PWRN in Szczecin, file number 11535, Minutes of organizational clubs' meetings, 1949, p. 100). Since 1950, sports clubs at the workplace and the District Councils of Sports Associations, related to specific trade unions, have been organized (APSz, Marshall Office in Szczecin – UWS, file number 1383, Associations and Unions, 1949–1950, p. 122). One of the consequences of such policy was the actual mass popularization of physical culture, often forcefully, as well as the fragmentation of the potential of competitive sport. While mass popularization of sport was easy to carry out in large cities, similar activities faced numerous problems in the rural environment. In addition to the lack of trained staff, there was simply a shortage of equipment. Programs and declarations were prepared, but usually had no realistic follow-up ("Kurier Szczeciński", 1949, No. 50). Moreover, it was easier to attract athletes for political demonstrations, parades on "the holiday of the working class" on May 1, or "People Holiday" (July 22) than to materially support the development of competitive sport.

Figure 2. Leading Szczecin cyclists on the March of the 1st May on Wały Chrobrego in Szczecin, beginning of the 1950s

Source: Private collections of Z. Borowski.

When on 28 September 1949 the Resolution of the Political Bureau of the Central Committee of the Polish United Workers' Party on Physical Culture and Sport modelled on the resolution of the Central Committee of the All-Union Communist Party (Bolsheviks) was promulgated, it was decided that the structure of Polish sport should be based on Soviet patterns. Physical education and sport became an instrument of the authorities in the process of indoctrination of the society and preparation of youth for work and military service (Szymański, 2004).

In Szczecin alone, the years 1949–1950 brought about the organization of a series of cycling events. They were prepared not only for training needs, nationwide classifications, central championships, but also for propagating this sport and attracting youth. Training took place twice a week, and on Sundays there were organized the so-called fitness training, i.e. cycling tours throughout the entire voivodeship.

Figure 3. Cycling tour of Szczecin's competitors in 1949

Source: Collections of WKFiZ US.

In 1949, the top cyclists from Szczecin included Kazimierz Broszczak, Tadeusz Janicki, Józef Sołtowski, Zygmunt Przezdomski, Eugeniusz Rotmajer and Zbigniew Borowski. They took part in nationwide competitions, often organized with the purpose of propaganda, and competed against the best athletes in Poland (APSz, PWRN in Szczecin, file number 11477; Protocols of meetings of the Szczecin Regional Cycling Federation, 1946–1949, p. 65). In 1949, K. Broszczak represented Szczecin in the biggest event of the year – the Tour de Pologne, and took the 58th place. On the other hand, the largest cycling event of international character in Szczecin at that time was Poland–Czechoslovakia track cycling competition (June 29, 1949). Although no local cyclist was included in the Polish national team, the race was an exceptional event in Pomorze Zachodnie.

The year 1949 witnessed the first great successes of the rising star from Szczecin – Zygmunt Przezdomski. The opportunity to present his physical prowess was the 3-stage "Brzegiem Bałtyku" ("Along the Baltic shore") road race on the route Gdańsk–Szczecin organized in July. The cyclist won in the third stage and was the winner in the general classification ("Kurier Szczeciński", 1949, No. 202). In addition to the races in the official annual competition schedule, the authorities organized purely propaganda events. Such events included, among others, a seven-day "propaganda-tourist" cycling rally in the territory of Szczecin voivodship (July 21–28, 1949), that was considered a part of the so-called uniting the city with the village. The program of the trip included community service by the participants, demonstration sports events and artistic performances. In the group of amateurs, referred to as tourists, there was a talented junior – Janusz Klabecki, who in later years achieved some considerable successes (APSz, PC PUWP, file number 3466, Resolutions and guidelines of the Executive Committee of the Polish United Workers' Party in sports, 1949, pp. 67–68). Another propaganda event was postman races organized as a competition accompanying the Race around Poland ("Kurier Szczeciński", 1949, No. 216).

Szczecin community was lucky to have a concrete cycling track, which is why the Polish Championship covering the distance of 50 km took place in the capital of the voivodeship on August 7, 1949. The race was won by Tadeusz Gabrych ("Włókniarz" Łódź), who came first before Bolesław Napierała ("Ogniwo" Warsaw) and Jan

Janicki ("Włókniarz" Wrocław). The best cyclist from Szczecin – Kazimierz Broszczak – took the 5th place, and Zygmunt Przezdomski – the 7th ("Głos Szczeciński", 1949, No. 128).

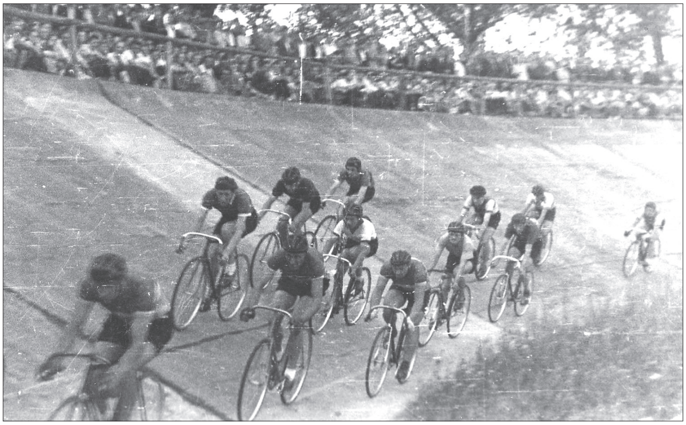

Figure 4. Polish Championships in Szczecin covering the distance of 50 km in Szczecin in 1949

Source: Collection of WKFiZ.

In 1950, another star of Szczecin cycling appeared – Tadeusz Drążkowski, as well as Bernard Pruski in Stargard near Szczecin. In his first competition, T. Drążkowski participated as a "tourist", i.e. an unassociated athlete, and in the subsequent ones, he represented the People Sports Team from Bezrzecze (the village in the vicinity of Szczecin – currently a district of the city). In September that year, he was moved to the militia club and from that moment he became a member of the "Gwardia" Sports Association in Szczecin.

At that time, the burden of popularizing cycling had to be carried by OZKol., as well as the individual sections of clubs and sports clubs, and the editorial office of the journal Kurier Szczeciński. A cyclical (annual) mass street race for the Editorial Cup was organized. About 200 cyclists took part in its first edition (May 21, 1950) ("Kurier Szczeciński", 1950, No. 140). However, it was not only its mass character that became the hallmark of Szczecin's sport. An extraordinary feature at that time was encouraging women, or rather girls, to start cycling. The program of street competitions organized on the day of the "People Holiday" (July 22, 1950) included open races on the track for non-members. Two women from the "Budowlani" Szczecin club decided to compete in a separate race ("Kurier Szczeciński", 1950, No. 201).

Until the end of that year, Szczecin cyclists took part in several competitions, both on national routes and tracks as well as in local races. They competed against the top Polish cyclists at nationwide events without any complexes.

Conclusions

In 1945–1950, cycling in Zachodniopomorskie voivodeship was developing systematically. Its progress depended on the settlement and economic processes, but primarily resulted from the pre-war traditions, personal involvement of activists and the growing popularity of sport in the urban environment. The communists gradually, but consistently, started to use sport in the process of indoctrination, i.e. to shape a "politically conscious citizen" who would obey the elites of the PUWP party. Despite these influences, for the majority of activists and athletes, sport remained a great, unique passion and a way of life in the socialist world. Therefore, acts of political manifestation, participation in parades, rallies and propaganda ceremonies were accepted by athletes in return for organizational and financial support.

The year 1950 brought progress in the development of Szczecin cycling. The number of OZKol.'s members visibly increased. The cycling units that operated in Szczecin clubs included "Budowlani", "Gwardia", "Kolejarz", "Ogniwo", "Spójnia" and "Związkowiec". Apart from Szczecin, cycling was being trained in "Spójnia" Stargard, "Ogniwo" Połczyn Zdrój, and "Stal" Słupsk. In the mid-1950s, the administrative reform of the country was carried out. As a result, the area of the voivodship, covering the whole of Pomorze Zachodnie, was divided into two smaller territorial units: Szczecińskie and Koszalińskie voivodeships. The constant development of cycling, however, compensated for these changes, especially since Szczecin was the center of this sport in the voivodship.

Cycling in West Pomerania, drawing from the before war traditions, developed gradually and sports societies had to overcome problems associated with lack of instructors, lack of available sports equipment and the state of infrastructure. Difficult living conditions, which often distracted residents from active participation in sports, also had significant meaning. However social work was supported by the government, which saw in sports the tools for integrating settlers and whole West Pomerania with the rest of the country as well as the propaganda impact on the population. The taken care by the state over the competitive sports and growing popularity of cycling contributed to systematic development of the said discipline in the concerned region, despite the marginalization of West Pomerania by the central power center.

In the first half of the fifties of the 20th century the work of Szczecin society promoted first cyclists who started to achieve successes in domestic and international competitions.

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THE EFFECTS OF TWO DIFFERENT HIIT RESTING PROTOCOLS ON CHILDREN'S SWIMMING EFFICIENCY AND PERFORMANCE

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Abstract On children, HIIT program is being used by coaches as a way of rapid improvement. The values of the intervals vary from the target of the period. The study's purpose was to find out if HIIT in different interval protocols improves children's swimming performance. In the study participated 18 rookie swimmers (9 boys and 9 girls), aged 11.6 ±1.5. The HIIT protocol in both groups included the set of 2 × 4 × 17.5 m (freestyle and freestyle kick, respectively). The first group (HIIT 1) had a 10 sec interval while the second (HIIT 2) – a 1 min between the HIIT reps. Swimmers performed in 35 m freestyle (35F) and 2 min free kick (2' FK) trials at maximum effort. The performance (T), the number of strokes (SN) and the stroke length (SL) were measured at 35F, the covered distance at 2' FK and the heart rate (HR), the rated perception of exertion (RPE) at 35F and 2' FK. Regarding the results, all parameters improved significantly (p = 0.01). The use of a 4-week swimming program with training 4 times per week, in which two were HIIT, improved children's performance and efficiency in swimming. Intervals of 10 sec or 1 min did not alter the improvement.

Key words swimming training, performance, intensity, interval, children

Introduction

Many of training methods contribute to the athletes' increase of physiological adaptions and performance. Common training methods are High Volume Training (HVT) and High-Intensity Training (HIT). These two methods seem to be helpful for an athlete's performance (Sperlich, Haegele, Achtzehn, De Marees, Mester, 2009a; Sperlich et al., 2009b). These training methods are used as the main part of a training session.

A training method which proves the most interesting in studying is High-Intensity Interval Training (HIIT). HIIT training is one of the most beneficial methods to improve almost all physiological and performance responses in a wide range of training. Moreover, they found significant performance improvements that reached from 6–20%.

Endurance performance, peak oxygen uptake, maximal oxygen uptake, running economy and distance cover were the parameters that got improved. The improvements concerned the sports of soccer, track, rowing, kayak and cycling (Helgerud, Engen, Wisloff, Hoff, 2001; Mosey, 2009; Buchheit, Bishop, Haydar, Nakamura, Ahmaidi, 2010).

HIIT is a training method that both male and female athletes can use with excellent results in physiological parameters such as maximal oxygen uptake, running economy, heart rate, perceived exertion (Buchheit, Simpson, Mendez-Villanueva, 2013), VO2max and anaerobic capacity (Tabata et al., 1996; Tabata et al., 1997; Buchheit, 2010). Moreover, HIIT can be used from prepubertal athletes too, with beneficial effects in speed performance between training protocols with maximal sprinting and aerobic speeds (Mendez-Villanueva et al., 2010).

Most of the studies in sports, particularly in football, showed that HIIT in different protocols can improve the performance and the physiological parameters like oxygen uptake, endurance, heart rate, and muscle energy sources (Dellal, Varliette, Owen, Chirico, Pialoux, 2012). These improvements associate both in adults and prepubertal athletes. On the other hand, it does not suggest that all young footballers are affected by repeated sprints because of different physical position demands that are needed in a match (Helgerud et al., 2001). In other study similar results reported with the use of HIIT and small side games after a six-week program with 5.1 and 6.6% improvement in Vameval test. Furthermore, improvements were found in the aerobic and recovery capacity (Dellal et al., 2012).

Other study, in football, proved that repeated sprint training is more beneficial in certain aspects than interval training, with greater effects in Yo-Yo test and repeated sprint ability. Specifically, it showed greater improvement regarding the Yo-Yo test in the repeated sprint training method, with an increase from 1,917 m to 2,455 m in addition with the interval training group which was from 1,846 m to 2,077 m (Ferrari et al., 2008).

A sport which can be an interesting field to examine HIIT effects is swimming, as it includes many sportsmen in different ages (especially children and adolescents) and there are many factors that affect performance. Although there are studies for the effects of HIIT training in swimmers, less attention has been paid as regards the role of HIIT on children. In K. Papadimitriou and S. Savvoulidis' (2017) research, many studies about HIIT's effectiveness in different ages of swimmers were reviewed. In this review, only one study examined the effects of a 5-week HIIT program versus high volume training in 9–11-year-old swimmers. The test protocols were 100 m and 2,000 m freestyle. The parameters calculated were VO2 peak and the rate of maximal lactate accumulation. Between two programs, 2,000 m time performance, lactate and VO2 peak increased following HIIT. On the other hand, no changes showed at the 100 m time. All these improvements were achieved with two hours less training than the high-volume training group (Sperlich et al., 2010).

D.A. Marinho et al. (2011) studied the relationship between anaerobic critical velocity and the ideal short distance that could be used in training for the four swimming techniques. The results revealed that short distances of 10, 15, 20 and 25 m could be a great indicator of anaerobic critical velocity in the distances of 50, 100 and 200 m. Thus, these distances probably describe the ideal distance that coaches could use in young swimmers for greater training stimuli.

Interval

An important part in high-intensity training is the interval. Some studies examined HIIT's effects after different interval protocols. In two studies performed 15 × 40 m sprints and six 4 min work bouts respectively. The rest time was 120, 60, and 30 sec for 15 × 4 m between each sprint and 240, 120 and 60 sec for the six 4 min work bouts.

The results in both studies suggested that 120 sec was the most beneficial rest time between maximal repetitions of exercise (Balsom et al., 2005).

So, the purpose of this study was to determine if a 4-week swimming program, 4 times per week, with HIIT, two times per week, with two different passive interval protocols, it could improve children's swimming performance. Children, due to their physiological demands, needs less time to recover after an exercise in addition to adults (Tabata et al., 1997). Thus, it is great of interest in this study to examine if there will be any difference between the two resting protocols.

Methods

Participants

All tests were conducted according to the ethical guidelines of the Research Committee of Aristotle University of Thessaloniki. In the study participated 18 children (9 boys and 9 girls) aged 11.6 ±1.5. The participants' swimming level was moderate. Height (H), weight (W) and body mass index (BMI) were measured (Table 1), while the participants were questioned if they were well on their health. Moreover, they were examined by a cardiologist before the study. All children's parents were informed about the procedures of this experiment and the possible improvements that this type of exercise could provide to their children's health. At the 16 exercise sessions, the attendance was 12 ±3 for HIIT 1 and 13 ±2 for HIIT 2.

Table 1. Age, height, weight and body mass index (BMI) of the participants

Parameters	HIIT 1 (10 s) n = 9	HIIT 2 (1min) n = 9
Age (years)	11.5 ±1.7	11.7 ±1.2
Height (cm)	154.7 ±11.5	150.7 ±12.4
Weight (kg)	50.3 ±11.2	39.9 ±14.5
BMI (kg/cm$^{2)}$	21 ±4	17 ±3.3

Study design

The study measured pre-post differences in a 4-week swimming program with training 4 times per week in which two programs were HIIT, in a 17.5 m pool. Premium school children took part in the study. The participants were informed about the protocols they would follow and the way they would have to answer about the rate of perceived exertion (RPE). Before training, the children's attendance was monitored and the training volume was calculated to find out if the training's frequency and volume were enough for performance adaptions.

Procedures

The 18 boys and girls were divided into two equal groups depending on their swimming level. The first group was named HIIT 1 and included 5 girls and 4 boys, and the second group was named HIIT 2 and included 4 girls and 5 boys. The HIIT protocol for both groups included 4 × 17.5 m freestyle and 4 × 17.5 m freestyle kick with a kickboard in maximal intensity. The difference between HIIT 1 and 2 was the interval. The passive interval in the sets was

10 seconds for the first group and 1 minute for the second group. Between the freestyle swim and freestyle kick protocols, there was a 5-minute passive interval for both groups.

Measures

To find out if there were any adaptions from the two HIIT programs the children were tested in two swimming protocols. The first protocol took place at the beginning (0 weeks) of the experiment and the other one at the end (4 weeks). These two protocols included 35 m freestyle and 2 min freestyle kick (Papadimitriou, Loupos, Tsalis, Manou, 2017) in maximal intensity, respectively. In the 35 m freestyle, the time (T), the number of strokes (SN) and the stroke length (SL) were measured. On the 2 min freestyle kick the covered distance was measured (D). Additionally, the heart rate (35F HR–2'FK HR) and the rate of perceived exertion (35F RPE–2'FK RPE) were measured for both tests. The HR parameters were estimated in 10 seconds (Nussinovitch et al., 2011) with the use of POLAR Electro.

Statistical analysis

For the statistical analysis the Shapiro-Wilk test of normality was used. Furthermore, to assess the effects of two HIIT resting protocols, before and after the intervention, in the parameters studied, there was used a two-way ANOVA with repeated measures (group × time). Moreover, a Pearson's - r correlation was conducted between the parameters that were studied. The analysis was performed using the SPSS Version 25.0 for Windows (SPSS Inc., Chicago, IL, USA). The level of statistical significance was set at $\alpha = 0.05$.

Results

From the Shapiro-Wilk analysis there was found a normality in the parameters that studied ($p > 0.05$). In two-way ANOVA with repeated measures analysis, there was found no significant differences between the two groups (HIIT 1 vs HIIT 2) in almost all parameters studied, except for HR in 2'FK test. On the other hand, statistically significant differences were found in combined groups (HIIT 1 + 2) between 0 and 4th weeks. Figures 1, 2, 3, 4, 5, 6 show the differences between measurements and groups. Figures 7 and 8 show the correlations between the parameters between 35F, 35F SN, 35F SL and 2'FK.

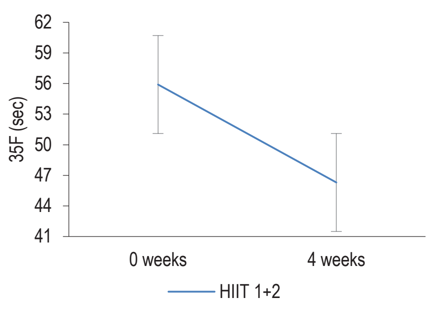

Figure 1. Performance at 35 m freestyle (35F)

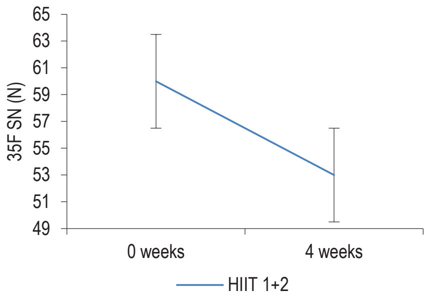

Figure 2. Stroke number at 35 m freestyle (35F SN)

From the results the 35F in HIIT 1 + 2 decreased and the difference was statistically significant. The decrease was from 55.9 ±13.8 to 46.3 ±9.3 sec ($p = 0.01$) (Figure 1). The 35F SN decreased from 60 ±16 to 53 ±15 strokes ($p = 0.01$) (Figure 2).

The 35F SL in HIIT 1 + 2 increased statistically significantly from 0.9 ±0.3 to 1 ±0.3 m ($p = 0.01$) (Figure 3). Moreover, the 35F HR increased from 27 ±2 to 28 ±2 beats/10 sec ($p = 0.01$) (Figure 4).

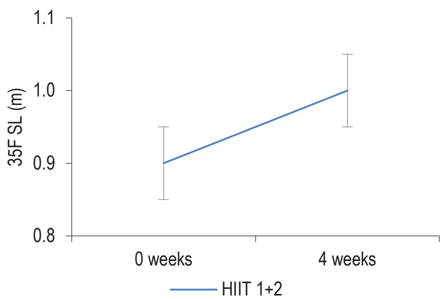

Figure 3. Stroke length at 35 m freestyle (35F SL)

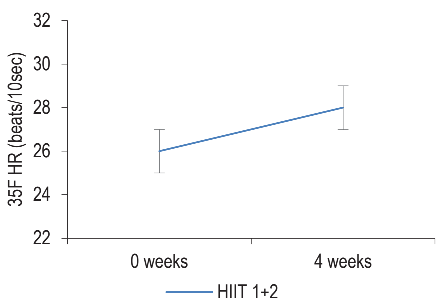

Figure 4. Heart rate at 35 m freestyle (35F HR)

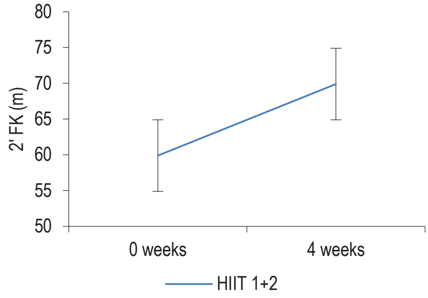

Figure 5. Distance covered at freestyle kick in 2' (2' FK)

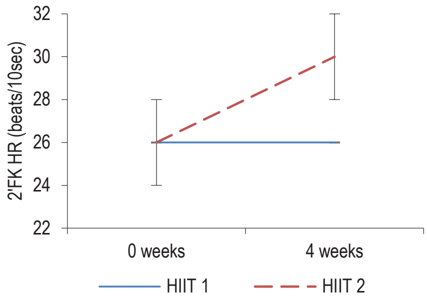

Figure 6. Heart rate at freestyle kick in 2' (2' FK HR)

In 2'FK there was found a statistically significant increase in the distance covered from 0 to 4th week in HIIT 1 + 2. Specifically, swimmers from 59.9 ±14.5 m in the 0-week covered 69.9 ±10 m in the 4th week ($p = 0.01$) (Figure 5). The only parameter which showed statistically significant difference between the two groups (HIIT 1 and HIIT 2) was 2'FK HR. The 2' FK HR in HIIT 2 group increased from 26 ±2 to 30 ± 3beats/10 sec ($p = 0.05$), while HIIT 1 group increased the HR from 26 ±2 to 28 ±3 beats/ 10 sec ($p = 0.04$) (Figure 6).

Statistically significant correlations were found between the parameters studied ($p < 0.05$). The time at 35F which swimmers swam correlated with the 35F SN at the second test of the measurements ($R^2 = 0.810$; $p = 0.900$; $p = 0.00$) (Figure 7a). The time at 35F B which swimmers swam also correlated with the 35F SL at the second test of the measurements ($R^2 = 0.768$; $p = –0.877$; $p = 0.00$) (Figure 7b). One more statistically significant correlation was found between the time at 35F B and the 2'FK B at the second test of the measurements ($R^2 = 0.396$; $p = –0.626$; $p = 0.05$) (Figure 8).

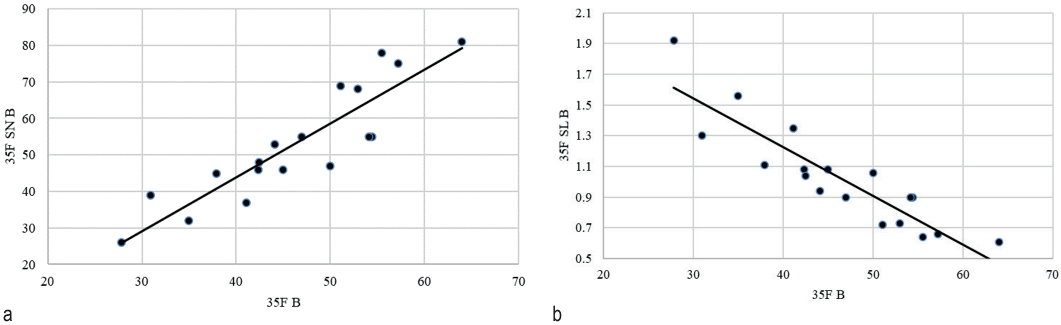

Figure 7. Correlations between 35 m freestyle (35F), stroke number (35F SN) and stroke length (35F SL)

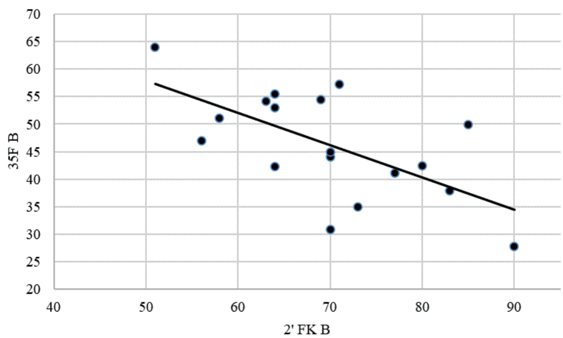

Figure 8. Correlation between 35m freestyle (35F) and 2' freestyle kick (2' FK)

Discussion

In the study it was found that high intensity training in different intervals contributes positively in performance and in physiological parameters. These results were common with other studies in various sports (Helgerud et al., 2001; Laursen, Jenkins, 2002; Buchheit et al., 2008; Mosey, 2009; Laursen, 2010). Probably, the anaerobic pathway used in that kind of exercise helps the athlete's physiology in gaining a stronger stimulus.

The time and the distance covered at the 35F and in 2' FK decreased and increased respectively in both of groups. Thus, HIIT independently of the interval rest between the sets helped the swimmers to improve. Probably, in both of HIIT sets, swimmers' physiology in childhood uses mainly the aerobic energy pathway. The rest of 10 sec gives an anaerobic pathway energy contribution. On the other hand, 1 min rest ensures a greater aerobic contribution. These hypotheses could be made only if the try was at its maximal intensity. The Borg's scale and HR in both of 35F and 2' KF tests in both of groups proves that swimmers swam in maximal intensity during the tests.

Why Borg's scale did not elevate in measurements after the 4-week period probably has two explanations. The swimmers' low skill level attenuated their ability to reach higher fatigue levels. Moreover, the performance enhancement contributed to finding the test easier after the 4-week intervention. This hypothesis is supported by the HR parameter which increased at the second measurement in both groups and tests.

Usually, after a long intervention of exercise, athletes gain the ability of lowering their heart rate in the phase of rest after set (especially elite athletes). The explanation is that cardiac sympathetic excitation outlasting causes bradycardia with enhanced sympathetic activity in athletes (Furlan et al., 1993). In the study, immediately after the tests of 35F and 2' KF, the young swimmers were found to increase their HR by 10 seconds comparing the 0 and 4th week in both groups. The probable explanation is that the children in these ages fulfill their body demands of oxygen by increasing their HR. Young children, when involved in an aerobic exercise program, showed progressive increases in left ventricular posterior wall thickness and left ventricular mass and no changes in left-ventricular end-diastolic dimension, shortening fraction or resting heart rate (Geenen, Gilliam, Crowley, Moorehead-Steffens, Rosenthal, 1982). Thus, the swimmers' heart should pump more blood to the body to respond to the exercise demands.

Another finding in the study was that the HIIT 2 protocol, which had more resting time than HIIT 1, in 2'FK test, was found to have increased the HR response. In that case, possibly, the greater resting time in HIIT 2 caused higher anaerobic contribution and greater HR stimuli, therefore higher heart rate demands among the young swimmers. Contrary to the lower resting time, which had the HIIT 1 protocol, the energy contribution was probably more aerobic; therefore, the heart rate demands were lower. From the unique study which examined the HIIT effects in young swimmers (Sperlich et al., 2010) it was concluded that HIIT enhances VO2 peak, the rate of maximal lactate accumulation and 2,000 m freestyle performance. The common finding is that in both studies HIIT improves aerobic and anaerobic contribution. On the other hand, an unclear field, which B. Sperlich did not analyze, is the interval which was used at HIIT period.

In the study it was found that, independently, in terms of the interval between HIIT's reps (10 sec or 1 min), the young swimmers improved their performance. P.D. Balsom et al. (Balsom, Seger, Sjödin, Ekblom, 1992) and S. Seiler and K.J. Hetlelid (2005) in their studies found that the optimal rest period for maximal repetition tries is 120 sec. Thus, greater distances need higher interval periods. Moreover, the main difference between our study, P.D. Balsom's et al. (1992) and S. Seiler and K.J. Hetlelid's (2005) is that their participants' age was higher than ours. So, the interval in children does not affect the aerobic or anaerobic stimulus.

Another aspect of performance which improved from the 4-week intervention program was the stroke length (SL) and the stroke number (SN). These parameters indicate that, probably, the improvement in technique contributed to the better performance, which both groups showed. The improved efficiency in the water was probably caused by technique exercises combined with the HIIT program. Thus, this combination affected the neuromuscular coordination and facilitation as well. Moreover, in correlation analysis the contribution of SN and SL with 35F makes the hypothesis about the importance of these parameters in performance stronger.

Conclusion

The study is a novel which examines different rest protocols between HIIT sets on children. From the results it can be seen that the resting period does not differentiate the performance enhancement in young swimmers. Thus, the coaches do not need to pressure the young swimmers with exhausting sets in low intervals. On the other hand, perhaps the swimmers' skill level affects the training adaptions. Therefore, more research is needed in this field to avoid the exhausting training which many coaches prefer to use on children.

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PHYSICAL EDUCATION AND SCHOOL SPORT OF THE GERMAN MINORITY IN POLAND IN THE INTERWAR PERIOD OF THE 20TH CENTURY

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Abstract In the interwar period of the 20th century, 30% of the total population of Poland was comprised of national minorities. Among them, the German minority of 740 thousand people played a very prominent role. The Germans lived mainly in the western parts of Poland: Pomeranian, Poznań and Silesian voivodeships, as well as in the district of Łódź. The German community was wealthy and influential thanks to the economic traditions and support provided by the German state. In order to stop the process of polonization, the Germans established and developed numerous forms of economic, cultural and social activity. They were very active in the area of physical culture. Their activities included taking great care of the development of physical education and sport in German schools at both primary and secondary education level. Physical education classes were taught and school sports competitions were organized. Physical education was one of the most popular school subjects and was intended to preserve the "German spirit" among pupils. The majority of German schools had a curriculum in place that included two hours of physical education per week and some of them even four hours of PE classes per week. The best teaching staff and sports facilities were to be found in private schools, especially secondary schools, where physical education and school sports enjoyed a very prominent status.

Key words German minority in Poland, school sport, physical education of national minorities

Introduction

There have been few papers to date describing the evolution and development of German physical culture in Poland between 1918 and 1939. Little attention has been paid to this issue either in Poland or in Germany. Only after the political breakthrough in Poland in 1989 and the reunification of Germany in the early 1990s, there were some studies or papers on the German minority living within the borders of the Second Polish Republic published. In the interwar period, the German community in Poland actively participated in numerous cultural activities as well as in physical education and sports. During this period, the German Gymnastics Association in Poland (Deutsche Turnerschaft in Polen) was active bringing together gymnastics organizations (Turnvereine) and being the largest sports organization of the German population in Poland. The only paper that fully presents the evolution of the gymnastics movement, physical education and sport among the Germans living in Poland until 1939 is a monograph written by Tomasz Jurek entitled “Kultura fizyczna mniejszości niemieckiej w Polsce w latach 1918–1939”. The paper discusses the activity of the Germans in the field of broadly defined physical culture in the Second Polish Republic. It is, therefore, worth presenting various aspects of German activity in the social and cultural sphere, including physical education and sport in German schooling and school education in Poland up to the year 1939 (Jurek, 2002).

German minority in Poland in the years 1918–1939

The third part of the population of the independent Polish state in the period 1918 to 1939 were national minorities. Consequently, every third citizen of the Second Polish Republic was of a nationality different than Polish. The most influential were the Ukrainian, Jewish and German minorities, reflecting their considerable numbers and their economic situation. Furthermore, the Germans living in Poland received extensive support from the German state (the Weimar Republic and later the Third Reich). After the end of World War I, the German population reached 2.2 million people, and then their numbers gradually dwindled. The census conducted in 1931 revealed that Poland was inhabited by 741 thousand people of German nationality, constituting 2.3% of the total population of the country. Most Germans lived in three western provinces or voivodeships: Poznań, Silesian and Pomeranian voivodeships, while the center of the German presence in Poland was the town of Bielsko-Biała, where Germans constituted 64% of the entire town’s population. Detailed data concerning the population in the relevant provinces in the years 1921–1931 is presented in Table 1.

Table 1. German population in the Second Polish Republic based on the results of Polish censuses of 1921 and 1931

Province/Voivodeship	Number of Germans (in thousands)		Percentage of the total population of Poland	
	1921	1931	1921	1931
Poznań	327.2	193.1	16.5	9.2
Silesia	292.9	90.6	27.5	7.0
Pomerania	175.4	105.4	18.5	9.8
Łódź	103.5	155.3	4.6	5.9
Warsaw	47.4	73.6	2.2	2.9
Volhynia	25.0	46.9	1.8	2.3
Stanyslaviv	15.0	16.7	1.3	1.1
Lviv	12.4	12.0	0.5	0.4
Lublin	10.9	15.9	0.5	0.6
Kraków	9.6	8.9	0.5	0.4
Rest	39.9	22.6	0.3	0.2
Total	1,059.2	741.1	3.8	2.3

Source: *Mały Rocznik Statystyczny 1938* (1939), pp. 22–23; *Statystyka Polski. Pierwszy Powszechny Spis Ludności Rzeczypospolitej Polskiej z dnia 30 września 1921 r.* (1927); *Statystyka Polski. Drugi Powszechny Spis Ludności z dnia 9 grudnia 1931 r.* (1938).

German minority’s schooling and school education

Under the Treaty on the Protection of National Minorities, Poland was obliged to provide its citizens with educational opportunities available in the mother tongue of the children subject to compulsory education. That law, in conjunction with the national legislation, made it possible for national minorities to establish and operate their own schools with the language of instruction other than Polish. The German communities made extensive use of that opportunity, placing a high priority on universal, general and vocational education. That was largely facilitated by the material support received from Germany, as education was seen as one of the strongholds of Germanness and a kind of defense against denationalization. The largest group of German educational institutions were common schools with German as the language of instruction, totaling 1,560 in the school year of 1921/1922. In Poland, some 1,908 teachers worked with a large group of 106,849 students. As the number of Germans in the Second Republic of Poland decreased, the number of schools also dropped, reaching 777 schools attended by 63,158 pupils in the school year of 1929/1930, and 577 schools with 54,693 pupils in 1938/1939. Common schools were divided into public (managed by the educational authorities) and private (established and funded by the German minority). In the second half of the 1920s, a more widespread action of itinerant teaching (the so-called "Wanderschulen") emerged, drawing on the principles of "Mutterschulen", i.e. teaching conducted at students' homes or anywhere, in particular in rural areas, where German schools were in short supply. A group of "itinerant teachers" was formed i.e. teachers who often travelled tens of kilometers between German homes and housing estates. In 1928, a total of 1,336 towns with over 11,000 students and 16 teachers across the country were involved in this form of illegal teaching. A good example of how significantly the German schooling system was subsidized is the secondary school located in Leszno, whose budget in the school year of 1933/34 amounted to 140,000 zlotys, including 93,000 zlotys provided by the Deutscher Schulverein. At the same time, about 112–116 thousand zlotys per annum was allocated to the whole educational system in the town (Komolka, 1984).

In the school year of 1937/1938, the other types of schools with German as the language of instruction included 14 secondary schools (including 11 private ones), 13 upper secondary schools (including 11 private ones) and 7 vocational schools attended by 3,086 pupils in total. The school statistics also included 52 German kindergartens (including 51 private ones) with 1,767 children attending (Iwanicki, 1984; Hauser, 1998, pp. 197–199; Mauersberger, 1968). The German School Association (Deutscher Schulverein – DSV) had its own branches operating within the schools and being in charge of all the activities carried out by the educational institutions. DSV with its headquarters in Bydgoszcz had 2,000 members and was chaired by K. Graebe and O. Schönbeck (Dąbrowski, 1978). Teachers working in German schools were affiliated with the National Association of Teachers in Poland (Landesverband deutscher Lehrer und Lehrerinnen in Polen – LVdLLP) founded in 1920. The LVdLLP, with its headquarters in Bydgoszcz, was chaired by Paul Jendricke. Jendricke had collected interesting personal stories and recollections of teachers working in German schools in Poland, stored in the J.G. Herder Institute in Marburg (Jurek, 1999).

Physical education classes in the curriculum of German schools

The Germans placed great value on teaching and educating children and youths deeming this activity to be one of the pillars of patriotic effort. Physical education was an important part of the curricula of primary and secondary schools. This type of attitude stemmed from the rich nineteenth-century tradition of German education in which physical education played an important role. Moreover, in many German communities, physical education and school sport were perceived as paramilitary exercises, indispensable for every student who was to be enrolled into the army in the future. However, it was not the Polish army that was meant but the German army, which was significantly weakened as a result of World War I (Jurek, 2002).German schools pursued a similar curriculum as the Polish educational institutions. The only differences were German language classes and teaching about Germany conducted as part of German language, history and geography classes. The teachers tried to impart to their students as much knowledge and information as possible about the German tradition. That also included physical education where they followed the teachings of Frederick Ludwig Jahn, a German gymnastics educator and founder of German gymnastics movement. Polish-German primary schools with German as the language of instruction had in place the following weekly timetable for physical exercise, often called gymnastics: grade one – 0.5 hours, grades two to six – 1 hour. The total weekly school workload for pupils at that time was as follows: grade one – 14 hours of school a week, grade two – 17 hours, grades three and four – 24 hours, grades five and six – 30 hours. Some schools that had very good housing conditions, e.g. those located in Poznań, offered as many as 4 hours of physical education classes per week (Archive of New Files). The number of hours of physical education in common schools with German as the language of instruction is shown in Table 2.

Table 2. Physical education in the curriculum of German primary schools in Poland in 1936

Type of school	School subject	Grade						
		1	2	3	4	5	6	7
6 teachers and more	PE	2	2	2	2	2	2	2
	total	18	21	27	28	30	30	30
6 teachers	PE	2	2	2	2	2 for boys + 2 for girls		
	total	18	21	27	28	30	30	30
5 teachers	PE	1	1	2		2 for boys + 2 for girls		
	total	16	18	27	28	30	30	30
4 teachers	PE	1	1	2		1 for boys +1 for girls		–
	total	15	18	26	26	30	30	–
3 teachers	PE	1	1	1		1		–
	total	15	16	23	24	30	30	–
2 teachers	PE	1 + singing	1 + singing	1		–	–	–
	total	12	13	20	22	–	–	–
1 teacher	PE	1 + singing	1 + singing	1 + singing	1 + singing	–	–	–
	total	15	15	19	19	–	–	–

Source: Deutsche Schulzeitung in Polen, no. 8/9, pp. 133–134.

Secondary schools had a different timetable in place. Those with German as the language of instruction had two physical education classes for a total of 30 hours of school per week. In private secondary schools, it was possible to increase the number of physical education classes from two to three and afterwards up to four hours per week. In 1929, secondary schools in Poznań launched a scheme aimed at increasing the total number of hours of physical education by one third so that they would constitute 10% of all school hours. An equally comprehensive curriculum was followed by the German secondary school (Goethe Gymnasium) in Grudziądz, where four hours of physical education per week were introduced, which accounted for 13% of all school hours (*Deutsche Schulzeitung in Polen*, 1932).

Physical education curriculum and its delivery

Physical education curriculum in German schools was executed in different ways, depending on the facilities in place and the teaching staff working there. The best conditions in this respect were offered by the largest German schools in major cities, especially in such places as Bielsko, Bydgoszcz, Chorzów, Grudziądz, Katowice, Leszno, Łódź and Poznań. Those schools were either housed in their own premises or in rented buildings. The secondary school (Goethe Gymnasium) in Grudziądz was unique in this respect as it had a modern gym measuring 32 m in length and 14 m in width. German secondary schools in Poznań also had their own gyms of 22 m x 10 m in size. However, the conditions for teaching physical education classes were hard across the country. The headmasters of German schools entrusted teaching of physical education to teachers who had the necessary experience that they had gained in gymnastics societies or associations (Deutsche Turnerschaft). By way of example, in the school year of 1924/1925 the secondary school in Bielsko offered physical education classes that were taught by six different teachers, mainly linguistic scholars, who were also teachers of other subjects such as chemistry, history, physics, Greek, German, Polish, Latin and life sciences. A similar situation was also observed in other German secondary schools, where qualified physical education teachers were not easily available. Five years later, three physical education teachers worked in the same school in Bielsko (Jahresbericht der Direktion des Staatsgymnasiums mit deutscher Unterrichtssprache in Bielitz fur das Schuljahr 1924/1925, p. 22). All in all, there were nine trained physical education teachers working in Poznań, Greater Poland and Łódź voivodeships, who taught mainly in German secondary schools, considered to be "a stronghold of German education and national activity". The group included the following teachers: Maria Correm, Alfons Stempel (Goethe Gymnasium in Grudziądz), Gerhard Drage (Schiller Gymnasium in Poznań), H. Schmidt (Kant Gymnasium in Leszno), Wilhelm Ruppenthal (private secondary school in Łódź), Alfred Coppe, Ruth Scheerschmidt (private secondary school in Bydgoszcz), A. Fiedler (private secondary school in Pabianice), Ruth Bicherich (secondary school in Poznań) (Federal Archives in Berlin, Deutsche Stiftung, file no. 447, p. 346).

The LVdLLP press service "Deutsche Schulzeitung in Polen" played an important role *(Deutsche Schulzeitung in Polen*, 1926*)* in the promotion of physical education in German schools. Physical education curricula and advice on PE methodology were published in the journal. It also featured articles on the teaching methods for gymnastics, athletics, team sports games and water and winter sports. Training materials were also published there, e.g. "On the Importance of Gymnastics in the Life of a Young Person". A special supplement on methodology of gymnastics was also published in the journal. It focused on physical education conducted in a variety of conditions, e.g. in the winter period. The journal published detailed sets of exercises, PE lesson scenarios as well as teaching materials on the modern system of physical education in German schooling system under the common title "Die Körperschule – Geschichtliches und Methodisches"*.* In their articles, the authors emphasized the German patriotism necessary for physical education classes and the texts were often published under the collective title of *Für unsere Schularbeit* (*Deutsche Schulzeitung in Polen*, 1935).

Physical education classes depended largely on the tradition of the school and its location, as evidenced by the annual report of the secondary school in Bielsko:

> As long as the weather permitted, the square in front of the school was used, as track and field disciplines could only be practiced in the open air. The track and field activities included only short and long distance running, long jump, high jump, triple jump, pole vault, discus and hand grenade throw, shot put and ball throw. The square also hosted outdoor games played during gymnastics classes and during designated afternoon sessions. The games included basketball, volleyball, the game of palant, Czech handball and volleyball. In addition, young people were given the opportunity to play various games and participate in fun activities. The school also offered skis, ice skates and sledges for rent to their pupils during the winter period (Jahresbericht der Direktion des Staatsgymnasiums mit deutscher Unterrichtssprache in Bielitz fur das Schuljahr 1928/1929, Bielitz, pp. 22–23).

Physical education classes were taught in a similar way in other German schools, in which games and fun activities were mainly held, often combined with singing classes and trips to the surrounding area. After gymnastics classes, which dominated in the 1920s, PE classes involving sporting games started to grow in popularity in the period that followed. The schools often arranged trips to the countryside to visit German farming estates, especially in Upper Silesia and in Bydgoszcz, Łódź and Poznań. School children aged 14 to 19 were also sent to Germany to spend their holidays. The trips to Germany were co-organized by the German Foundation (Deutsche Stiftung) (*Posener Tageblatt*, 1925; Federal Archives [Bundesarchiv Berlin], Deutsche Stiftung, file no. 447, p. 364).

Considerable emphasis was placed in German secondary schools on the organization of numerous sporting events with local pupils (school championships) and visitors (inter-school competitions) taking part. The biggest school competitions of this type, usually held around the end of the school year, were organized by German secondary schools in Bielsko, Grudziądz and Poznań. As many as half a thousand people participated in such sports competitions. In April 1934, the secondary school in Grudziądz was the center of preparations for the German sports festival called Ostlandturnfest in Gdańsk. German athletes from such places as Bydgoszcz, Chojnice, Szamocin, Tczew, Toruń and Tuchola participated in the preparations. The event was organized by a teacher from this secondary school, Alfons Stempel (National Archives [Archiwum Państwowe Bydgoszcz], Urząd Wojewódzki Pomorski, file no. 4604, p. 127).

The development of physical education and German school sport was not without its difficulties or problems. One of them was the restriction imposed by the Polish authorities on the participation of pupils under 14 years of age in sporting activities. However, German schools did not attach as much importance to this ban as the Polish schools and tried to evade it. They tolerated the participation of their pupils in the activities of German sports clubs and gymnastics associations. Another serious problem was the attempts of the pupils to obtain the Third Reich Sports Badge, which was forbidden to be worn on the school premises. Eventually, in April 1937, the young people and teachers from German secondary schools refrained from obtaining those badges. The Polish authorities were concerned about the involvement of teachers and school management of German schools in the German athletic movement in Poland and restricted the participation of teachers and pupils in sporting competitions (Federal Archives [Bundesarchiv Berlin], Deutsche Stiftung, file no. 447, pp. 251, 301).

College and university sport

Students studying at Polish universities were also interested in sport. They were members of the Association of Student Societies in Poland (Verband der Vereine der Hochschüler Polens – VVHP), which was established in 1925. Students from Poznań, belonging to the Society of German Students (Der Verein Deutscher Hochschüler – VDH), a member of the VVHP, were very active in this area. In summer, they practiced running and track and field jumps as well as shot put and javelin throw. In winter, they made use of the premises of the Schiller secondary school, where they practiced gymnastics. Fencing and rowing groups were also formed. Rowing was practiced in two clubs, i.e. “Germania” and “Neptun”. The most important test for the sporting skills of German students were the unofficial national university championships, held among others in Katowice and Łódź. The students from Poznań were among the best and achieved excellent results when confronted with representatives of other cities. According to one of the participants of the competition G. Meissner, the leading athletes demonstrated a high level of sportsmanship, obtaining very good individual results: 11.4 seconds for a 100 m sprint; 23.0 s for a 200 m sprint; 52.0 s for a 400 m sprint; 17 minutes for a 5 km run; 11.80 m for shot put; 70 m for javelin throw; 6.60 m for long jump (Bierschenk, 1988, pp. 96–98).

Conclusions

Taking stock of the accomplishments and achievements of physical education and sport in German schooling system in Poland in the period of 1918 to 1939, it should be concluded that the German minority in Poland as well as the system of material support provided by Germany have significantly helped to boost the development of this area of activity. Patriotism and commitment to the country of origin, i.e. Germany, were strongly emphasized during the physical education classes in order to avoid the polonization of the young generation of Germans in Poland. As a result, young people did not yield to Polish influence and remained within the sphere of influence of the German national tradition.

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FIT AND HEALTHY IN MIDDLE ADULTHOOD – DO FITNESS LEVELS MAKE A DIFFERENCE

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Abstract Strong evidence exists that fitness is a physical health resource, which serves to protect one's health. There is still uncertainty about which fitness level provides the best health outcome and which measurements can be used for analyzing this question. This cross-sectional study analyzed 462 (64.07% female) German middle-aged adults regarding their fitness status, physical activity (Non-Exercise test), body composition (Body Mass Index) and heart-related health status. Motor tests were used to measure the health-related fitness status. The heart-related health status was surveyed by questionnaire and diagnosis was done in part by a physician. Relationships between risk factors and fitness factors are visible during the correlative analysis. They are substantially more visible in the differentiation of people with and without risks. People with low fitness show noticeable risks in activity, Body Mass Index and heart-related health. People with high fitness show health resources for activity, Body Mass Index and heart-related health. This study points out that all fitness dimensions influence one's heart-related health in a positive way. Fitness is measured objectively and includes all health-related fitness dimensions such as endurance, strength, coordination and flexibility. Apart from this standardization, we ask for more longitudinal studies and more objective health measurements.

Key words fitness, health, middle age, physical activity, heart-related risk

Introduction

Fitness is a popular term and everyone wants to be "fit". However, the understanding of fitness is different. Subjective perceptions can be to feel good or to feel strong, to have energy or to have strength. It is common that "being fit" is mostly associated with "being healthy". What does it mean to be fit or to be healthy? Which fitness level do people need to reach to be healthy?

In this paper, the clarification of terms and their relationships is done based on the model of health-related fitness (HRF) (see Figure 1) by C. Bouchard, S.N. Blair and W.L. Haskell (2012).

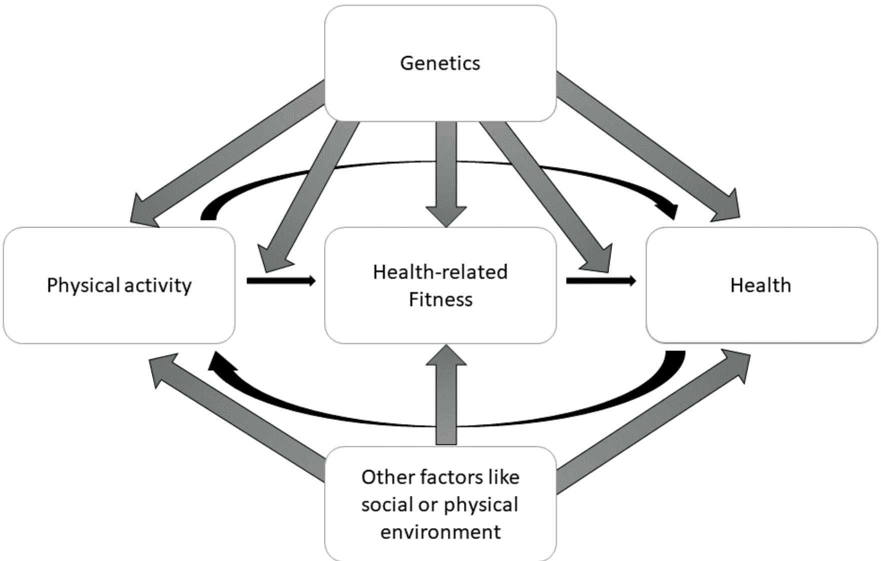

Figure 1. Model of health-related fitness

Source: own illustration based on Bouchard et al. (2012).

Defining health is challenging due to the flexible definitions of disease and the progress in treating them and developing resources (Hardman, Stensel, 2009). The World Health Organization (WHO) (1986) defines health as a concept emphasizing social and personal resources as well as physical capacities. A. Antonovsky (1996) adds that physical, social and psychological dimensions are characterized on a continuum with positive and negative poles. Hence, health is not just the absence of disease, but the capacity to enjoy life and to withstand challenges (Bouchard, Shephard, 1994). In their study over 20 years ago, P. Becker et al. examined parameters influencing health and named them "health-related variables" (Becker, Bös, Opper, Woll, Wustmans, 1996). Existing current literature in the context of fitness and activity concentrates mostly either on the understanding of health in the physical context (mortality, body composition, blood values etc.) (Warburton, 2006) or on the understanding of health in a psychological context (well-being, enjoying life) (Bize, Johnson, Plotnikoff, 2007; Olivares, Gusi, Prieto, Hernandez-Mocholi, 2011). This paper concentrates on aspects of the physical context, in particular the heart-related health of a person.

According to Figure 1, Physical Activity (PA), HRF, genetics and other factors, such as the individual environment, directly influence health. PA is every bodily movement produced by the skeletal muscle that results in energy expenditure (Caspersen, Powell, Christenson, 1985). Physical exercise, in turn, is a subcategory of PA and describes planned and structured activity (Caspersen et al., 1985). In fact, it aims to maintain or improve components of physical fitness (PF).

There is strong evidence that fitness is a physical health resource which serves to protect one's health (Blair, Cheng, Holder, 2001; Woll, 2006). HRF is a component of PF, which evolved out of the examined relationship among fitness, health and PA (Malmberg et al., 2002; Suni et al., 1998). PA favorably affects HRF, whereas sedentary behavior unfavorably affects it (Bouchard et al., 2012). The most important components of HRF are cardiorespiratory fitness (endurance), muscular fitness (strength), coordination and flexibility (Bös, Mechling, 1985; Caspersen et al., 1985; Oja, 1991; Samitz, Baron, 2002; Suni et al., 1998). Sometimes other components, particularly body composition and posture, are added to this health-related understanding of fitness (Bös, Mechling, 1985; Caspersen et al., 1985; Oja, 1991; Samitz, Baron, 2002; Suni et al., 1998).

Middle age, also called middle adulthood, is defined as the life period between early and late adulthood, including men and women aged 30 to 65 (Berk, 2017; Lademann, Kolip, Deitermann, Bucksch, Schwarze, 2005). Research groups in fitness/activity context focus mostly on men and women aged 40 to 59 (Sandvik et al., 1993; Zadworna-Cieślak, Ogińska-Bulik, 2018). We adopt this definition for further possibilities of comparison.

In middle adulthood, people often have their first contact to age-related health problems. Decrease of muscle mass and bone density, decline in physical capacities, increase of fat mass, sleep complaints, increase in frailty, chronic and cardiovascular diseases characterize typical symptoms of adults in this life period. People at this age experience a midlife crisis or menopause and change roles from caring for children to caring for parents (Berk, 2017; Dishman et al., 2015; Hardman, Stensel, 2009; Lademann et al., 2005; National Center for Health Statistics, 2009; Rockwood, Song, Mitnitski, 2011; Zadworna-Cieślak, Ogińska-Bulik, 2018).

In the scientific community, it is strongly evident that fitness is a meaningful predictor for health (Blair, Church, 2004; Blair et al., 1989; Bös, Tittlbach, Woll, Suni, Oja, 2012; Brehm, Sygusch, Tittlbach, 2008; Tittlbach, Jekauc, Schmidt, Woll, Bös, 2017; Williams, 2001). Having a close look at the literature of the last two decades, many reviews investigated if PA in middle adulthood influences different factors of health (Bize et al., 2007; Blair et al., 2001; Bucksch, Schlicht, 2006; DiPietro, 2001; Kokkinos, 2012; Reiner, Niermann, Jekauc, Woll, 2013; Trost, Owen, Bauman, Sallis, Brown, 2002; Vuori, 1998; Wagner et al., 2004; Warburton, 2006). Some reviews addressed the question of which dose of PA has the highest impact (Haskell, 1994; Lee, Skerrett, 2001; Oja, 2001; Warburton, 2006) or which health outcomes were improved the most by PA (Bucksch, Schlicht, 2006; HHS, 1996; Kokkinos, 2012; Reiner et al., 2013; Warburton, 2006). Nevertheless, up to now, just a few studies exist that examined the coherence of fitness and health in a longitudinal way (Blair et al., 1995; Sandvik et al., 1993; Schmidt, Tittlbach, Bös, Woll, 2017). Recently, P. Kokkinos et al. (2017) demanded for extending research with objectively measured aspects of fitness, such as using valid and reliable tests, like the treadmill test for measuring cardiorespiratory fitness. Research groups of S.N. Blair (1995) and L. Sandvik (1993) assessed PF using a treadmill test and bicycle ergometer respectively. S. Schmidt et al. (2017) assessed health during a laborious health examination conducted by a practicing physician and fitness with 13 motor performance tests in four motor dimensions: cardiorespiratory fitness, strength, coordination and flexibility. Results of this longitudinal study are various; central to the purpose of this paper is that health limitations rise with increasing age and with decreasing PF.

Among others, the research groups of L. Sandvik (1993), J. Myers (2004) and S.N. Blair (1989) analyzed the effect among cardiorespiratory fitness and mortality risk, according to different stages of fitness. L. Sandvik et al. and J. Myers et al. divided their sample in quartiles, according to the result of an exercise test (cycle ergometer or treadmill test). S.N. Blair et al. split their sample into quintiles, according to the result of a treadmill test. All three studies reported an inverse reduction of mortality rates when the fitness level increased. L. Sandvik et al. executed a follow-up of middle-aged men after 16 years. The highest fitness quartile had a relative risk of mortality of 0.54 in comparison to the lowest fitness quartile, though results were adjusted for age, smoking, serum lipids, blood pressure, resting heart rate, vital capacity, Body Mass Index (BMI), PA level and glucose tolerance. J. Myers et al. executed a follow-up study with men in middle age, too. The highest fitness quartile displays lowest age-adjusted mortality risk in comparison to the lowest quartile (hazard ratio = 0.28). S.N. Blair et al. executed a follow-up of around eight years, but with middle-aged men and women. For both sexes, relative risk (with highest quintile as reference with 1.0) decreased from 1.0 to 3.44 for men and to 4.65 for women. Further studies (Blair et al., 1995; Kampert, Blair, Barlow, Kohl III, 1996; Katzmarzyk, Church, Blair, 2004) differentiate just two groups: fit and unfit, but they confirm the findings of Sandvik, Myers and Blair.

Considering all of this evidence, it seems that a lot has been done so far with regards to examining the construct of HRF, PA and health. However, most of these studies focus on cardiorespiratory fitness. Still, there is a need of further research, including objective measures of other fitness aspects such as strength, coordination and flexibility. This is we want our study to complement, while using objective measures in health-related fitness and heart-related health for our target group of middle-aged adults.

The central aim of this study is to compare middle-aged adults' risks in activity, body composition and heart-related health with their HRF level. Related to this, the research question of this study is in which way the level of HRF influences middle age people's health.

Derived from the afore mentioned studies, the following working hypotheses are proposed:

1. A higher fitness level relates to a higher activity level.
2. A higher fitness level relates to better results in BMI.
3. A higher fitness level relates to a lower number of heart-related health issues.

Methods

Sample

For the last three years (2015–2017), data has been recorded from different executed studies of our research group in Germany. This data has now been analyzed for the above-named research question.

The sample includes 462 participants (64.07% female) with an average age of 50.28 years (SD = 4.92) and an average activity level of 3.69 (SD = 1.32), according to the N-Ex classification[1]. The average BMI value is 25.34 (SD = 4.17) and around 9% of the sample suffers from heart-related health issues.

All participants first answered different questionnaires including the Non-Exercise questionnaire (N-Ex) (Jurca et al., 2005) as an activity questionnaire and the Physical Activity Readiness Questionnaire (PAR-Q)[2] (Chisholm, Collis, Kulak, Davenport, Gruber, 1975) as a health questionnaire. A physician partly (n = 250) diagnosed participants regarding different health issues. Secondly, they performed several motor tests in the dimensions of endurance, strength, coordination and flexibility without a specific order. Additionally, they were measured in height, weight and waist circumference.

[1] Non-Exercise questionnaire from 1 = "no physical activity" to 5 = "more than three hours physical active per week"; see Jurca et al. (2005).

[2] For a detailed description and the handling of the PAR-Q at the EFB see the Handbook for Instructors (Bös, Brehm, Klemm, Schreck, Pauly, 2017).

Methodology

The sample was analyzed for the following parameters: motor test results, body composition, activity and health status. In detail, the analysis integrates one motor test per dimension. For endurance, a step and walking test are taken into account. Both tests are well validated (Aadahl, Zacho, Linneberg, Thuesen, Jørgensen, 2013; Laukkanen, Oja, Pasanen, Vuori, 1993). R.M.T. Laukkanen et al. for the 2-km walking test and M. Aadahl et al. for the step test developed algorithms for estimating the VO_2max. Further motor tests were a push-up test for strength (number of push-ups), a flamingo balance test for coordination (number of fails) and a sit & reach test for flexibility (reaching length). All tests are well evaluated and used often (Klemm, Brehm, Bös, 2017; Tittlbach et al., 2017). BMI represents the body composition[3]. BMI is classified in a bivariate parameter with either a healthy BMI from 18.5 to 24.9 (0) and an unhealthy BMI starting from 25.0 (1). People who were underweight were negated because of different health risks and low participant numbers (n = 7).

PA is displayed through the N-Ex test (questionnaire from 1 = ”no physical activity” to 5 = ”more than three hours physically active per week”) (Jurca et al., 2005). PA in this context is described as “at least moderate intensity, that means with substantial increases in breathing and heart rate” (Bös et al., 2017; Jurca et al., 2005). Activity is calculated into a bivariate parameter as well. According to WHO recommendations (WHO, 2010) and the possible threshold the N-Ex allows, people with an activity level below one hour per week were classified with “1” and people with at least one hour per week of activity with “0”.

Health is measured either by self-assessed health questionnaire and/or by diagnosis from a physician. The physician was not available at all test days. That is why 212 participants just answered the self-assessed health questionnaire. To have the best possible display of heart-related health we matched the following questions of the self-assessed questionnaire with the cardiovascular diagnosis of the physician:

1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
2. Do you feel pain in your chest when you do physical activity?
3. In the past month, have you had chest pain when you were not doing physical activity?

This diagnosis rated the cardiovascular status of the participant in five categories: (1) chronical manifest; (2) chronical beginning; (3) acute long-term; (4) acute short-term and (5) unremarkable healthy.

In summary, these questions were pooled to the bivariate parameter “heart-related health” with either no heart problems (0) or any heart problems (1). Fitness and activity are identified as heart disease risk factors through studies and meta-analysis in the last few years (Blair et al., 2001; Williams, 2001). Mostly, activity was focused. In our study, the focus lies on fitness including all relevant fitness dimensions.

Statistics

Statistical analysis is separated for sex, but not for age. Regarding the analyzed fitness parameters, men and women display great significant differences. The chosen age group of middle-aged people display low mean value differences. Therefore, a comparison regarding age for fitness, activity and BMI was neglected.

[3] Full descriptions and scientific background of every single test item can be found in the Handbook for instructors (Bös et al., 2017).

First, correlations were calculated. Second, extreme value comparisons were executed due to an assumed limited linear correlation. People at risk concerning activity (less than one hour per week of PA), body composition (BMI ≥ 25.0) and coronary risks (acute heart issues) were compared with people without risk regarding fitness in the dimensions of endurance, strength, coordination and flexibility. It is anticipated that both groups display great differences in their fitness.

Hypotheses were proven through 1) examining a correlation matrix; 2) examining mean values of extreme groups (with risk, without risk).

The significance level is set for .05 (*significant ≤ 0.05, **highly significant ≤ 0.01). Pearson's correlations are categorized as low (r ≥ 0.10), medium (r ≥ 0.30) or high (r ≥ 0.50) (Cohen, 1992). Partial eta square (η^2) is as well categorized after J. Cohen (1992) to low ($\eta^2 \geq 0.01$), medium ($\eta^2 \geq 0.06$) or high ($\eta^2 \geq 0.14$). Calculations are done with IBM SPSS Version 24. All study participants agreed in writing to the usage of the anonymized data for scientific calculations and publications.

Results

Correlative Relationships between fitness and risk factors:

Table 1. Correlations between the fitness dimensions and activity, BMI and heart-related health

	Men (n = 166)			Women (n = 296)		
	N-Ex	BMI	Heart	N-Ex	BMI	Heart
Endurance	0.46**	–0.39**	–0.19*	0.30**	–0.28**	–0.23**
Strength	0.25**	–0.17*	–0.26**	0.28**	–0.28**	–0.21**
Coordination	0.21**	–0.33**	–0.17*	0.26**	–0.38**	–0.29**
Flexibility	0.19*	–0.23**	–0.18*	0.22**	–0.28**	–0.19**
Fitness overall	0.35**	–0.36**	–0.28**	0.29**	–0.37**	–0.25**

Table 1 displays the significant correlations between activity, BMI, heart-related health and all fitness dimensions, which spread from 0.17 to 0.46. Explanation of variance ranges between 3% and 21%.

The highest correlations are visible between activity and fitness, especially at endurance (males = 0.46, females = 0.30). Almost the same values display the correlation between BMI and all fitness dimensions. In particular, endurance shows highest correlation for men and coordination for women in terms of BMI. Correlations between health index and fitness is lower, but for fitness overall, correlations of 0.28 (men) and 0.25 (women) occur.

All three working hypotheses can be verified, though relations are somehow low. The question now is if correlations between activity, BMI, health index and fitness become clearer through comparing extreme groups (with risk, without risk).

Extreme groups comparison (with risk, without risk) regarding fitness:

1. Activity and fitness

Table 2. Extreme groups comparison of activity regarding the fitness dimensions in male participants

	n	Endurance	Strength	Coordination	Flexibility	Overall fitness
Q1 (M(SD))	31–36	0.58 (0.50)	0.36 (0.49)	0.38 (0.49)	0.38 (0.49)	0.48 (0.51)
Q5 (M(SD))	24–44	0.10 (0.31)	0.16 (0.37)	0.23 (0.42)	0.18 (0.39)	0.08 (0.28)
F		20.277	3.459	1.965	3.152	12.012
P		0.000	0.067	0.165	0.081	0.001
η^2		0.26	0.05	0.03	0.05	0.19

Table 3. Extreme groups comparison of activity regarding the fitness dimensions in female participants

	n	Endurance	Strength	Coordination	Flexibility	Overall fitness
Q1 (M(SD))	48–66	0.40 (0.49)	0.42 (0.50)	0.52 (0.50)	0.38 (0.49)	0.43 (0.50)
Q5 (M(SD))	46–85	0.11 (0.32)	0.17 (0.38)	0.26 (0.44)	0.18 (0.39)	0.15 (0.36)
F		12.750	8.640	9.753	5.297	10.419
P		0.001	0.004	0.002	0.023	0.002
η^2		0.11	0.07	0.07	0.05	0.09

Activity displays the results of the N-Ex questionnaire. People at risk in activity (Q1) are defined as less than one hour active per week (less than 400 kcal energy expenditure per week). The differences between people with and without risk are all significant and partly very high (Tables 2 and 3). η^2 varies from 0.03 to 0.26 for men and from 0.05 to 0.11 for women. The greatest differences show the endurance for men and women. The smallest differences occur for men regarding coordination and for women regarding flexibility.

Mean values are scaled 0–1, which allows a direct interpretation with a percentile score. As displayed in Tables 2 and 3, 36–58% of men and 38–43% of women in Q1 have the risk factor inactivity. In the fit group of Q5, only 8–23% of men and 11–26% of women have the risk factor inactivity.

This result is clear and confirms working hypothesis 1. Low fit people (Q1) more often display the risk factor inactivity than high fit people do.

2. Body composition and fitness

Table 4. Extreme groups comparison of BMI regarding the fitness dimensions in male participants

	n	Endurance	Strength	Coordination	Flexibility	Overall fitness
Q1 (M(SD))	31–39	0.84 (0.37)	0.72 (0.46)	0.78 (0.42)	0.75 (0.44)	0.81 (0.39)
Q5 (M(SD))	24–45	0.27 (0.45)	0.47 (0.51)	0.38 (0.49)	0.50 (0.51)	0.21 (0.41)
F		29.259	4.747	14.229	4.089	32.052
P		0.000	0.033	0.000	0.048	0.000
η^2		0.33	0.06	0.16	0.06	0.37

Table 5. Extreme groups comparison of BMI regarding the fitness dimensions in female participants

		n	Endurance	Strength	Coordination	Flexibility	Overall fitness
Q1 (M(SD))		51–68	0.48 (0.50)	0.63 (0.49)	0.67 (0.48)	0.48 (0.50)	0.53 (0.50)
Q5 (M(SD))		43–81	0.15 (0.36)	0.24 (0.43)	0.17 (0.38)	0.19 (0.39)	0.09 (0.29)
	F		14.352	18.752	43.299	11.670	26.584
	P		0.000	0.000	0.000	0.000	0.000
	η^2		0.12	0.15	0.25	0.09	0.20

BMI represents the parameter for body composition. People at risk concerning body composition display a BMI of 25 or higher (according to WHO (2018) classification), and therewith have the risk of being overweight.

Differences between people with and without risk are all significant and partly very high (Tables 4 and 5). η^2 varies from 0.06 to 0.37 for men and from 0.09 to 0.25 for women. The greatest differences show the overall fitness for men and the coordination dimension for women. The smallest differences occur when looking at flexibility for men and women.

Mean values are scaled from 0–1, which allows a direct interpretation with a percentile score.

According to table 4, 19–26% of men in Q1 have the risk factor of being overweight, whereas 10–22% of women in Q1 display this risk factor (Table 5). In the fit group of Q5, 0–7% of men and 0–2% of women display the risk factor of being overweight.

This result is clear and confirms working hypothesis 2. Low fit people (Q1) more often have the risk factor of being overweight than high fit people (Q5) do.

3. Fitness and heart-related health

Table 6. Extreme groups comparison of heart-related health regarding the fitness dimensions in male participants

		n	Endurance	Strength	Coordination	Flexibility	Overall fitness
Q1 (M(SD))		30–35	0.23 (0.43)	0.26 (0.44)	0.19 (0.40)	0.26 (0.44)	0.25 (0.44)
Q5 (M(SD))		24–41	0.03 (0.18)	0.03 (0.18)	0.05 (0.22)	0.07 (0.27)	0.00 (0.00)
	F		5.495	7.243	3.999	3.513	7.714
	P		0.023	0.009	0.049	0.066	0.008
	η^2		0.09	0.10	0.05	0.06	0.13

Table 7. Extreme groups comparison of heart-related health regarding the fitness dimensions in female participants

		n	Endurance	Strength	Coordination	Flexibility	Overall fitness
Q1 (M(SD))		47–66	0.16 (0.37)	0.17 (0.38)	0.22 (0.42)	0.10 (0.31)	0.15 (0.36)
Q5 (M(SD))		45–83	0.00 (0.00)	0.00 (0.00)	0.01 (0.11)	0.02 (0.14)	0.00 (0.00)
	F		10.332	9.374	19.248	3.395	8.213
	P		0.002	0.003	0.000	0.068	0.005
	η^2		0.09	0.08	0.13	0.03	0.07

The heart-related health index includes coronary risks, built up through health questions and a diagnosis by a physician.

People with the risk factor for coronary risk have been classified by a physician or confirmed this risk with a self-assessed questionnaire.

The differences between people with and without risk are all significant and partly very high (Tables 6 and 7). η^2 varies from 0.03 to 0.26 for men and from 0.05 to 0.11 for women. The greatest differences show the endurance for men and women. The smallest differences occur regarding coordination for men and flexibility for women.

The mean values are scaled 0–1, which allows a direct interpretation with a percentile score. As displayed in Tables 6 and 7, 19–26% of men and 10–22% of women in Q1 have the risk factor coronary risk. In the fit group of Q5, only 0–7% of men and 0–2% of women have the risk factor coronary risk.

This result is clear and confirms working hypothesis 3. Low fit people (Q1) more often have coronary risk than high fit people (Q5) do.

Discussion

In summary, these results suggest first tendencies regarding the statement “fitter people are healthier people” and “the more fit the healthier”. The above shown aspects of activity, body composition and heart-related health display mostly definite results for male and female subjects in relation to their fitness level. All working hypotheses can be confirmed.

The relationships between risk factors and fitness factors are visible during the correlative analysis. They are substantially more visible in the differentiation of people with and without risks. People with low fitness show noticeable risks in activity, BMI and heart-related health. People with high fitness show health resources for activity, BMI and heart-related health.

Activity (measured with N-Ex) and fitness show the clearest relationship. It is evident that especially the endurance dimension displays a strong relationship with fitness as well as the overall fitness value. Flexibility and activity display low relations. These results are in line with our expectations.

Body composition, measured with BMI, displays an expected clear relationship to the fitness dimensions. In those dimensions, where body mass needs to be moved (endurance dimension), overweight and obese people have considerable disadvantages. With female participants, coordinative-weak women are most overweight.

Heart-related health, measured with a questionnaire and a physician’s diagnosis, displays clear relationships to fitness as well. The extreme value comparison suggests that there exists a threshold, and no strict linear relation between fitness and heart-related health exists. However, these results provide further support for people with high fitness to have better health chances.

It is unfortunate that the study includes some limitations. One source of weakness of this study is the sample bias. Though part of the sample was gathered in a random-control study, altogether subjects are on average fit and healthy. It is more striking that within this group of limited variances, those clear relationships between activity, body composition, heart-related health and fitness can be observed. It can be assumed that a more representative sample displays even clearer results.

Additionally, heart-related health in parts and activity are measured via questionnaires that subjects answered by themselves. Health is a broad construct as well (WHO, 1986). Body composition and heart-related health cover just a small part of this construct. Furthermore, self-assessed health and objectively diagnosed health are summed up for having one comparable parameter of health. Finally, yet importantly, this study presents cross-sectional data. No statement can be made regarding the question if people with a higher coordination or flexibility level stay healthier over the long term, for example. As stated in the introduction, long-term studies focusing on cardiorespiratory endurance are numerous, but studies including the further health-related fitness dimensions are hard to find. A concrete next step needs to be a follow-up study regarding the motor dimensions displayed in our study. This point will be broadly described in the conclusion section.

This study points out that the level of fitness relates to one's health, and vice versa, in a positive way. Precisely, a higher fitness level in endurance, strength, coordination and flexibility relates to lower issues in heart-related health.

In sum, this study presents a tendency other research groups can confirm with their studies (Blair et al., 1989; Myers et al., 2004; Sandvik et al., 1993; Schmidt et al., 2017; Tittlbach et al., 2017). However, some challenges still remain and need to be focused on in further studies:

1. Assessing fitness objectively must be standardized. Not just assessing one aspect of PF like cardiorespiratory, which is evidently linked to health issues (Blair et al., 1989; Myers et al., 2004; Sandvik et al., 1993; Schmidt et al., 2017; Tittlbach et al., 2017). Measuring a broad fitness status including strength, coordination and flexibility can reveal further acknowledgments, which at this moment no one thought of in detail (Brehm, Wagner, Sygusch, Schönung, Hahn, 2005).
2. Having a clear standard for displaying fitness levels. Different authors structured fitness levels in quintiles, quartiles or according to the metabolic equivalent of task (MET). This study focused on quintiles according to percentile ranks. In general, all of these studies generated their reference group out of their own sample.
3. Assessing health with the help of practicing physicians or the like. This study only integrated BMI and heart-related health in part as objectively measured health aspects. However, the aim must be to have a fully objective measured health construct (Brehm et al., 2005).
4. There should be a demand to examine different specific health aspects that are influenced through an increase of PF. In completion to the first point, PF should be measured in different dimensions to have concrete recommendations for the practical field. In general, more studies should be executed as longitudinal studies to get statements regarding the dose-response-relationship.
5. Current studies focus on sedentary behavior as a higher risk factor than inactivity (Katzmarzyk, 2010; Thorp, Owen, Neuhaus, Dunstan, 2011). We could not examine this parameter with our sample. The focus of further research needs to have a full investigation of this risk factor as well.

This study is part of an overall evaluation of the EFB. This instrument aims to measure fitness and additional aspects such as body composition and posture to figure out individual recommendations for each participant. Every participant gets a certificate and seven pages of detailed feedback according to the results achieved. Based on this, they receive recommendations by their trainer e.g. for attending special sport classes (Klemm et al., 2017). This study confirms the assumption that a rise in PF, independent of people's fitness level, can improve the heart-related health of a person. This is the fundamental motivation of the EFB and its developers.

The most common reasons for Europeans to be physically active is to improve their health (54%) or to improve their fitness (47%) (European Commission, 2018). With the help of the EFB counselling, they get an idea of how to raise their fitness level and therewith to improve their health. Still, there is a need for more studies with standardized tests, broad samples and executed longitudinal style to tell participants what they will benefit from. For practical relevance it can be stated that an increase in structured and well-planed activity (Tittlbach et al., 2017) increases fitness and therewith increases health.

Declarations

Ethics approval and consent to participate

The ethics committee of the Karlsruhe Institute of Technology approved the study "Gesundheit zum Mitmachen", which display the participants in parts. The other data part is a data sample of European Fitness Badge (EFB) participants during a gymnastic festival in Berlin, Germany in 2017. Content of the EFB (test items and body measurements as height, weight and waist circumference) is similar to content of the study "Gesundheit zum Mitmachen" – that is why we presume that an approval by an ethic committee is not necessary. Adults chose voluntary if they want to participate and if they did, they read and signed a written informed consent including:

- data protection declaration according to EU data protection law,
- usage of the anonymized data for scientific calculations and publications,
- participation at one´s own risk,
- the availability to stop the test anytime.

Availability of data and material

The datasets analyzed during the current study are not publicly available due to data protection but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Legend/List of abbreviations

ANOVA – Analysis of Variance

BMI – Body Mass Index

EFB – European Fitness Badge

HRF – Health related fitness

KIT – Karlsruhe Institute of Technology

N-Ex – Non-Exercise Questionnaire

PA – Physical activity

PAR-Q – Physical Activity Readiness Questionnaire

PF – Physical fitness

VO_2max – Maximal oxygen consumption

WHO – World Health Organization

MET – Metabolic equivalent of task

P – Significance

R – Correlation coefficient

F – F-value

η^2 – Eta square

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DEVELOPMENT OF HEALTH TOURISM IN WEST POMERANIAN VOIVODESHIP

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Abstract Health resort treatment is an important element of the Polish health care system. An aging population, an increase in the amount of free time and income, as well as a healthy lifestyle trend are the main factors for the development of health tourism. West Pomeranian voivodeship ranks 3rd in the country in terms of the number of health resorts, as well as is the undisputed leader in terms of the number of people visiting Polish resorts. In 2017, over 25% of patients underwent medical treatment in health resorts in West Pomeranian voivodeship. The aim of the study was to analyze the potential of health resorts in West Pomeranian voivodeship and to assess the development of tourist traffic in health resorts in recent years.
West Pomeranian voivodeship observes a steady increase in the number of health resort visitors using the services offered by health establishments and a changing structure of patients in regard to the financing method – there is a growing number of people who finance their stay in the health resort on their own. In order to maintain the leading position on the market of health tourism services, it is necessary to raise the standard of health services, carry out further investments in modern health resort infrastructure that is open to innovative and unconventional solutions combining traditional and modern methods of treatment as well as preventive healthcare and leisure. There is a need to constantly adapt the health tourism product to the changing needs of patients and to create new brand of products as well as acquire new groups of recipients who finance their stay in health establishments.

Key words health tourism, health resort treatment, health resort brand

Introduction

From the end of the 20th century, health resort treatment began to experience a kind of renaissance, constituting an important element of the Polish health care system. The main function of health resorts is to improve patients' health as well as provide preventive healthcare and health education (Dryglas, 2006). An aging population, an increase in the amount of free time and income, as well as a healthy lifestyle trend are the main factors for the development of health tourism (Makała, 2016). Health resorts are a kind of health sanctuaries that give the opportunity to move to another environment that enables many stimuli beneficial to the body (Meyer, Bordun, 2013). Health tourism is based on health resort treatment provided by qualified medical staff in health establishments using the healing properties of natural resources, mineral water and climate. Their existence is one of the premises for granting a particular area the status of a health resort. The most important methods used in health resort treatment are: balneotherapy with peloid therapy and climatotherapy. The specialization of health resorts depends primarily on their availability.

In Poland, the majority of health resorts are located in the mountains and by the sea. In their immediate surroundings there are areas with high natural and geographical values. Many of them are adjacent to national and landscape parks. Thanks to this location, they display not only medicinal properties, but also recreational and tourist values (Gotowt-Jeziorska, Wyrzykowski, 2005).

Almost half of Polish health resorts are located in two voivodeships: Dolnośląskie (11 resorts) and Małopolskie (9 resorts). West Pomeranian voivodeship ranks 3rd in Poland in terms of the number of health resorts (5). However, in terms of the number of patients visiting Polish resorts, West Pomeranian voivodeship is the undisputed leader. In 2017, over 25% of patients (184.8 thousand people) underwent medical treatment in health resorts in West Pomeranian voivodeship. The well-developed tourist accommodation establishment base offering 10,412 beds allowed the reception of such a large number of patients (23.47% on the scale of national health resort treatment) (GUS, 2018).

The aim of the study was to analyze the potential of health resorts in West Pomeranian voivodeship and to assess the development of tourist traffic in health resorts in recent years.

Basics of health resorts in West Pomeranian voivodeship

The coastal location of West Pomeranian voivodeship and the presence of rich peloid deposits and healing waters have contributed to the creation and development of attractive climate, peat and mineral health resorts. Even before the war, resorts such as Kołobrzeg (Kolberg), Połczyn Zdrój (Bad Polzin), Świnoujście (Swinemünde) and Międzyzdroje (Misdroy) experienced dynamic development. Health resort activities are carried out in West Pomeranian voivodeship in the area of 5 gminas that currently have the status of a health resort (Kołobrzeg, Połczyn Zdrój, Kamień Pomorski, Świnoujście and Dąbki) and through individual centers in other coastal towns, e.g. in Rewal gmina (Pobierowo, Pogorzelica and Niechorze) (Urząd Marszałkowski, 2013).

The health resort tradition of Świnoujście dates back to 1822, when patients went there mainly to try the then fashionable sea bathing. After the discovery of brine springs in 1897, Świnoujście gained popularity and over time developed into one of the most attractive health resorts with the best offer in Europe (Urząd Marszałkowski, 2013). Before the Second World War, Świnoujście was one of the largest German resorts.

The Kamień Pomorski Health Resort was established as a result of the discovery of a nearby brine deposit in 1876. The later discovered peloid deposits, an attractive geographical location and a unique microclimate resulted in the city quickly taking on the character of a health and recreation center. Although in the interwar period it was a small health resort, its greatest development occurred after the Second World War.

Kołobrzeg is one of the oldest cities in Pomorze. The greatest development of the city occurred after 1872, when the city lost its fortress status and transformed into a resort. It is the largest Polish health resort. It can accommodate over 7,000 patients and holiday-makers at one time. In the city and its surroundings there are sources of mineral water, as well as brine and peat deposits. An additional advantage is the well-developed transport network (Kubicki, Kulbaczewska, 2013). Kołobrzeg was the first health resort in Poland with a railway connection, which was established in 1859.

Połczyn Zdrój is a resort known in Poland and abroad since the 19th century. Due to rich deposits of excellent quality peat and Permian brine, the city successfully cultivates and develops over 300-year-old health resort traditions, since mineral waters were discovered there as early as 1688. Połczyn-Zdrój is the only health resort located in Drawskie Lakeland, among moraine hills, lakes and forests, 57 km from Koszalin and 150 km from Szczecin. The location of the city in "Połczyn Switzerland" as well as climate and medicinal values contribute to its charm (Urząd Marszałkowski, 2013).

The youngest health resort in West Pomeranian voivodeship – Dąbki – is a small town located in Darłowo gmina. It obtained the status of a health resort in 2007. However, the beginnings of the resort date back to the beginning of the 20th century, when the town became a well-known seaside resort. Before the Second World War, a resort that was a part of the Berlin healthcare fund operated there (GUS, 2011). Dąbki is a rather unusual seaside resort, as on the one hand, it has a beautiful, sandy beach, and on the other hand, is located next to Bukowo Lake.

Although natural conditions completely determine the location of health resorts, obtaining the status of one is not an arbitrary decision, but one based on legal regulations, which allow the separation of areas called "health resorts" in order to use and protect natural medicinal raw materials that are the basis for conducting health resort treatment (Kasprzak, 2016). The activity of health resorts in Poland is regulated by the Act of July 28, 2005 on Health Resort Medical Care, Health Resorts, Health Resort Protection Areas (Journal of Laws of 2005, No. 167, item 1399), together with its amendment (Act of 4 March 2011 amending the Act on Health Resort Medical Care, Health Resort Protection Areas and Health Resort Gminas and other acts) (Journal of Laws of 2011, No. 73, item 390).

Health resort treatment is mainly carried out by health establishments, which are therapeutic entities that operate in the health resort. Patients can undergo treatment or rehabilitation. The core of health resort treatment is comprehensive therapeutic management, conducted in a different place than the one in which one lives, i.e. in isolation from daily stress and harmful environmental conditions (Ponikowska, 2001). The establishments use the unique natural conditions of the health resort in which they operate. Health establishments include, among others: health resort hospitals, sanatoria, health resort hospitals for children and sanatoria for children, health resort clinics, natural healing centers, hospitals and sanatoria equipped in underground mining excavations (https://www.gov.pl/web/zdrowie/wykaz-uzdrowisk-wraz-z-kierunkami-leczniczymi).

Therapeutic treatment profiles of health resort are understood as specialization in the treatment of specific disease groups. They are specified for the entire health resort. Moreover, all health establishments located in a given resort are required to carry out therapeutic activity only within the scope of the profiles of a given health resort (Makała, 2016).

The greatest demand for health resort treatment is for rheumatic, orthopedic-traumatic, neurological, heart diseases and diabetes (Ponikowska, 2010). Health resorts in West Pomeranian voivodeship specialize in the following therapeutic profiles:

1. Dąbki – orthopedic-traumatic, rheumatic, heart and hypertension, upper and lower respiratory tract, endocrine diseases.
2. Kamień Pomorski – orthopedic-traumatic, neurological, rheumatic, heart and hypertension, lower respiratory tract diseases.
3. Kołobrzeg – orthopedic-traumatic, nervous system, rheumatic, heart and hypertension, lower and upper respiratory tract, endocrine, diabetes, obesity, osteoporosis and skin diseases.

4. Połczyn Zdrój – orthopedic-traumatic, nervous system, rheumatic, obesity, osteoporosis, women's diseases.
5. Świnoujście – orthopedic -traumatic, nervous system, rheumatic, lower and upper respiratory tract, endocrine, heart, hypertension, obesity, osteoporosis and skin diseases (https://www.gov.pl/web/zdrowie/wykaz-uzdrowisk-wraz-z-kierunkami-leczniczymi).

Tourist accommodation establishments

Tourist accommodation establishment is one of the tourism development factors enabling the use of all tourist values, including spa qualities. Its capacity affects the volume of tourist traffic and stimulates its development (Kowalczyk, Derek, 2010).

In 2011, 47 health resorts operated among tourist accommodation establishments in West Pomeranian voivodeship. They accounted for 5.6% of all accommodation facilities in the voivodeship, while in Poland the share of health establishments in total establishments amounted to 2.2%. For comparison, this percentage was 4.6% for West Pomeranian voivodeship and 1.6% for Poland in 2000 (Kubicki, Kulbaczewska, 2013).

In Poland, health resorts are characterized by a diverse ownership structure. Today, the owners of health resorts and health resort hospitals are mostly private persons. There are five health resorts in West Pomeranian voivodeship, including two state-owned companies: Świnoujście Health Resort and Kołobrzeg Health Resort, the privatized health resorts in Połczyn Zdrój and Kamień Pomorski, as well as Dąbki Health Resort, which has never been a state company, and received the status of a health resort in 2007.

There are currently 45 health establishments operating in West Pomeranian voivodeship, which constitute 16% of all national establishments (Table 1). They have over 10,000 beds from among 44.4 thousand beds in the country, i.e. almost 24% of national health resort treatment. In 2017, they serviced 184.8 thousand patients (over 25% of the number of patients in the country). In comparison to 2010, the number of beds increased by 0.97 thousand, and by as many as 2.7 thousand in 2000. On the other hand, the number of in-patients increased by 21.7 thousand people as compared to 2010, and as many as 97.81 thousand people when compared to 2000 (Table 2). The largest number of patients was recorded in Kołobrzeg (117 thousand), followed by Świnoujście, Kamień Pomorski and Połczyn Zdrój. When comparing the number of in-patients served by national health establishments in 2000 and 2017, there was an increase of 77%, while West Pomeranian voivodeship recorded an increase by as many as 112% (GUS, 2011; 2018). Therefore, the region is the undisputed leader of Polish health tourism. Performing approx. 2 million medical services annually, health resorts in the voivodeship handle 90% of all traffic regarding health resort treatment in Pomorze, and 97% of foreign patients visiting Pomorze (Strategia rozwoju turystyki w województwie zachodniopomorskim do 2015 roku).

This data confirms the important role of health tourism in the economic development of West Pomeranian voivodeship.

Table 1. List of health establishments in West Pomeranian voivodeship

No.	Health resort	Health establishments	Number of beds
1	2	3	4
1.	Dąbki	**Health resorts:**	
		Sanatorium przemysłu metalowego H. Cegielski	300
		Sanatorium Kopalni “Argentyt”	160
		Sanatorium “Dukat”	216
		Sanatorium “Delfin”	104
		Sanatorium “Bursztyn”	152
		Sanatorium “Hutmen”	395
		Sanatorium “Geovita”	195
2.	Kamień Pomorski	**Establishments of Uzdrowisko Kamień Pomorski Sp. z o.o.**	
		Health resort hospitals:	
		Szpital Uzdrowiskowy “Mieszko”	159
		Health resorts:	
		Sanatorium Uzdrowiskowe “Chrobry”	139
		Sanatorium Uzdrowiskowe “Gryf” – subdepartment of “Mieszko” Hospital	30
		Natural healing centres:	
		Zakład przyrodoleczniczy “Feniks”	–
3.	Kołobrzeg	**Establishments of “Uzdrowisko Kołobrzeg” SA**	
		Health resort hospitals:	
		Szpital uzdrowiskowy “Mewa”	279
		Szpital uzdrowiskowy “Muszelka”	160
		Szpital uzdrowiskowy “Słoneczko” (for children and adolescents)	246
		Health resorts:	
		Sanatorium uzdrowiskowe “Kombatant”	459
		Health resort clinics:	–
		Health resort clinic in Zakład przyrodoleczniczy nr 1 (Natural healing centre No. 1)	
		Natural healing centers:	
		Zakład przyrodoleczniczy nr 1	–
		Zakład przyrodoleczniczy nr 2 (located in “Muszelka” health resort hospital)	–
		Establishments of other entities	
		Health resorts:	
		Sanatorium uzdrowiskowe “Willa Fortuna”	100
		Sanatorium uzdrowiskowe “MSWiA”	349
		Sanatorium uzdrowiskowe „Centrum rehabilitacji Rolników KRUS “NIWA”	318
		Sanatorium uzdrowiskowe “Węgiel Brunatny”	460
		Sanatorium uzdrowiskowe “Mesko”	182
		Sanatorium uzdrowiskowe “San”	288
		Sanatorium uzdrowiskowe “Jantar”	138
		Sanatorium uzdrowiskowe „Rawar”	115
		Sanatorium uzdrowiskowe “Lech”	164
		Sanatorium uzdrowiskowe “Koral-Live”	160
		Sanatorium uzdrowiskowe “Holtur”	434
		Sanatorium uzdrowiskowe “Perełka”	135
		Sanatorium uzdrowiskowe “Arka Mega”	772
		Sanatorium uzdrowiskowe “Bałtyk”	624
		Sanatorium uzdrowiskowe “Poznanianka”	90
		Sanatorium uzdrowiskowe “Posejdon”	250
		Sanatorium uzdrowiskowe “Albax”	140
		Sanatorium uzdrowiskowe “Mona Lisa”	59

1	2	3	4
4.	Połczyn Zdrój	**Establishments of: "Uzdrowisko Połczyn" SA**	
		Health resort hospitals:	
		Szpital uzdrowiskowy "Gryf"	430
		Szpital uzdrowiskowy "Podhale"	135
		Szpital uzdrowiskowy "Borkowo"	176
		Health resorts:	
		Sanatorium uzdrowiskowe "Irena"	45
		Health resort clinic	–
		Establishments of other entities	
		Health resorts:	
		Sanatorium uzdrowiskowe "Leo Karli"	194
		Sanatorium uzdrowiskowe "Marta"	100
		Sanatorium uzdrowiskowe "Hopferówka"	35
5.	Świnoujście	**Establishments of "Uzdrowisko Świnoujście" SA**	
		Health resort hospitals:	
		Szpital uzdrowiskowy "Światowid"	79
		Health resorts:	
		Sanatorium uzdrowiskowe "Henryk"	50
		Sanatorium "Admirał I"	79
		Sanatorium uzdrowiskowe "Admirał II"	90
		Sanatorium uzdrowiskowe "Bursztyn"	64
		Sanatorium uzdrowiskowe "Swarozyc"	31
		Sanatorium uzdrowiskowe "Tryton"	100
		Sanatorium uzdrowiskowe "Trzygłów"	47
		Sanatorium uzdrowiskowe "Bałtyk"	84
		Sanatorium uzdrowiskowe "Adam i Ewa"	90
		Sanatorium uzdrowiskowe "Koral"	54
		Sanatorium "Złoty Kłos"	170
		Natural healing centers:	
		Zakład Przyrodoleczniczy "Rusałka" with a health resort clinic	–
		Establishments of other entities	
		Sanatorium uzdrowiskowe "Energetyk"	149
		Sanatorium uzdrowiskowe "Złoty Kłos"	170

Source: Ministerstwo Zdrowia (2017).

Table 2. Activities of Health Establishments in West Pomeranian voivodeship and in Poland in the years 2000–2017

In years		Number of health establishments	Number of beds (in thousands)	In-patients (in thousands)	Out-patients (in thousands)
2000	Poland	291	34.98	412.91	73.10
	Zachodniopomorskie voivodeship	47	7.71	86.99	17.50
2010	Poland	268	37.77	572.88	65.14
	Zachodniopomorskie voivodeship	50	9.44	163.10	16.97
2017	Poland	271	44.37	734.40	73.70
	Zachodniopomorskie voivodeship	45	10.41	184.80	13.30

Source: own elaboration based on GUS (2011, 2018).

In Poland, more than half of in-patients benefited from the stay funded by the National Health Fund, while over 1/3 of patients were self-pay patients (Table 3).

Table 3. Structure of in-patients treated in health resort establishments by type of funding stay in 2017

No.	Financing method for the stay of patients at health resorts	Percent
1.	NFZ	55.3
2.	Self-pay	34.7
3.	ZUS	6.7
4.	PEFRON	1.5
5.	KRUS	1.1
6.	Other	0.7

Source: GUS (2018).

In West Pomeranian voivodeship, the majority of patients also benefit from funding from the National Health Fund. However, it is assuring to see that the number of people who finance their stay in the health resort on their own is growing. Kołobrzeg was the first health resort to receive more self-pay patients (54%) than those co-financed by the National Health Fund. Foreigners contribute significantly to this (Regionalny Program Operacyjny Województwa Zachodniopomorskiego, 2017). Polish health tourism, especially after joining the European Union, attracts more and more people from abroad (Makała, 2016). Poland occupies a high place in the European ranking in terms of the number of health resorts, which puts it in a good starting position when it comes to the possibility of competing for a foreign client. In this competition, the diversity of individual health resorts, which creates favorable conditions for meeting the needs of various customer groups, is important (Makała, 2016; Krupa, Wołowiec, 2010).

An important advantage of the flourishing health tourism in West Pomeranian voivodeship is its border location, which makes it an attractive place to stay for foreign tourists, in particular Germans, but also Swedes and Danes (Figure 1). The high tourist attractiveness of health resorts in West Pomeranian voivodeship means that health resorts can win in the competitive struggle for not only domestic but also foreign tourists (Januszewska, 2005).

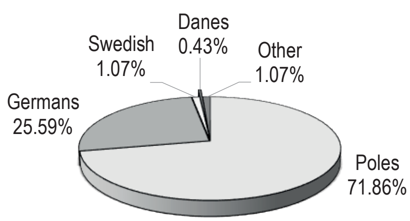

Figure 1. The structure of health resort tourists visiting statutory health resorts in West Pomeranian voivodeship by nationality

In West Pomeranian voivodeship, the years 2000–2004 saw an upward trend in the number of foreign tourists' overnight stays in health establishments. Nationwide trends were similar. The next three years were characterized by stabilization. However, the years 2008–2011 observed a downward trend. Despite this, in 2011, Polish health resorts recorded over 63% more foreign tourists than in 2000. In West Pomeranian voivodeship this increase was almost 74%. In 2011, over 571,000 stays were granted to foreign tourists in Polish health resorts, of which as many as 87.8% were organized in West Pomeranian voivodeship. In the years 2000–2011, the dynamics of the number of overnight stays offered to foreign tourists in health establishments was similar to the variable number of foreign tourists in these establishments. In 2011, as compared to 2000, the number of overnight stays provided to foreign patients in health resorts increased by 52.2% in Poland and by 70.1% in West Pomeranian voivodeship (Kubicki, Kulbaczewska, 2013). In 2016, 93% of foreigners who used health tourism services in Poland were in health establishments in two voivodeships: West Pomeranian and Dolnośląskie (Ministerstwo Zdrowia, 2017).

Health resort brand in West Pomeranian voivodeship

Growing competition on the global health services market and changes in the needs of patients necessitates continuous work on the quality of offered health tourism services. Quality is an inseparable element of a strong brand. Creating the health resort brand is one of the goals of the Self-Government in West Pomeranian voivodeship, which in 2012 became the new owner of Uzdrowisko Świnoujście SA and Uzdrowisko Kołobrzeg SA. In the years 2013–2015, both companies invested almost PLN 40 million in order to improve the quality of health resort services. Several facilities have been modernized and expanded. However, these are not the only elements that comprise the health resort brand. This industry is more and more often expecting brand products. Uzdrowisko Świnoujście SA offers a professional cosmetics line based on natural brine. The set includes creams, gels, bath salt and soaps. A similar series is offered by Uzdrowisko Kołobrzeg SA – under the name “Kołobrzeskie SPA”, which proposes products based on peat from the mine belonging to the company (Regionalny Program Operacyjny Województwa Zachodniopomorskiego, 2017).

Połczyn Zdrój Health Resort has also been popularizing its brand product and specializing in the production of cosmetics from the “Połczyńskie Kosmetyki” series, which are based on medical peat and brine water. Body oil, healing soap, bath salt and face mask are an exclusive combination of the unique power of peat and medicinal brine, which can be a substitute for health resort treatments after returning home. Połczyn peat is considered one of the best in Central Europe (http://tfi.kghm.pl/nowa-linia-kosmetykow-z-polczyna).

The health tourism products are now part of the offer of the increasingly competitive health tourism market. This forces entrepreneurs operating in the health resort market to take actions to improve product competitiveness (Hadik, Szromek, Żylak, 2010). The constantly growing number of people traveling for health reasons means that cities with health resorts compete with each other, trying to distinguish and attract as many potential patients as possible. Skillful use of one’s own potential and effective presentation of tourist attractions are of key importance in this process (Meyer, Bordun, 2013).

A modern tourist offer based on branded products is a great opportunity for health resorts in West Pomeranian voivodeship. Obtaining the status of a branded product is an indicator of a strong position on the tourist market. Health tourism itself requires constant modification with innovation in the field of health tourism becoming a necessity (Górka, Wartecka-Ważyńska, 2013.

Health tourism is one of the fastest developing forms of tourism. It is one of the prioritized Polish brand products, whose development is of key importance for the regions to achieve competitive advantage, as most often neighboring regions have similar tourist potential, especially in terms of their tourist values. Created tourist products are usually similar and directed to the same target group, therefore, brand tourist products become a chance to be distinguished (Meyer, 2013).

Summary

Two health resort models have been developed on the global health tourism market: resorts that refer to traditional health tourism based mainly on the therapeutic-preventive model, and SPA & Wellness resorts based on broadly understood recreation and leisure tourism. Polish health treatment with independent medical specialization, balneology and physical medicine is a competitive brand among European Union countries. Current health needs and demographic trends require constant modernization of the system, which aims to ensure comprehensiveness and optimization of treatment and rehabilitation.

West Pomeranian voivodeship, taking advantage of its coastal location with high natural-landscape and health values characterized by the richness of deposits of excellent quality peat and Permian brine and sodium-chloride waters, has become a leader on the market of health tourism services by combining the provision of health treatment services with tourist functions. This position has been maintained and developed for years by investing in modern health resort facilities and creating a competitive global brand. The tourist product, which is based on the therapeutic-prophylactic features offered in health resorts in West Pomeranian voivodeship, is adapted to the needs of modern customers, while maintaining the individuality of the offers of individual health resorts and emphasizing their special features. This is reflected in the steady increase in the number of patients using the services offered by health establishments and in the changing structure of patients in regard to the financing method. The fact that the number of people who finance their stay in a health resort on their own is growing bodes well for the industry. Kołobrzeg was the first health resort in Poland to receive more self-pay patients (54%) in 2017 than those benefiting from the stay covered by the National Health Fund.

Conclusions

1. In order to maintain the leading position on the market of health tourism services, it is necessary to raise the standard of health services, carry out further investments in modern health resort infrastructure open to innovative and unconventional solutions that combine traditional and modern methods of treatment as well as preventive health care and leisure.

2. There is a need to constantly adapt the health tourism product to the changing needs of patients and to create new brand products as well as acquire new groups of recipients who finance their stay in health establishments.

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EFFECTIVENESS OF CARDIOPULMONARY RESUSCITATION DEPENDING ON LIFEGUARD'S LEVEL OF EXHAUSTION

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Abstract Rescue operation consists of many connected parts which are called rescue chain links. The quality of the whole operation depends on the accuracy of execution and compliance with each link. Undue hurry, sluggishness or excessive exhaustion of lifeguard may decrease the quality of the performed resuscitation procedures, which are an important element of the whole rescuing process. The presence of a qualified lifeguard or rescue team is essential to the rescuing process. Situations in which lifeguard is on duty as a single unit are permitted in Polish legal regulations. In such cases, up to the point of transferring the victim to emergency medical services, rescue operation lies in the hands of a single lifeguard. The aim of this report is a comparative analysis of the quality of two-minute CPR procedures performed on QCPR anatomical models (Resusci Little Anne), in case of a one-person rescue operation at the swimming pool. 22 students of Water Safety, University of Szczecin took part in the experiment. The results of the experiment showed that the exhaustion of the lifeguard did not have a substantial impact on the quality and effectiveness of the rescue procedures. The study was conducted in conditions isolated from fatigue and after a rescue operation performed in water.

Key words cardiopulmonary resuscitation, aquatic safety, physical capacity

Introduction

Deaths on Earth are still too often caused by cardiopulmonary arrest. 55–113 out of 100,000 people die yearly due to this reason, i.e. 350,000–750,000 people in the world (Grasner, Bossaert, 2013). World Health Organization (WHO) evaluates that every hour more than 40 people die from drowning, which makes 372,000 deaths yearly (Global Report on Drowning, 2014). A great amount of people dies because they do not receive aid at the right time from the first-contact lifeguard. Expertise and abilities of basic resuscitation procedures allow for so-called "buying time for the victim", through performing chest compressions and rescue breaths on the victim. Abandonment of these actions in time above 4 min. may result in irreparable consequences in human organism, which will affect the quality of their life. The commonness of training and post-training exercises is still not high enough. There is a lot of areas in the world, in which people do not know CPR (cardiopulmonary resuscitation) activities; there are even areas in which people have not even heard of them. Another problem is the decision making in situations requiring first aid rescue operations. Restraint, fear of infection, stress and fear of legal implications are only a few psychological mechanisms affecting the abandonment of rescue operations (Savastano, Vanni, 2011). In most societies, the average time from the emergency call to the arrival of the emergency medical team is 5–8 min. (Lilja et al., 2015) or 8–11 min. from the emergency call to the first defibrillation (Sulzgruber et al., 2015). In this time the survival rate of victims depends on taking CPR and the use of an automatic external defibrillator (AED) by the rescuer.

Main services in Poland established for rescue operations are Emergency Medical Services, State Fire Service, Volunteer Fire Service, Mountain Volunteer Search and Rescue, Water Rescue Services and many other institutions providing professional and social service. In Poland, water safety is managed by entities obtaining permission to perform emergency medical services (Ustawa z 18.08.2011 r. o bezpieczeństwie osób przebywających na obszarach wodnych). These entities are obliged to competent rescue not only in the search, taking and evacuation of the victim or victims, but also in providing qualified first aid (Ustawa z 8.09.2006 r. o Państwowym Ratownictwie Medycznym). Each of the rescuers who provide first aid should remember and implement the “Chain of Survival” (Figure 1) in their actions. The chain of survival sums up the most important activities required to perform effective resuscitation. Most of the Chain’s links are related to the victims who have had cardiopulmonary arrest as an originally cardiogenic result, but also as a result of asphyxiation (Wytyczne resuscytacji, 2015, p. 12).

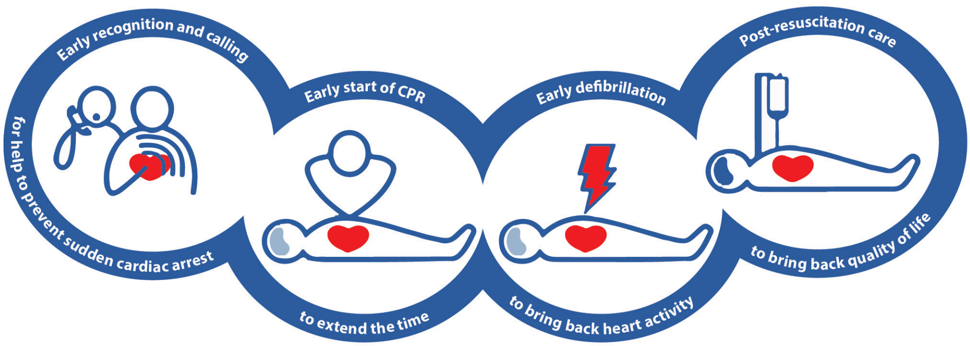

Figure 1. Chain of survival

In the context of the topic raised in this material, the treatment of cardiac arrest, which occurred in specific locations, deserves attention. These locations include health care facilities, commercial aircraft, sports fields, external environments such as water, high altitude, backfilling and electric shock (Wytyczne resuscytacji, 2015, p. 12). When focusing attention on providing assistance in and around water areas, one should remember about significant differences in performing CPR activities for an unconscious person pulled out of the water (Szpilman et al., 2014) (Figure 2).

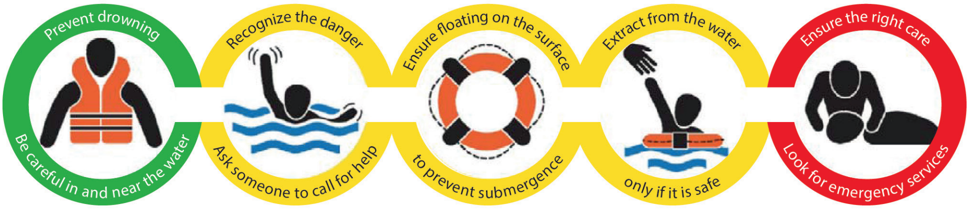

Figure 2. Chain of survival in the case of drowning

The chain of survival in the case of drowning demonstrates five important links related to the improvement of survival rate in drowning (Szpilman et al., 2014). The first two links include drowning prevention and danger recognition (Wallis et al., 2015). The remaining three links relate to ensuring of flotation on surface and extraction from water and undertaking rescue operations, including calling the emergency. The algorithm of the procedure in cases of drowning applies to rescuers with an obligation to provide first aid and people with appropriate training in water rescue (Wytyczne resuscytacji, 2015, p. 12) (Figure 3).

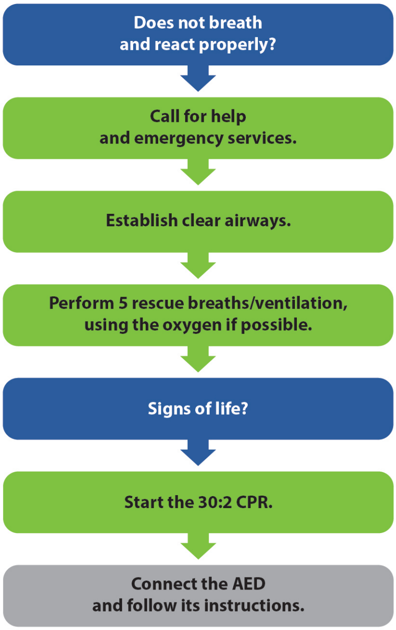

Figure 3. Algorithm of the procedure in cases of drowning applies to rescuers with an obligation to provide first aid

In the scope of assisting flooded person extracted to the surface of the water, it is recommended to ventilate the injured person in the water, preferably with the help of a rescue buoy. Some of the injured people might react to the rescue breaths given in the water during the evacuation. However, if this does not happen, then due to the difficulties (wave, distance from the shore, equipment support), the rescuer should extract the victim to shore as fast as possible without further ventilation attempts. One of the studies shows a greater survival rate when using ventilation in water (Szpilman et al., 2014). It happens that the lifeguard does not have the support of a second lifeguard or a rescue team. Such cases are reflected in swimming pools up to 25 meters in length, where regulations allow the presence of one lifeguard (Rozporządzenie MSW z dnia 23 stycznia 2012 r.). In such cases, a single lifeguard undertakes rescue operations both in and outside the water. The issue of performing rescue procedures after executing rescue operations in the water mainly raises the subject of the quality of these procedures depending on the mental and physical conditions of the rescuer providing aid. Studies on this subject in Poland, with the participation of candidates for Senior Rescuers, show that there are no significant correlations between the fatigue of a rescuer and the effectiveness of CPR treatments (Stanula, 2008). The focus was also given to the dimorphic differences in the context of CPR. It turned out that women get tired much faster during resuscitation, which disrupts the quality of these activities (Sanchez-Lopez, Rovira-Gil, González-García, Ferrer-López, Martínez-Vizcaíno, 2015). In 2019, research was carried out confirming the importance of height above sea level (3,259 m a.s.l.) at which CPR procedures were performed by mountain rescuers. In the case of the “mountain” experiment, it turns out that performing CPR in simulated hypoxia significantly increases the physiological requirements of the rescuer, but does not affect their quality, at least in the first 10 minutes (Carballo-Fazanes et al., 2019). Researchers studying the subject of CPR in water rescue attempted to examine a situation where a first contact rescuer was not trained in water assistance. Our knowledge of the basic BLS algorithm procedures has an impact on the quality of aid and the number of patients who survive cardiac arrest (Sulovic et al., 2018). There is a tendency to shorten the time at which CPR starts. Both in the water and sea rescue, treatments begin on the water. The research results appearing in 2014 assess the innovative ALS rescue concept, based on the operation of a helicopter simulator, where the self-inflating platform Heliboat was used during the action, which enabled the initiation of resuscitation activities on the water, just after extracting the sinking (Winkler et al., 2015). Catarina Qeuiroga took care of the quality and effectiveness of resuscitation procedures after the operation in the swimming pool. Research results from 2014 show that physical fatigue caused by rescuing in the swimming pool negatively affect the quality of the two-minute CPR performance. 27 students participating in the study made mistakes in the number of compressions performed, as well as in the ratio of compression performed to the given breaths. The authors state that CPR treatments are more effective when training of the lifeguards is conducted in conditions similar to those accompanying the actual rescue operation (Queiroga, Barcala-Furelos, Abelairas-Gomez, Garcia-Soidan, 2014). Similar studies were carried out in 2012 in Spain. Based on 60 students (30 women and 30 men) previously trained in water rescue, who, after the effort caused by the rescue operation in inland waters, performed a five-minute CPR at the Resusci Anne anatomical model. The results showed that effort-induced fatigue during open-water rescue has an impact on the total amount and quality of chest compressions and ventilation (Barcala-Furelos, Abelairas-Gomez, Romo-Perez, Palacios-Aguilar, 2013).

Aim of the study

The aim of the study was to try and determine the effect of fatigue on the effectiveness of a rescue operation. Comparative analysis of the quality of two-minute CPR treatments on QCPR anatomic models (Resusci Little Anne) in a one-man rescue operation. Comparison of the results of a rescuer performing CPR in two different situations: without inducing fatigue by physical effort and with inducing fatigue by one-man rescue operation.

Research hypotheses

1. The fatigue of a lifeguard simulated by a rescue operation has a significant impact on the quality and effectiveness of resuscitation procedures.

2. The fatigue of a lifeguard in a simulated rescue operation has a significant impact on some of the selected CPR "indicators".

3. The obtained results of CPR procedures in a state without fatigue, and in fatigue differ statistically significantly.

Material and methods

The study was carried out in November 2019 among 22 students of Water Safety, Institute of Spatial Management and Socio-Economic Geography of the University of Szczecin. All students are members of the Voluntary Water Rescue Service of West Pomeranian Voivodeship in the rank of Water Rescuee (Ustawa…, 2011). The first part of the experiment was carried out in the Rescue Lab. The second part of the experiment was carried out in a 25 m long and 2.5 m deep indoor sports swimming pool. Preparation of the research group consisted of readiness for water rescue classes in the swimming pool. Equipment used in the research: rescue tube, a hand-held stopwatch, a hand-held device Polar Vantage M for measuring the pulse rate, DLRG pool rescue dummy, an anatomical model of an adult (Little Anne Laerdal, QCPR) for cardiopulmonary resuscitation and an iPad to generate and collect data. During the part in which the rescuers performed CPR procedures, the application "QCPR Instructor" was used. Thanks to the application on a mobile device, the obtained results were provided by the device in a precise manner. The individual elements of the CPR study were called "indicators". The indicators checked and generated for the assumed purposes and research hypotheses are general index, relaxation, depth of compression, rate of compression, breath share (given as a percentage – %); the rate of compressions to rescue breaths given (data are given in quantities). The research began with "initial resuscitation" which each student performed at the anatomical model in the Rescue Lab. When approaching the tests, the students were not tired, and their pulse before approaching the rescue dummy did not exceed 72 beats per minute. The CPR procedures performed on the phantom were in line with ERC (European Resuscitation Council) guidelines, which adopt: compression depth about 5 cm, compression frequency 100–120/min, minimizing interruptions in chest compressions, firm ground, proper chest deformation, appropriate work cycle 50/50% (Wytyczne resuscytacji, 2015, p. 12).

The scenario was in line with ERC guidelines and assumed:

1. Checking the response and correct breathing.
2. Calling for help and emergency medical team.
3. Establishing a clear airway.
4. Performing 5 rescue breaths/ventilation (using oxygen if possible).

5. Checking for signs of life.
6. Start of CPR 30:2.

The research task assumed a scenario in which the injured person was pulled out of the water WBLS (Water Basic Life Support). There was a person with a telephone in the presence of the rescuer, and no AED was present in the building. The course of the mock rescue operation, in which CPR procedures were used, consisting of control of consciousness and breathing, emergency medical team call, initiation of cardiopulmonary resuscitation from 5 rescue breaths, 30 chest compressions and 2 rescue breaths, 30:2 CPR continuation. The duration of "initial resuscitation" is two minutes, counted from the start of five rescue breaths. Before the preliminary test, all students were trained in first aid according to the guideline of the European Resuscitation Council, during the BLS and AED course (Figure 4).

Figure 4. Fragments of CPR procedures at the QCPR anatomical model performed by a lifeguard who is not shortly after physical effort

The model of the rescue operation on the basis of which the survey was conducted was determined taking into account the applicable provisions (Ustawa, 2011) referring to the regulation of the MSW regarding the minimum requirements for the number of water rescuers ensuring constant control of a designated water area (Rozporządzenie, 2012), where one lifeguard was on duty at the 25-meter sports pool. The model of simulated rescue operation consisted of lifeguard stride entry into the water with a rescue tube, rescue front crawl swimming on the distance of 20 meters, dynamic headfirst surface dive, diving to the rescue dummy on the distance of 5 meters, extracting the rescue dummy on the surface of water, securing the rescue dummy by using the rescue tube, the return towing the rescue dummy in a way used in case of passive person on the distance of approximately 23–24 meters, lifeguard getting out of the water, pulling out the rescue dummy of the water on the shore, proceeding to the CPR (Figure 5).

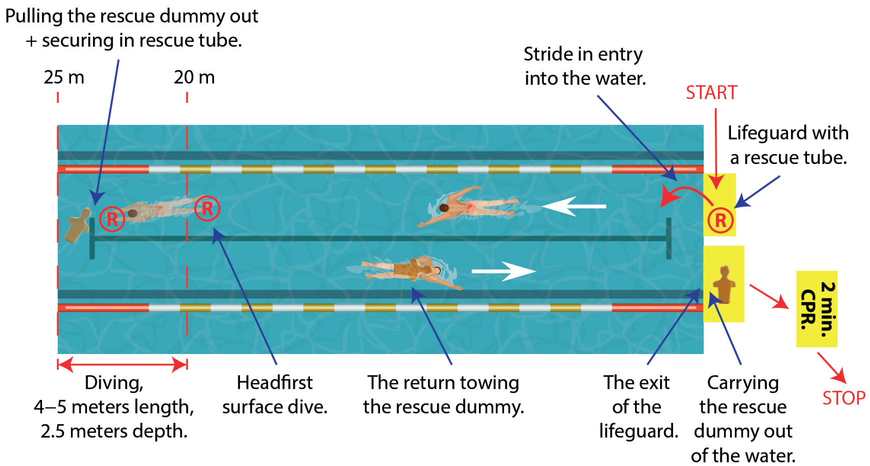

Figure 5. Scheme of a mock rescue operation in an indoor swimming pool up to 25 m

The course of the two-minute "resuscitation by fatigued rescuer" action concerned the victim pulled out of the water and began in each case the same as in the case of "initial resuscitation". The results of each of the tested students were divided into the fitness part, in which the times of the mock rescue operation were recorded when the stopwatch was turned on at the start signal and turned off when the rescue dummy was placed on the edge of the pool, and the part where CPR procedures were performed (Figure 6). After completing the task, the highest value of pulse of each student between the end of the rescue operation in the water and commencement of CPR procedures was read. The indicators which were taken into account and used in the results chapter are:

1. Time of the action with the participation of a lifeguard, when performing rescue tasks with maximum commitment (time)[1].
2. Post-exercise heart rate recorded after the end of the rescue operation in water but before the start of resuscitation procedures (heart rate/min.)[2].
3. The general result is the result of all other indicators reported by the application (relaxation, depth of compressions, rate, the proportion of breathing in %).
4. Relaxation – an appropriate way of releasing the chest after pressing (%).
5. Compression depth – correct should be in the middle of the chest at the bottom of the sternum to a depth of 5 cm, but not more than 6 cm (%).
6. Compression rate – the average number of compressions per minute; the correct rate is 100–120/min. (%).
7. Share of breaths – the quality of rescue breaths given (quantity, time and strength with which they are given – in %).
8. The ratio of compressions to rescue breaths – the correct value of this indicator is 30/2.

[1] Indicator examined in the second part of the study, which used fatigue of the rescue operation and post-exercise heart rate.

[2] Indicator not taken into account in the tabular distribution of results.

Figure 6. Fragments of the model rescue operation

Results

The data collected during the research underwent statistical treatment using the Statistica 12 application. Basic data analysis presents the general characteristics of the listed variables (in the system before and after the effort made), the tested group of students based on location and dispersion measures. Then, an analysis of the correlation between selected variables was carried out, and also to check the differences in the results obtained regarding the elements of the rescue operation before and after the student's effort (appropriate tests of significance of differences).

Based on selected statistical parameters (Table 1 and 2): arithmetic mean ($x_{śr}$), median (Me), modal (Mo), minimum (Min) and maximum (Max), quartile 1 (Q_1), quartile 3 (Q_3), standard deviation(s), coefficient of variation (V_s), relating to the results measured before and after exercise, it can be stated that:

1. The general result is more satisfactory in the case of post-exercise CPR procedures.
2. The number of students performing flawlessly depth of compressions before and after exercise is very similar and amounts to 14–15 people.
3. In the case of the relaxation indicator, there is a difference in the number of people performing correct releasing of the chest by up to 11 people in favor of the action in the fatigue of the rescuer.
4. The vast majority of students, both before and after exercise, performed the Compression Depth element best (Mo = 100; Me = 100; Q_3 = 100).
5. The results of students in relation to conducted rescue operations (before and after exercise) differed the most in relation to the rate of compressions (V_s = 35.5%; V_s = 37.2%); while the least in the share of breaths/before exercise (V_s = 9.2%) and the depth of compressions/after exercise (V_s = 0.6%).

The measurement results also indicate that the number of people who correctly performed the ratio of compressions to given breaths (30/2) before effort was 100%, while after effort it was 38.5% (i.e. 10 people).

Table 1. Summary of statistical parameter values for pre-exercise study results (%)

Indicator	$x_{śr}$	Me	Mo	Cardinality Mo	Min.	Max.	Q_1	Q_3	s	V_s
General	**87.8**	98.0	Multiple	7	23.0	99.0	88.0	99.0	21.0	23.9
Relaxation	77.5	86.0	**100.0**	**4**	21.0	100.0	65.0	98.0	24.1	31.1
Compression depth	91.6	100.0	**100.0**	**14**	43.0	100.0	97.0	100.0	17.8	19.5
Rate	79.9	93.0	100.0	5	0.0	100.0	63.0	99.0	28.4	35.5
Share of breaths	92.4	96.0	97.0	5	65.0	100.0	90.0	98.0	8.5	9.2

Table 2. Summary of statistical parameter values for post-exercise study results

	$x_{śr}$	Me	Mo	Cardinality Mo	Min.	Max.	Q_1	Q_3	s	V_s
Time of the action/s	87.0	88.5	Multiple	2	58.0	140.0	72.0	99.0	20.45	23.52
Heart rate after effort/number	141.2	142.0	Multiple	4	104.0	164.0	136.0	148.0	13.31	9.43
General (%)	**92.2**	93.5	99	6	65.0	100.0	89.0	99.0	8.12	8.81
Relaxation (%)	92.5	100.0	**100**	**15**	19.0	100.0	97.0	100.0	18.61	20.12
Compression depth (%)	99.5	100.0	**100**	**15**	98.0	100.0	99.0	100.0	0.58	0.58
Rate (%)	75.3	88.5	Multiple	3	0.0	100.0	63.0	97.0	28.02	37.21
Share of breaths (%)	81.9	89.0	100	8	0.0	100.0	75.0	100.0	25.83	31.53

Before proceeding with further analysis of the results of the carried out test, it was necessary to decide whether the variables tested had a normal distribution. This was done using the W Shapiro-Wilk test (Table 3). The results of the W Shapiro-Wilk test to assess the normality of the distribution of variables measured before exercise (H_0: The distribution of the studied variable is a normal distribution; assumed level of significance ≤0.05).

Table 3. Assessment of distribution normality by W Shapiro-Wilk test before physical effort (%)

Variables/indicators	The value of the W Shapiro-Wilk test	Level of significance p*
General	0.582	0.000
Relaxation	0.853	0.002
Compression depth	0.524	0.000
Rate	0.725	0.000
Share of breaths	0.767	0.000

* Computer level of significance; if p < 〈 then H_0 should be rejected.

As can be seen from the table presenting the results of the distribution normality test, no indicator has a normal distribution. The consequence of this is the use of nonparametric correlation based on the Spearman rank correlation coefficient, which allowed the assessment of the correlation between these variables (Table 4).

Table 4. The use of nonparametric correlation based on Spearman's rank coefficient (%)

Indicator	General	Relaxation	Compression depth	Rate	Share of breaths
General	1.000	0.396*	0.532*	0.491*	0.796*
Relaxation		1.000	0.285	0.475*	0.174
Compression depth			1.000	0.293	0.428*
Rate				1.000	0.292
Share of breaths					1.000

* Statistically significant results for ≤0.05.

Considering the use of nonparametric correlation based on Spearman's rank coefficient, each of the indicators listed in Table 4 significantly correlates (positive correlation) with the "general" indicator; the strongest correlation relationship occurs between the general indicator and the indicator expressed by the share of breaths. The other two values occur in the case of relaxation and compression rate (0.475) as well as in the case of compression depth and the share of breaths (0.428). This means that people who achieved a high compression rate result also maintained a relatively high score in the depth of compression; as well as the correlation relationship between the depth of compressions and the share of breaths, which is a visible effect of properly performed resuscitation.

Considering the results obtained by students after the effort, which was based on the model of the rescue operation on the short pool and included: rescue jump, swimming, diving, recovering the injured person, securing the injured person, towing the injured person and evacuating the injured ashore and commencing CPR procedures – similarly, the normality of the distribution was assessed first (Table 5).

The results of the W Shapiro-Wilk test to assess the normality of the distribution of variables measured after physical effort (H_0: the distribution of the studied variable is a normal distribution; assumed level of significance ≤0.05).

Table 5. Assessment of distribution normality by W Shapiro-Wilk test after physical effort

Variables/indicators	The value of the W Shapiro-Wilk test	Level of significance p
Time of the action (s)	0.946	0.183
Heart rate after exercise (number of beats/min)	0.953	0.270
General (%)	0.821	0.000
Relaxation (%)	0.473	0.000
Compression depth (%)	0.702	0.000
Rate (%)	0.824	0.000
Share of breath (%)	0.719	0.000

The results of the distribution normality test indicate that only the variables: "Time of the Action" and "Heart Rate After Exercise" have a normal distribution. Therefore, the Spearman rank correlation coefficient was similarly used (Table 6).

Table 6. Application of nonparametric correlation based on Spearman's rank coefficient

Variable	Time of the action (s)	Heart rate after exercise (number of beats/min)	General (%)	Relaxation (%)	Compression depth (%)	Rate (%)	Share of breath (%)
Time of action (s)	1.000	0.495*	–0.091	0.102	–0.134	0.015	–0.084
Heart rate after exercise (post exercise heart rate?) (number of beats/min)		1.000	–0.059	0.088	0.058	–0.465*	0.108
General (%)			1.000	0.329	–0.108	0.275	0.810*
Relaxation (%)				1.000	0.045	0.172	0.281
Compression depth (%)					1.000	–0.087	–0.137
Rate (%)						1.000	0.030
Share of breath (%)							1.000

* Statistically significant results for ≤0.05.

In the case of the values presented in Table 6, there are also presented two post-exercise indicators: time of the action and post-exercise heart rate, which are an assessment of the lifeguard's fitness. In the case of results showing statistically significant correlations, the correlation occurring in the case of the pulse rate and the time of the action (0.495), which indicates that the time of the action lengthened in people who finished the action with a higher heart rate, deserves attention. On the other hand, the compression rate index shows a negative correlation with the rescuer's post-effort heart rate (–0.465) – the higher the rescuer's post-effort heart rate, the lower (worse) the quality of the correct pressure rate. In turn, taking into account the components of the rescue operation, similar to the situation before exercise, the result indicates a strong correlation between the quality of rescue breaths given and the general result of the rescue operation, although between the other components such as rate, depth of pressure or relaxation and the general result there is no statistically significant correlation.

Having two measurements (before and after exercise) of the same group of students, for selected indicators, it was checked whether the results obtained differ significantly from each other, and therefore whether the effort affects the quality of the rescue operation. In this case, the test for two dependent samples was used, i.e. the Wilcoxon (T) pair order test (Table 7).

Table 7. Results for the Wilcoxon test (%)

Parameters	T test value	p value
General before & general after	131.500	0.597
Relaxation before & relaxation after	61.500	0.011
Compression depth before & compression depth after	26.000	0.017
Rate before & rate after	135.500	0.679
Share of breaths before & share of breaths after	95.500	0.119

Comparing the results of the general assessment of the rescue operation, as well as the assessment of the rate and share of breaths, the values do not differ statistically, so the physical effort preceding the action generally (especially taking into account the general rating) does not affect the quality of the action. This confirms the good preparation of WOPR rescuers to conduct a reliable rescue operation, even in the situation of an additional factor which is physical fatigue caused by a rescue operation.

In relation to the other indicators, the results of the components of the rescue operation elements, measured before and after the exercise (relaxation and compression depth) differ statistically significantly. The physical effort had an impact on these components.

Discussion and conclusions

An experiment consisting of checking whether the quality of cardiopulmonary resuscitation procedures will depend on fatigue and after the given physical effort of the rescuer who took these actions. The research included a number of "indicators" that were compared with each other by various statistical methods that can be used to summarize the results:

1. The general result (indicator) is more satisfactory in the case of CPR performed by a rescuer after exercise.
2. The vast majority of students, both before and after exercise, best performed the CPR fragment associated with the depth of compression indicator (Mo = 100; Me = 100; Q_3 = 100).
3. In the case of the relaxation indicator, there is a difference in the number of people performing correct chest releasing, up to 11 in favor of the action in fatigue of the rescuer.
4. The number of students who provide the correct depth of compressions before and after exercise is very similar and amounts to 14–15 people.
5. The results of students in relation to rescue operations (before and after exercise) differed the most in relation to the rate of compressions (V_s= 35.5%; V_s = 37.2%); while the least in the share of breaths/before exercise (V_s = 9.2%) and the depth of compressions/after exercise (V_s = 0.6%).
6. The measurement results also indicate that the number of people who correctly performed the ratio of compressions to given breaths (30/2) before exercise was 100%, while after the exercise it was 38.5% (i.e. 10 people).
7. Each of the indicators listed in Table 4 significantly correlates (positive correlation) with the "general" index; the strongest correlation relationship exists between the general index and the index expressed as the share of breaths.
8. The other two values occur in the case of relaxation and compression rate (0.475) as well as in the case of compression depth and the share of breaths (0.428) and are statistically significant.
9. In the case of results showing statistically significant correlations, the correlation occurring in the case of the pulse rate and the time of the action, which is 0.495, which indicates that the time of the action lengthened among people who finished the action with a higher heart rate, deserves attention. On the other hand, the compression rate index calculates the negative correlation with the rescuer's post-effort heart rate (–0.465) – the higher the rescuer's post-workout heart rate is, the lower (worse) the quality of the compression rate adjustment becomes.

Based on the summary of results above, the following conclusions can be sorted out:

1. Fatigue of the rescuer with a short rescue operation at the 25-meter pool in the given action model did not affect the quality of the two-minute CPR resuscitation performed on the QCPR anatomic model.
2. Fatigue of the rescuer with a short rescue action in the 25-meter pool, in the given action model, had a positive effect on the observance of relaxation and had no negative impact on the depth of chest compressions.
3. The features examined on which fatigue had a negative impact were:
   - the rate of compressions, which in the case of the rescuer after the action, was the indicator with the highest level of disturbance, which means that maintaining a stable, correct rhythm of performed compressions is difficult to achieve by a fatigued rescuer,
   - the ratio of compressions to given breaths, in which a significant number of rescuers were wrong about the number of both compressions and given rescue breaths.
4. The rescuer's physical condition is reflected in the pulse rate. The duration of action increased for people who had a higher heart rate after physical effort.

The above data indicate the validity of the research in the direction of certain variables occurring in the human relation and performed rescue tasks. It would seem that a tired rescuer will be less effective in their actions. The applied model of the rescue operation turned out to be so mild in the context of the adaptation of the rescuer's body that it had a mobilizing effect on them and thus on the quality of resuscitation procedures. Consideration should be given in further research to extending the rescue operation in water or the duration of CPR operations. However, it should be remembered that both rescue operations in the swimming pool are, due to the characteristics of the reservoir, shorter than those in open waters, as well as the first minutes of CPR activities are the most important. These considerations allow us to draw the most important conclusion that good preparation of lifeguards for conducting a reliable rescue operation, even in the situation of an additional factor which is physical fatigue as a rescue operation, is a priority value.

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APPLIED PHYSICAL PROGRAM ON CHANGES OF BODY POSTURES AND DYNAMIC SPINE FUNCTION IN FEMALE SECONDARY SCHOOL STUDENTS

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Abstract The aim of research was to identify the changes of body posture and dynamic spine function of female secondary school students after adaption of physical program which was within lessons of physical and sport education. The research group consisted of 45 female students of the first year of secondary school in Žilina (age – 15.42 ±0.38 years; body weight – 55.13 ±3.69 kg; height – 167.82 ±2.51 cm; body mass index – 19.72 ±1.51). In terms of data acquisition methods, we applied standardized tests and methods. To evaluate the impact of adapted physical program on muscular and skeletal system of secondary school students within lessons of physical and sport education we applied Wilcoxon test (W_{test} $p < 0.01$; $p < 0.05$). The statistical significance of differences between observed variables of pre-tests and post-tests, as practical and material significance, was evaluated by Effect size, Pearson's – r. While evaluating the body postures, positive shifts of body postures were recorded (35 ×), as it was noted with statistical significance and large effect size ($p < 0.01$; $Z = -5.8413$; $r = 0.8694$). Within the dynamic spine function, the evaluation detected all of the tests as statistically significant, but the left lateroflexion was recorded with negative effect size ($p < 0.01$; $Z = -3.7271$; $r = -0.3217$).

Key words body posture, female students, muscular and skeletal system, physical program

Introduction

The school reform, which is valid from the school year 2008/2009, has changed the status of physical and sport education and, with Education Act, the State Education Program has become the highest target and program project (Antala, Labudová, 2008). The minimum number of lessons of physical and sport education was set at two; however, there has been the possibility for an increase of one lesson, which is subject to the creation of the School Education Program (Antala, 2009; Bendíková, 2018). Despite of listed information, the Slovak Republic has reached the last place within member states of the European Union in the number of lessons of physical and sport education; however, the school institutions do not increase the listed lessons through the School Education Program (Stupák, 2017). Another modification has been accomplished within physical and sport education, as it has undergone modernization in 2015, which has led to many innovations within the State Education Program (2015).

The positive aspect of the State Education Program was the possibility of using and applying the proven innovations at lessons of physical and sport education.

While respecting the interests of pupils, students at physical and sport education, it is necessary to create and stabilize positive attitudes towards physical activity (Uherová, 2012) because for the constantly increasing number of school children and secondary school students, it is the only realized physical activity. The school children and secondary school students support it mainly through their passive (non)participation in lessons of physical and sport education. Some reasons are objective, but most of them are subjective (Boreham, Riddoch 2001; Zrnzević, Arsić, 2013; Balážová, 2014; Harris, 2015). Increasing the popularity of physical and sport education can be achieved through the possibility of creating an education program with its own program structure and curriculum, which is approved by the subject commission (Bendíková, Smoleňáková, 2018).

The physical program is an organized and systematic summary of characters, such as the physical activities, sports and recreations. It is realized during the period of free time (Miňová, 2003; Łubkowska, Tarnowski, Terczyński, 2018) but in terms of school education, it is realized during the lessons of physical and sport education. The intervention of physical programs is reflected in the levels of physical and health-oriented fitness, which is characterized as an impact on health. It has preventive measures for health problems, which are associated with the physical inactivity (Teplý, 1995).

The physical programs on muscular and skeletal systems, mainly in areas of the spine, differ as it is depending on the areas of influence (body posture, muscle imbalance and back pain). In the Slovak/Czech Republic, there are researches of the physical programs that impact the body postures or the muscle imbalances (Kopecký, 2004; Kanásová, 2006; Kanásová, Bukovcová, 2011; Bendíková, Stackeová, 2015; Bendíková, Marko, Rozim, Martinský, 2019; Marko, Bendíková, 2019), but researches of other countries, such as the United States of America or India have been dealing with spinal pain (Suni, 2006; Šarabon, 2011; Inani, Selkar, 2013; Kim, 2013).

Even basic physical activities positively influence the level of muscular and skeletal systems, which are visible in all age categories. However, the incidence of the various spinal disorders, diseases, etc. (functional and structural) increases annually – or even doubles (Bendíková, 2016) – as it starts in pre-school period, continues in younger school age/period of pubescence (Bendíková, Pavlović, 2013; Popova, Mitova, Gramatikova, 2014; Walther et al., 2014; Mitova, 2015; Azabagic, Spahic, Mulic, 2016; Müller et al., 2019) or period of adolescence (Acasandrei, Macovei, 2014; Ludwig, Mazet, Schmitt, 2016; Noll, Candotti, Rosa, Loss, 2016) and culminates in adulthood (Holmes, Freburger, Carey, 2009; Ferreira et al., 2011; Singh, Manchikanti, Falco, Benvamin, Hirsch, 2014) and old age (Anderson, Wolf, Starfield, 2002; Fleming et al., 2011; Gheno, Cepparo, Cotten, 2012).

Aim

The aim of research was to identify the changes of body postures and dynamic spine functions of female secondary school students after adaption of physical program, which was within lessons of physical and sport education.

Methods

Based on the aim of research, the research group consisted of 45 female students of the first year of secondary school in L. Mikuláš (age – 15.42 ±0.38 years, body weight – 55.13 ±3.69 kg, height – 167.82 ±2.51 cm and body mass index – 19.72 ±1.51). The selection of research group (n = 45) was intentional, in relation to not having any health problems. The research group was in period of pubescence; the measured values of primary somatometry are presented in Table 1.

Table 1. The primary characteristics of the research group (n = 45)

Measured values	Research group
Age (years)	15.42 ±0.38
Body weight (kg)	55.13 ±3.69
Body height (cm)	167.82 ±2.51
Body mass index (kg/m^2)	19.72 ±1.51

The research was realized within the interval of October 1, 2019–December 6, 2019. The realized experiment was terrain (lessons of physical and sport education), one-group (selected group, within the research group [n = 45]), pedagogical (selected secondary school) and multifactorial (areas and tests of muscular and skeletal system). The realization of adapted physical program which consisted of 12 exercises with character of strengthening was realized as follows: 10 weeks/2 ×/12 minutes at the end of lessons of physical and sport education. The research consisted of three stages:

1. Pre-test – realized by physiotherapist (October 1, 2019).
2. Realization of physical program (October 1, 2019–December 6, 2019).
3. Post-test – realized by physiotherapist (December 6, 2019).

In terms of data acquisition methods, the method of somatometry (Šimonek, 2000; Selekman, 2012) was applied, as the age, body weight and height of research group members (n = 45) was collected and calculated by using body mass index (Hošková, Matoušová, 2005). Within data acquisition methods we applied standardized tests and methods, such as Klein and Thomas modified by Mayer, which was widen by dynamic spine function. The evaluation of body posture, which is typical for physical and sport education, was based on body components (I. Head and neck posture; II. Shape of chest; III. Shape of abdomen and pelvic inclination; IV. Overall curvature of spine; V. Height of shoulders and scapulae position), to which points are given (1–4) according to quality of body posture. The overall body posture is expressed by total points (Correct posture – 5 points; Good posture – 6–10 points; Bad posture – 11–15 points; Incorrect posture – 16–20 points) (Vojtaššák, 2000). The last data acquisition method was dynamic spine function (tests of Schober, Stibor, Otto, Thomayer and Lateroflexion). It is a typical method for medical and physical practice, and therefore it was realized by physiotherapist (Labudová, Thurzová, 1992; Labudová, Vajcziková, 2009). What is more, the spine development of the research group was evaluated with gradual relaxation, symmetry of chest and paravertebral muscles.

The evaluation of research results was realized by using data processing methods such as qualitative and quantitative methods. To be more specific, analysis and synthesis, inductive and deductive approaches, comparisons and generalizations were used. The muscular and skeletal system within the research group was evaluated by primary statistics, such as median (Mdn), arithmetic mean (±), variation range ($V_{R=max–min}$) standard deviation (Sd) and percentage frequency analysis (%). To evaluate the impact of physical program on the muscular and skeletal systems of secondary school students, within lessons of physical and sport education, Wilcoxon test

(W_{test} $p < 0.01$; $p < 0.05$) was applied. The statistical significance of differences between observed variables of pre-tests and post-tests as the practical and material significance was evaluated by Effect size, Pearson's – r.

Results

Based on the aim of research and before presenting the research results, which are subject to more accurate monitoring and processing, it is necessary to understand them in overall context, in relation to health, through the prism of muscular and skeletal systems, mainly in the spine area. The reached results cannot be generalized but one should stress the necessity and importance of using and applying various innovations at lessons of physical and sport education.

For better uptaking and understanding, the research results are presented in tables, while Table 1 shows the results of evaluation body postures of research group (n = 45). It was evaluated by the method of Klein and Thomas modified by Mayer, in which the adapted physical program as the acting factor caused positive shifts and changes, as the average given points inverted from 11.31 ±2.22 to 7.11 ±1.62. At pre-test, the correct body postures were recorded in 0%, but it changed by the physical program to 13.40%. The positive shifts and changes were discovered within the good body postures, as it increased from 26.70 to 80.00%. However, the acting factor of the adapted physical program helped to decrease the bad body postures from 73.30 to 6.60% of the research group. The incorrect body postures were not recorded within the research group, as the evaluation of body postures was statistically significant, even with large effect size (W_{test} $p < 0.01$; $Z = –5.8413$; $r = 0.8696$).

The body components such as head and neck posture, shape of abdomen and pelvic inclination, height of shoulders and position of scapulas are the most common deviations (Véle, 2006; Bendíková, 2016) of muscular and skeletal systems. The head and neck postures as the body components were recorded with positive shifts and changes in all given points (1–4), as the point 1 was given at the pre-test to 11.10% of the research group, but after acting of physical program – to 48.90%. The head was slightly deflected and leaning forward, therefore the point 2 was given to 35.50% and then to 46.70% of the research group. The acting factor of adapted physical program influenced the head postures, which were inclined forward and backward, as at the pre-test was the incidence of 42.30% and at the post-test – 4.40% of the research group. The lowest percentage representation was registered within the point 4 (from 11.10% to 0%). All the shifts and changes are statistically significant, even with the large effect size (W_{test} $p < 0.01$; $Z = –5.4424$; $r = 0.7898$) (Table 2).

Within the shape of the chest as the second body component, the point 4 was not given to the research group, not even at the pre-test (0%). However, the highest percentage representation concerned the point 1, as the physical program caused positive shifts and changes from 33.40 to 64.40% of the research group. The chest slightly flattened was recorded in 48.90% (pre-test), but after 10 weeks – only in 31.20% of the research group. The low values were recorded within the point 3, as it decreased from 17.70 to 4.40%. What is more, the statistical significance was also recorded, again with the large effect size (W_{test} $p < 0.01$; $Z = –3.9199$; $r = 0.7107$) (Table 2).

The next body components of the research group were recorded with the highest statistical significance (W_{test} $p < 0.01$; $Z = –5.2316$; $r = 0.8315$) (Table 2), as the point 1 given within the shape of abdomen and pelvic inclination positively increased from 4.40 to 44.40% of the research group. The acting factor of physical program changed the shape of abdomen, which resulted in 51.20% (post-test; pre-test – 37.90%). The huge drop of percentage was recorded within the point 3, as the value of pre-test was 48.90% and after 10 weeks – only 4.40%. Even the point 4 was observed (8.80%), however at the post-testing it vanished (0%).

Within the overall curvature of spine, 0% was recorded thrice, namely in the points 4 (re-test and post-test) and 3 (post-test). The biggest improvement was accomplished in physiological curvature range within normal limits (point 1), as the ratio (pre-test vs post-test) was 4.40 to 66.70%. The point 2 and its description positively shifted and changed from 64.50 to 33.30%. The listed shifts and changes are statistically significant and still with the large effect size (W_{test} $p < 0.01$; $Z = -5.5786$; $r = 0.7954$) (Table 2).

The last body components (height of shoulders and scapulae position) are defined by 3 × of 0%, as it was the case in previous body components (see: overall curvature of spine). The biggest increase was recorded in height of shoulders and scapulae, which were equal and symmetrical. The ratio was 20.00 to 75.60%. 24.40% was in the point 2 at post-test and point 3 at pre-test. The shifts and changes resulted in statistical significance, which was confirmed by the large effect size (W_{test} $p < 0.01$; $Z = -5.2316$; $r = 0.8170$) (Table 2).

Table 2. The measured values of body components within the research group (n = 45) (%)

Body components/ Given points	Head and neck posture[a]		Shape of chest[b]		Shape of abdomen and pelvic inclination[c]		Overall curvature of spine[d]		Height of shoulders and scapulae position[e]	
	Pr.T.	Po.T.	Pr.T.	Po.T.	Pr.T.	Po.T.	Pr.T.	Po.T.	Pr.T.	Po.T.
1	11.1	48.9	33.4	64.4	4.4	44.4	4.4	66.7	20.0	75.6
2	35.5	46.7	48.9	31.2	37.9	51.2	64.5	33.3	55.6	24.4
3	42.3	4.4	17.7	4.4	48.9	4.4	31.1	0.0	24.4	0.0
4	11.1	0.0	0.0	0.0	8.8	0.0	0.0	0.0	0.0	0.0

Legend: Pr.T. – Pre-test; Po.T. – Post-test; [a] $p < 0.01$; $Z = -5.4424$; $r = 0.7898$; [b] $p < 0.01$; $Z = -3.9199$; $r = 0.7107$; [c] $p < 0.01$; $Z = -5.2316$; $r = 0.8315$; [d] $p < 0.01$; $Z = -5.5786$; $r = 0.7954$; [e] $p < 0.01$; $Z = -5.2316$; $r = 0.8170$.

The evaluation of dynamic spine function is based on spine bending. It consists of 5 tests, of which the most visible shifts and changes are in tests of Schober (norm of 4–6) and Stibor (norm of 7.5–10.0). If it is below the norm, it is defined as decreased flexibility, however if it is above the norm, it is defined as increased flexibility (Labudová, Vajcziková, 2009). At the pre-test, the decreased flexibility of the test of Schober was recorded in 93.30% of the research group (which equals 43 members), as the average values were 2.86 ±0.76. The most of decreased flexibility was due to wrong spine arch, which was not smooth, and it was caused by the paravertebral muscles. However, the acting factor of physical program caused that the average values increased to 4.86 ±0.73. The number of research group members who were in the norm increased to 97.80% (44 subjects), thus it can be seen as an effective physical program. The positive shifts and changes within test of Schober were proved by the statistics at 5.00% level of significance, even by the large effect size (W_{test} $p < 0.05$; $Z = -1.9131$; $r = 0.5303$) (Table 3) (Rosnow, Rosenthal, 2009).

Based on testing the mobility of thoracic spine (Test of Stibor), the pre-test uncovered the alarming numbers, as the norm (Vojtaššák, 2000) was reached by 4.40% (2 members) of the research group. The average values of the pre-test were 6.44 ±0.80, which was less than 1 point from the norm, however the most of research group was around the lower limit of being in the set norm. After applying of the 10-week physical program, there was not registered any increased flexibility, but all of the research group members were in the norm of 7.50–10.00. Therefore, the adapted physical program which was applied 2 ×/12 minutes, within the lessons of physical and sport education, was effective and successful. It is supported by the statistical significance at 1.00% level significance and even by the large effect size (W_{test} $p < 0.01$; $Z = -2.8251$; $r = 0.7406$) (Table 4). The statistical improvements within the tests of Schober (W_{test} $p < 0.05$; $Z = -1.913\,1$; $r = 0.5303$) and Stibor (W_{test} $p < 0.01$; $Z = -2.8251$; $r = 0.7406$) were reached because of larger extension of pelvis around the joints of hips.

Table 3. Measured values of Schober's test within the research group (n = 45)

Research group/Measured values	Schober's test (norm: 4.00–6.00)								
	1	2	3	4	5	6	7	8	9
Pre-test	3.00	2.00	3.00	2.00	3.00	1.00	2.00	2.00	3.00
Post-test	5.00	4.00	4.00	4.00	4.50	4.00	4.10	4.00	4.20
Research group	10	11	12	13	14	15	16	17	18
Pre-test	3,50	2.80	3.90	4.00	3.00	3.00	3.00	3.50	3.00
Post-test	5.00	4.20	5.00	5.50	4.30	4.60	5.50	5.00	5.00
Research group	19	20	21	22	23	24	25	26	27
Pre-test	4.00	2.00	3.00	2.50	3.40	2.90	3.80	3.80	3.50
Post-test	5.90	4.00	4.80	4.20	4.50	4.00	5.00	5.50	4.30
Research group	28	29	30	31	32	33	34	35	36
Pre-test	2.40	1.90	2.30	4.00	2.70	3.60	3.00	3.00	2.00
Post-test	4.00	3.90	4.60	6.00	5.10	4.50	6.00	6.00	5.00
Research group	37	38	39	40	41	42	43	44	45
Pre-test	3.50	3.00	3.80	2.50	3.00	3.00	3.50	2.00	2.90
Post-test	6.00	6.00	6.00	5.40	6.00	5.90	5.50	5.00	4.00
Wilcoxon test	$p < 0.05$; $Z = -1.9131$								
Effect size	$r = 0.5303$								

Table 4. Measured values of Stibor's test within the research group (n = 45)

Research group/Measured values	Stibor's test (norm: 7.50–10.00)								
	1	2	3	4	5	6	7	8	9
Pre-test	6.00	6.50	5.00	5.40	5.80	7.00	7.20	7.00	5.40
Post-test	8.30	8.50	7.90	8.00	8.10	9.00	10.00	10.00	7.90
Research group	10	11	12	13	14	15	16	17	18
Pre-test	6.90	7.00	7.00	5.00	4.90	5.90	6.30	6.20	5.50
Post-test	8.00	9.00	9.00	9.00	7.50	7.90	8.40	8.90	9.00
Research group	19	20	21	22	23	24	25	26	27
Pre-test	5.90	7.30	7.00	6.00	5.80	7.20	7.00	6.40	7.00
Post-test	8.70	10.00	10.00	9.00	8.00	9.50	8.90	8.10	10.00
Research group	28	29	30	31	32	33	34	35	36
Pre-test	7.00	7.50	6.90	7.50	7.00	7.30	5.00	5.00	7.00
Post-test	9.00	10.00	10.00	9.80	10.00	10.00	7.50	8.00	9.00
Research group	37	38	39	40	41	42	43	44	45
Pre-test	7.00	7.00	7.00	6.00	7.00	7.00	5.00	7.00	7.00
Post-test	9.00	10.00	10.00	9.00	9.50	10.00	7.50	10.00	7.50
Wilcoxon test	$p < 0.01$; $Z = -2.8251$								
Effect size	$r = 0.7406$								

The ratio of pre-test and post-test was 0% to 77.80% (35 members), which translates to: 4.07 ±1.15 to 5.94 ±0.15. The decreased spine mobility was showed by weakened thoracic spine and the problems with declination were due to weakened areas of lumbar spine. However, the physical program helped 35 × (77.80%) and it is proved by the statistics at 1.00% level significance, but with small effect size (W_{test} $p < 0.01$; $Z = -3.3057$; $r = 0.2812$) (Table 5).

Table 5. Measured values of Otto's test within the research group (n = 45)

Research group/Measured values	Otto's test (norm: 6.00)								
	1	2	3	4	5	6	7	8	9
Pre-test	3.00	2.00	3.00	4.00	2.00	3.00	2.00	4.00	5.00
Post-test	6.00	6.00	6.00	6.00	6.00	6.00	5.50	6.00	6.00
Research group	10	11	12	13	14	15	16	17	18
Pre-test	3.00	2.00	3.00	3.50	4.50	5.50	4.00	4.00	5.50
Post-test	5.90	6.00	5.80	6.00	6.00	6.00	6.00	6.00	6.00
Research group	19	20	21	22	23	24	25	26	27
Pre-test	5.80	4.30	5.30	4.00	5.00	5.20	3.00	2.00	4.00
Post-test	6.00	5.90	6.00	6.00	6.00	6.00	6.00	5.80	6.00
Research group	28	29	30	31	32	33	34	35	36
Pre-test	3.00	5.00	5.00	5.00	5.00	5.00	4.00	5.00	5.00
Post-test	5.90	6.00	6.00	6.00	6.00	6.00	5.50	6.00	5.70
Research group	37	38	39	40	41	42	43	44	45
Pre-test	7.00	4.00	4.00	4.50	4.50	5.00	2.90	4.00	4.00
Post-test	6.00	6.00	6.00	6.00	6.00	5.80	5.70	6.00	6.00
Wilcoxon test	$p < 0.01$; $Z = -3.3057$								
Effect size	$r = 0.2812$								

As the test of Thomayer evaluates deep bending forward while reaching the ground, the set norm was not reached by the research group at the pre-testing. What is more, in some cases there was a deficit of –21.00 points, which was associated with weakened and shortened thigh muscles (Véle, 2006). It reflects in not being able to reach the ground, therefore nobody from the research group was able to fulfil the set norm of 0.00. However, after applying the physical program the research results shifted to 12 members (26.70%) who were able to reach the ground with the fingers. The listed changes are statistically significant, even with the large effect size (W_{test} $p < 0.01$; $Z = -3.1894$; $r = 0.8879$) (Table 6). Not to mention the recorded average values of pre-testing and post-testing, which were in ration of –10.01 ±4.07 and –2.37 ±1.83. The statistical improvement (W_{test} $p < 0.01$; $Z = -3.1894$; $r = 0.8879$) was reached in terms of larger extension of pelvis around the joints of hips. What is more, the listed improvement was also reached because the research group (n = 45) was informed about the importance of larger extension of pelvis around the joints of hips.

Table 6. Measured values of Thomayer's test within the research group (n = 45)

Research group/Measured values	Thomayer's test (norm: 0.00)								
	1	2	3	4	5	6	7	8	9
Pre-test	–15.00	–12.00	–10.00	–13.00	–18.00	–16.00	–10.00	–12.00	–9.00
Post-test	–5.00	–4.00	–3.00	–4.00	–5.00	–6.00	–2.00	–3.00	–2.00
Research group	10	11	12	13	14	15	16	17	18
Pre-test	–8.00	–5.00	–2.00	–5.50	–8.90	–13.40	–12.10	–11.00	–15.00
Post-test	–2.00	0	0	0	–2.00	–4.00	–2.00	–3.50	–5.00
Research group	19	20	21	22	23	24	25	26	27
Pre-test	–21.00	–13.00	–12.60	–5.00	–4.60	–5.90	–8.90	–11.00	–12.00
Post-test	–6.00	–4.50	–2.90	0	0	0	–3.00	–5.00	–2.00
Research group	28	29	30	31	32	33	34	35	36
Pre-test	–10.00	–9.00	–8.90	–7.00	–5.00	–2.00	–10.00	–5.00	–5.00
Post-test	–2.00	–2.00	0	0	0	0	–2.00	0	0
Research group	37	38	39	40	41	42	43	44	45
Pre-test	–12.00	–11.00	–9.00	–7.00	–15.00	–14.00	–9.00	–9.00	–13.00
Post-test	–2.00	–3.00	–4.00	–1.00	–3.00	–4.00	–2.00	–2.00	–4.00
Wilcoxon test	$p < 0.01$; $Z = –3.1894$								
Effect size	$r = 0.8879$								

While evaluating the left and right later flexion as the tests of dynamic spine function, the pre-tests showed limited spine motions to both sides of the research group. Even the pre-tests showed that set norm was less reached in left (20.00%, n = 9) than in right (22.30%, n = 10) lateroflexion of the research group; the average values were higher in left (19.43 ±1.53) than in right (18.79 ±0.87) lateroflexion. The reached results proved decreased mobility of lumbar spine; however the post-testing results were matching the set norms (Vojtaššák, 2000), as the average values were 20. 93 ±1.67 (left lateroflexion – 100.00%) and 21.62 ±0.38 (right lateroflexion – 100.00%). The both lateroflexions proved statistical significance at 1.00% level significance, however the left lateroflexion was recorded with negative effect size ($p < 0.01$; $Z = –3.7271$; $r = –0.3217$), in contrast to right lateroflexion, in which small effect size was recorded ($p < 0.01$; $Z = –4.3915$; $r = 0.2235$) (Table 7, 8).

Table 7. Measured values of left lateroflexion within the research group (n = 45)

Research group/Measured values	Lateroflexion – left (norm: 20.00–22.00)								
	1	2	3	4	5	6	7	8	9
1	2	3	4	5	6	7	8	9	10
Pre-test	19.00	18.00	19.00	16.00	19.00	18.00	17.00	19.00	19.50
Post-test	22.00	21.00	22.00	21.50	22.00	20.00	21.00	22.00	22.00
Research group	10	11	12	13	14	15	16	17	18
Pre-test	18.80	17.00	18.00	18.00	19.00	19.50	19.00	20.00	17.90
Post-test	21.50	21.90	21.00	21.00	22.00	22.00	22.00	22.00	20.00
Research group	19	20	21	22	23	24	25	26	27
Pre-test	18.00	19.00	20.00	17.00	18.00	19.00	18.00	19.00	20.00
Post-test	22.00	21.00	21.00	22.00	21.00	22.00	22.00	22.00	22.00

1	2	3	4	5	6	7	8	9	10
Research group	28	29	30	31	32	33	34	35	36
Pre-test	18.60	19.30	20.00	20.00	20.00	20.00	22.00	22.00	21.00
Post-test	22.00	22.00	22.00	22.00	22.00	22.00	18.00	18.00	19.00
Research group	37	38	39	40	41	42	43	44	45
Pre-test	20.00	21.00	21.00	21.00	22.00	22.00	21.00	22.00	22.00
Post-test	17.00	18.00	19.00	20.00	20.00	20.00	19.00	18.00	18.00
Wilcoxon test	p < 0.01; Z = –3.7271								
Effect size	r = –0.3217								

Table 8 Measured values of right lateroflexion within the research group (n = 45)

Research group/Measured values	Lateroflexion – right (norm: 20.00–22.00)								
	1	2	3	4	5	6	7	8	9
Pre-test	18.00	18.00	19.00	17.00	19.00	18.00	17.40	19.00	19.00
Post-test	21.00	22.00	22.00	21.00	22.00	20.00	21.50	22.00	22,00
Research group	10	11	12	13	14	15	16	17	18
Pre-test	19.00	18.00	19.00	19.00	19.00	19.50	19.10	20.00	18.00
Post-test	21.50	22.00	21.00	21.00	22.00	22.00	22.00	22.00	20.00
Research group	19	20	21	22	23	24	25	26	27
Pre-test	18.40	19.50	20.00	18.00	18.00	19.00	18.00	19.00	20.00
Post-test	22.00	21.00	21.00	22.00	22.00	22.00	22.00	22.00	22.00
Research group	28	29	30	31	32	33	34	35	36
Pre-test	18.00	19.00	20.00	20.00	20.00	20.00	18.00	18.00	18.00
Post-test	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00
Research group	37	38	39	40	41	42	43	44	45
Pre-test	19.00	17.00	18.00	19.00	20.00	20.00	20.00	19.00	18.00
Post-test	21.00	21.00	21.00	21.00	21.00	22.00	22.00	21.00	22.00
Wilcoxon text	p < 0.01; Z = –4.3915								
Effect size	r = 0.2235								

Discussion

The incidence of bad and incorrect body postures have been discussed by many authors in various studies and researches (Majerík, 2006; Marko, Bendíková, 2019). For example, in research of Kratěnová (2005), the bad and incorrect body postures were recorded in 33.00% (7 years of age), 40.80% (11 years of age) and 40.60% (15 years of age) of research group. The most alarming was the research by J. Majerík (2006), who recorded the incidence of muscle imbalances in 100% of the research group, which consisted of school children (15–17 years of age). Even J. Kanasová (2006) recorded similar findings of muscle imbalance, which was shown by around 93.2% of the research group which consisted of school children (10–12 years of age). After two years, the same author realized research in which bad and incorrect body postures were recorded in 91.6% of girls and 100% of boys, while the physical program reduced the high incidence of listed body postures. What is more, the research group consisted of school children who were from 10 to 12 years of age. In terms of physical programs and changes of body postures, the impact of physical program was recorded by M. Malátová, J. Markesová and J. Kanásová (2014) who recorded positive shifts and changes of research groups (12–13 years of age) in relatively short period of time (6 weeks). In terms of length, E. Bendíková et al. (2019) realized research which lasted for 12 weeks and showed positive shifts and changes of body postures. The given points of body components decreased from 12.4 to 7.9, which was significant at 5.00% level of significance.

In terms of body components of the research group, the head and neck posture was weakened because of deep neck flexors, which was confirmed by the research of E. Bendíková (2016). The shape of chest, as the second body component, was associated within the female students with gradual growth of secondary sexual characteristics, but the point 4 was not given to the research group (n = 45), not even at the pre-test (0%). Therefore, the listed body components, such as the shape of abdomen and pelvic inclination (III.), in which the most weakened muscle groups are m. rectus abdominis and m. transversus abdominis, are not affected. It is associated with the combination of wrong postural stereotype and body weight, which causes the pelvis to tilt forward and subsequently leads to spinal deformations, resulting in incorrect fixation of vertebrae and formation of the enlarged lordosis (Bendíková, Pavlovič, 2013). Within the overall curvature of spine, the most common amongst school children is thoracic hypokyphosis, which is known as flat spine. The listed body postures are functional but may transform into structural deviations (Vlach, 1986). What is more, the results of listed body postures are reflected in decreased spinal resistance to overloading, thus the weakening of muscle groups may cause less spine stiffness and flexibility. While being the indicator of bad and incorrect body postures, the research group (n = 95) who had bad and incorrect body postures was not able to lean and bend forward and backward, resp. turn around (properly). The height of shoulders and scapulae positions is one of the most affected areas of body components, while the bad and incorrect body postures are defined by the weakening of scapular muscles, which was recorded in our research group (n = 45). The spinal erectors and scapulas lower fixators did not reach the adequate strength, which was necessary for maintaining the upright body postures, thus the fixation functions failed and overactive muscles, such as pectoral muscles, increased the resting muscle tone, which caused the shortening od listed muscles, even to formation of upper crossed syndromes (Bendíková, 2016).

In terms of dynamic spine function, the research by E. Bendíková and D. Stackeová (2015) was proven by statistics at 1.00% level of significance, thus the physical program proved successful, while the content of physical and sport education was adopted for the research groups, which consisted of school children (12–15 years of age). Very similar findings were recorded by J. Kanásová (2006), J. Majerík (2006) and M. Lee, S. Park and J. Kim (2013), who registered the increased mobilities in areas of lumbar spine, which was proved by the statistical significances ($p < 0.05$), while the region of lumbar spine was closely associated with the left and right lateroflexions ($p < 0.01$; $Z = –3.7271$; $r = –0.3217$; $p < 0.01$; $Z = –4.391\ 5$; $r = 0.2235$). Within the test of Schober, the pre-testing of lumbar spine mobility revealed abnormal developments, which was caused by the spine curvatures, which were not smooth, as paravertebral muscles were weakened. At post-testing, the results showed positive shifts and changes within the research group (n = 45), which was proven by statistics at 5.00% level of significance (Bendíková, Palaščáková, Tomková, Vágner, 2018). The spine mobility, mainly of thoracic regions, was evaluated in the test of Stibor, which was also proven by statistics, but at 1.00% level of significance, while it was also reached by the larger extension pelvis around the joints of hips. The research results of the test of Otto's inclination and declination were similar to those of M. Cools (2003) and E. Heyman and H. Dekel (2009), in which the set norm was not reached by the research groups (n = 45).

Conclusions

The physical activity is closely related to lifestyle, quality of life and health (Nowak, 1997). And so the innovations and diversifications of physical and sport educations, in forms of physical programs (Abbaszadegan, Achachlouei, Eghbalmoghanlou, 2012; Ahmad, Akthar, 2014; Sivachandiran, Kumar, 2016), are usable within the School Education Program (Bendíková, Pavlović, 2013; Bendíková, Stackeová, 2015; Bendíková, 2016), as well recreational sports (Mulligan, Cook, 2013; Mignogna, Welsch, Hoch, 2016).

The findings are considered as statistically significant ($p < 0.01$; $p < 0.05$), mainly between the pre-test and post-test evaluation of body structures. The positive shifts and changes were recorded in all of the body components ($p < 0.01$); therefore, the overall evaluation of research group ($n = 45$) was statistically significant, even with the large effect size (W_{test} $p < 0.01$; $Z = -5.8413$; $r = 0.8696$). The statistical significance was detected in all of the tests of dynamic spine function, however, only the left lateroflexion was recorded with negative effect size ($p < 0.01$; $Z = -3.7271$; $r = -0.3217$). These findings are very important for physical and clinical practice, because the positive shifts and changes were reached in relatively short period of time (10 weeks). If more adapted physical programs are used and applied at lessons of physical and sport educations:

a) it may improve the self-image of school children,
b) it may increase the popularity of physical and sport education,
c) it may increase the participation of school children in physical and sport education,
d) it may prevent incidence of various diseases, disorders, etc. of muscular and skeletal systems.

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STABILITY TRAINING AND EFFECTIVENESS OF PLAYING BASKETBALL

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Abstract The aim of this study is to review the available literature for factors affecting a basketball throw and the stabilization of the trunk. Searching for the most important elements which ought to be improved during training to increase the effectiveness of a throw and those which condition the correct stabilization of the trunk.
The obtained results, after analyzing the literature, show that it is not possible to determine a single factor affecting a throw and the stabilization of the trunk. There are many factors that influence each other and, therefore, must be trained as one. There are biomechanical relationships between the effectiveness of making a throw, the positioning of the limbs, the trunk and the trajectory of the ball. It is important to mention the role of a factor outside biomechanics, such as the player's psyche. Muscles have the greatest impact on stabilization. Muscle function would not be possible without proper control by the nervous system
The conclusion section shows a large number of interacting factors responsible for the quality and effectiveness of the throw as well as for the stabilization of the trunk. This allows better planning and conducting of basketball training aimed at improving technique and throw effectiveness.

Key words basketball, free throw, core stability, trunk control

Introduction

Basketball is a sport in which players must make many decisions. The estimated number of people playing basketball around the world is 450 million (Bonato, Benis, La Torre, 2018). This shows how greatly popular this sport is. The most important aspect of basketball is a) when, b) where, c) from and d) how to take a shot in order to score points. If a shot is taken with the minimal usage of energy it means that the player is the most stable and the shot has a greater probability of finding its way into the basket (Huston, Grau, 2003). The share of shots for two points is estimated at 41%, whereas the number of shots taken from a distance is variable, depending on the prowess of the team (Tang, Shung, 2005). The authors state that in better teams the percentage is higher than 45%, whereas in weaker teams it is around 35%. Free throws are one of the most important elements in basketball, as 20% of all points scored during a game is scored from the free-throw line. Many matches are won or lost over this element of the game (Kaya, Callaghan, Donmez, 2012; Oancea, Ionescu, 2015). Ordinarily, two throws are made (the exception being when points are scored when fouled, which results in the points being awarded and one free throw is carried out) and are always performed from the same place without the participation of the defence, jumps and pivots (Gomez, Avugos, Onoro, 2018; Hung, Johnson, Coppa, 2004).

W.T. Tang and M. Shung (2005) state that the most important factor in the effectiveness of an in-game throw is the shot angle of the ball. They also stated that the average speed of a 2-point throw is 5.27 m/s and 8.39 m/s for 3-point throws. Other authors emphasize the importance of linking together basic motor skills (jumping, running), psyche and training (Savas, Yuksel, Uzun, 2018). There are many elements influencing the effectiveness of carrying out free throws. The available literature accurately describes the technique of a throw, from the positioning of the lower limbs, trunk and upper limbs (Kaya et al., 2012; Ball, 1989; Stankovic, Simonovic, Herodek, 2006; Tang, Shung 2005; Oancea, Ionescu, 2015; Cetin, Murati 2014; Podmenik et al. 2017), through the mechanics and timing of the releasing of the ball (Verhoeven, Newell, 2016; Cetin, Murati, 2014), putting on the proper rotation (Huston, Grau, 2003), ending with the psychological aspect (Gomez et al., 2018; Verhoeven, Newell, 2016; Ocak, Savas, Isik, 2014; Su, Yang 2018). The correct biomechanics of the free throw has been widely written on. It defines the bending of the knees, keeping the elbow ideally below the ball, using all five fingers to support the ball, throwing using the elbow joint as a pendulum, putting rotation on the ball by finishing the throw with a flex of the radiocarpal joint and also tilting the trunk forward (Kaya et al., 2012; Hung et al., 2004; Podmenik et al. 2017). An important element that has been written about by authors is the recreation of the finishing of the throw and a stable posture (Gomez et al., 2018; Verhoeven, Newell, 2016; Oanecea, Ionescu, 2015; Cetin, Murati, 2014; Barbieri, Rodrigues, Polastri, 2017; Dong, Yang, Pu, 2014). Of course, there exists a relationship between the accuracy of free throws and the time and type of training (Huston, Grau, 2003; Savas et al., 2018; Ocak et al., 2014). A. Schmidt (2012) presents the free throw as a game of joints in a closed kinematic chain, in which good stability and mobility on all levels involved in the movement are needed. He states that in more advanced players, who are better at free throws, it can be observed that during the throw greater global stability and better peripheral mobility is shown. Furthermore, the position on the court determines better (positions 1, 2, 3) or worse (positions 4, 5) efficacy of performing a free throw (Sindik, 2015). These parameters allow for the assessment of free throws not only in terms of accuracy but also in terms of whether it has been performed correctly. Thanks to this, it is possible to determine which aspects an individual player needs to improve during training for their free throws to be more effective.

The first aim of this study is the exploration of available literature that indicates elements influencing a free throw in basketball. The second aim is the demonstration of factors conditioning good stabilization of the trunk as significantly influential on the quality and effectiveness of free throws.

Material and methods

The review of the literature concerned factors which influence the effectiveness of free throws in basketball and the elements that condition the stabilization of the trunk during the throws. The analysis was conducted in March of 2019 from the databases of PubMed, ScienceDirect, Ebsco and Springer. The criteria, with regard to what would be included or excluded, were defined to narrow down the number of articles reviewed. This criterion was introduced on the basis of the analysis of titles and introductions of said works regarding the technique of a free throw in basketball and factors affecting the stability of the trunk. Due to the lack of significant changes in the technique of free throws over the years, the analyzed articles were published in the year 2000. Articles regarding stabilization of the trunk were published within the last 5 years.

The articles were reviewed if they met the following inclusion criteria:

1. The subject of the work concerned the technique of carrying a free throw in basketball or factors influencing the stabilization of the trunk.
2. The study regarded sport/basketball/training of the core.
3. The study did not describe the effects of specialist training.
4. The study included results from the most recent studies regarding the technique of a free throw from the year 2000, and regarding the stabilization of the trunk – from the last 5 years.

The review rejected papers if they contained the following exclusion criteria:

1. The study did not regard sport/training of the core.
2. The study took note of the external factors influencing the free throw.
3. The study took note of the effects of specialist training.
4. The study included data stretching back further than the year 2000 regarding the technique of the free throw or further than 5 years regarding the stabilization of the trunk.

The keywords and the resulting key phrases used in this article are basketball, free throw, torso stability (central stability) and trunk stability. After entering all key word phrases from more than 25,000 papers regarding throws in basketball, 331 papers remained. However, from over 500,000 works regarding the stabilization of the trunk, about 400 works remained after entering the key phrases. After the addition of the correct criteria of inclusion and exclusion and abstract analysis, 28 works remained regarding the technique of the free throw, and regarding the factors affecting the stability of the trunk – 14 works. Works were excluded from the analysis if they did not concern issues related to sport or specialized sports/stabilization training. Works describing the impact of external elements influencing a throw such as the texture of the board, the material of the ball, color and material of the court floor were not taken into account. Furthermore, works were excluded if they included pilot studies or if they did not fall within the set time frame. The two most important aspects of this analysis were determining (a) the factors influencing a throw in basketball and the elements on which (b) conditioned the stabilization of the trunk in an athlete.

Results

Technique and biomechanics of carrying out a throw

D. Kaya (2012) and G. Hung (2004) very accurately state the technique for carrying out a free throw. In the starting position, the knee joints should be bent at 90° and the trunk should be inclined vertically in the direction of the bend at 50°. The authors also determine the flexion of the shoulder joint when releasing the ball to be 140–150°. They highlight the large role of cooperation between the torso, knees, ankle joints and upper limbs that they play during a throw – knees, ankle joints and torso straighten up, and at the same time the shoulder joint bends (Kaya et al., 2012; Hung et al., 2004). B.M. Oancea and R. Stankovic add the alignment of the shoulder, elbow and radial joint within the projection line and parallel to each other (Oancea, Ionescu, 2015; Stankovic et al., 2006). This is also confirmed by V. Okazaki, who adds the vertical positioning of the forearm during the throw and the positioning of the elbow joint perfectly under the ball (Okazaki, Rodacki, Satern, 2015). The authors highlight the beginning of the throw underneath the chin and ending it over the head, also finishing with flexion of the wrist and further phalanges which put spin on the ball – spin meaning reverse rotation which allows for the ball to bounce off the board in the direction of the basket. Ch. Tran determines that the ideal frequency for rotation is 3Hz. The same author states that the aforementioned average height from which the ball is released over the head of the thrower is about 15 cm (Tran, Silverberg, 2008). M.-A. Gomez describes the large role of the “non-throwing” hand which until the last moment helps to keep the ball on the throwing hand, stabilizing it during a throw (Gomez et al., 2018). V. Okazaki highlights the use of the weight of the ball to give it momentum by utilizing a hyperextension in the radial-carpal joint (Okazaki et al., 2015). C. Button and D. Mullineaux state, however, that the biggest factor in giving the ball speed is the extension of the elbow joint (Button, Macleod, Sanders, Coleman, 2003; Mullineaux, Uhl, 2010). Thanks to these movements, the proper flight angle of the ball is accomplished, which G. Hung sets at 56–59°, in order to obtain the ideal angle of the ball’s entry to the basket – 45° (Hung et al., 2004). However, analyzing other authors, such as F.J. Rojas, H. Nunome, L. Malone, V. Okazaki and A.L.F. Rodacki, the flight angle of the ball is set at between 44 and 63° (Rojas et al., 2000; Nunome et al., 2002; Malone et al., 2002; Okazaki et al., 2015; Rodacki et al., 2002). Finally, M. Verhoeven and V. Okazaki highlight the role of stabilizing the body during a throw. The former author demonstrates the differences when the ball is released from the hands in terms of shifting the centre of gravity between players shooting free throws with greater and lesser effects. The second author shows the impact that the lack of a stable torso has on the swing of the upper limbs outside the correct (in line with the basket) path (Verhoeven, Newell, 2016; Okazaki et al., 2015). In addition to this, Q. Huang provides information regarding the impact of the throw itself on the loss of stability based on the shift in the centre of gravity during a throw. This means that during elevating the ball for a throw, the player loses stability. The player must possess a very high level of stability for this loss to not affect their accuracy (Huang, Hodges, Thorstensson, 2001). Confirmation of this may be the work of L. Malone, in which he assesses the effectiveness of players playing basketball on wheelchairs, and highlights that the weaker shooters are those which, due to their disability, experience problems with stabilizing their trunk (Malone et al., 2002).

Table 1. Factors influencing the effectiveness of a throw according to the literature

Author	Factor	Value	Phase of the throw
1	2	3	4
D. Kaya et al., 2012 G. Hung et al., 2004	Angle of bent knees	90°	Finishing position
	Vertical tilt angle of the trunk	50°	
	Flexion of the shoulder joint	140–150°	Releasing the ball
B.M. Oancea, B.D. Ionescu, 2015 R. Stankovic et al., 2006	Linear alignments of the elbow, shoulder and radiocarpal joint	–	Starting position Elevating the ball
V. Okazaki et al., 2015	Vertical position of the forearm	–	Starting position Elevating the ball
Ch. Tran, L. Silverberg, 2008	Putting on spin	3Hz	Releasing the ball
	Finishing the throw above the head	15 cm	Releasing the ball
V. Okazaki et al., 2015 C. Button et al., 2003 D. Mullineaux, T. Uhl, 2010	Giving momentum to the ball: Hyperextension of the wrist joint Extension of the elbow joint	–	Releasing the ball
G. Hung et al., 2004 F.J. Rojas et al., 2000 H. Nunome et al., 2002 L. Malone et al., 2002 V. Okazaki et al., 2015 A.L.F. Rodacki et al., 2002 W.T. Tang, M. Shung, 2005 N. Podmenik et al. 2017	Release angle of the ball	44–63°	Releasing the ball

1	2	3	4
M. Verhoeven, K.M. Newell, 2016; V. Okazaki et al., 2015; Q. Huang et al., 2001; F. Barbieri et al., 2017; A. Schmidt, 2012; F. Dong et al., 2013; E. Cetin, S. Murati, 2014	Stabilisation of the trunk	–	Starting position Elevating the ball Releasing the ball
Y. Ocak et al., 2014; S. Savas et al., 2018; R. Huston, C. Grau, 2003	Training time and prowess	–	–
M.-A. Gomez et al., 2018; B.M. Oancea, B.D. Ionescu, 2015; Y. Ocak et al., 2014; J. Su, B. Yang, 2018	Psyche	–	–

Repeatability of the starting position and stable posture

As M.-A. Gomez describes, free throws are always carried out from the same place without the participation of the defence. This allows for the opportunity to train the repeatability of the throw and the proper stable posture accordingly, in order to ensure throws are as effective as possible (Gomez et al., 2018). The analysis of the available information reveals that one of the most important factors influencing the repeatability of free throws is the stability of the player. A. Ahmed and Y. Kim clearly state that responsible for the motor control of the trunk are the corresponding muscle groups in between chest and pelvis, commonly referred to as the “belly”. The authors divide these muscle groups into motor and stabilization muscles. Both of these groups generate the appropriate tension responsible for maintaining a stable trunk. The co-contraction of these muscle groups and the proper timing of their tensions is decisive in determining the stability of the torso in a standing position but also in any other position required in a related sporting discipline (Ahmed, Waquas, Ijaz, 2017; Kim, Kim, Yoon, 2015). A. Joyce, and S.G. Grenier before him, supplement this information with how the stomach tenses. Distinguishing two ways, they state that the most appropriate/correct method of tension is called “bracing”, which not only allows for the tension of the transverse abdominal muscle but all muscles contained between chest and pelvis (Joyce, Kotler, 2017; Grenier, McGill, 2007). J. Muller, however, reminds us that the strength of trunk muscles conditions the ability to absorb external loads on the body (Muller, Muller, Stoll, 2014; Prieske et al. 2016). R. Szafraniec, K. Anderson and E. Whyte suggest that correctly tensed and appropriately activated trunk muscles allow for greater motor control within limbs, which allows not only for the prevention of injury but also more effective movement during competition and training (Szafraniec, Barańska, Kuczyński, 2018; Anderson, Deluigi, Belli, 2016; Whyte, Richter, O’Connor, 2018). D. Barbado also describes the strength and quality of trunk muscle tension as a decisive factor for a stable trunk during sports (judo, kayaking). Comparing two groups of athletes, amateurs and professionals, he decisively states that a greater and better trunk tension is seen within the professional group. This manifests itself as a better reaction time of the torso muscles to loads, which in turn allows players for more effective and quicker usage of motor muscles during training and competition. The same author highlights that strength training of the trunk stabilization muscles should be specifically tailored to every sports discipline (Barbado, Barbado, Elvira, 2016). In turn, P. Paula Lima claims – by using the example of people training capoeira – that apart from the strength of torso muscles, a large part in stability is played by the balance between antagonistic groups of muscles. This sport requires many complex movements in which balance plays a major role, allowing the body to adapt to perform them (Paula Lima, Camelo, Ferreira, 2017). Similarly, G. Glofcheskie describes an athlete's ability to adapt to changing conditions during competition and to immediate situations by showing the differences in trunk stabilization in response to immediate situations in athletes and people who do not train. A decisive majority of athletes showed a good, quick reaction of torso stabilizers which allow to prevent injury (Glofcheskie, Brown, 2017). I. Jeon, and much earlier J. Peltonen, highlights a very clear role of the lumbar muscle (PSOAS) as one of the torso stabilisers (Jeon, Kwon, Weon, Choug, Hwang, 2015; Peltonen, Taimela, Erkintalo, 1998). At this point it ought to be noted that L. Cavaggioni states that one of the most important elements that allows for the correct stomach tension and hence a stable posture is the correct rhythm of breathing (Cavaggioni, Ongaro, Zannin, Iaia, Alberti, 2015. T. Vasconcelos also highlights breathing as a key element of muscle function, both those stabilizing the posture and those carrying out the movement (Vasconcelos, Hall, Viana, 2017). P. Hodges adds the role of the diaphragm, which is not only a respiratory muscle but also a stabilizing one, which allows for the maintenance of correct posture, i.e. during upper limb movement (throwing) (Hodges, Gandevia, 2000). These studies demonstrate how important breathing is with regards to the stabilization of the trunk and movement of the limbs. In 2008, D. Alpini added and M. Ditroilo confirmed in 2018 that apart from control gained through muscle strength stability, motor control is influenced by sight, sensory-motors and the proper functioning of the vestibular system (Alpini, Hahn, Riva, 2008; Ditroilo et al., 2018). Alpini highlights the changes in the centre of gravity in different audiovisual conditions, assessing the possibilities of an athlete adapting to them, by using the example of ice hockey and stating the adaptability strategies that allow for maintaining proper stability despite the occurrence of destabilising bumps.

Table 2. Literature regarding factors responsible for trunk stability

Author	Factor	Effect
Ahmed et al., 2017; Y. Kim et al., 2015	Co-contraction of motor and stabilisation groups in the trunk	Better motor control of the trunk
A. Joyce, D. Kotler, 2017	Correct tension of muscles between the chest and pelvis – stomach	Trunk stabilization
J. Muller et al., 2014; D. Barbado et al., 2016 O. Prieske et al., 2016	Strength of trunk muscles	Absorption of external forces
R. Szafraniec et al., 2018; K. Anderson et al., 2016; E. Whyte et al., 2018	Correct activation of trunk muscles	Better motor control of the limbs
P. Paula Lima et al., 2017; G. Glofcheskie, S. Brown, 2017	Balance between antagonistic groups of muscles within the trunk	Better reactions to immediate forces of changes of conditions
I. Jeon et al., 2015	PSOAS tension	Trunk Stabilizatio
L. Cavaggioni et al., 2015; T. Vasconcelos et al., 2017	Correct breathing and function of the diaphragm	Stable Trunk More effective function of stabilizing and movement muscles
M. Ditroilo et al., 2018	Sight, sensory-motor function, vestibular system	Effectiveness of stabilization muscles

Discussion

The first aim of this study was the determination of factors influencing a free throw in basketball. Based on the carried out review of the available literature, there is not one most significant factor impacting the quality of the throw. These factors also influence each other, which means that training of at least a few of them at the same time allows to concretely improve the technique and effectiveness of the throw. The factors discussed in this review are not only biomechanical factors, such as the release angle of the ball, correct flexion angles of the shoulder joint, knee and elbow, correct positioning of the limbs tasked with the throw or most importantly the stabilization of the trunk. The psyche, training regime and control of breathing is also very important.

It must be highlighted that not all of the authors held biomechanical factors as the dominant with regards to improving the effectiveness of a free throw in basketball. Some of the authors selected the players' psyche as the decisive element (Gomez, Kreivyte, Sampalo, 2017; Oancea, Ionescu, 2015; Ocak et al., 2014; Su, Yang, 2018). The amount of literature addressing this element shows how important it is within the game. It is very difficult to clearly state whether biomechanical or psychological elements are more important with regards to the accuracy of throws during a game (where match emotions are present). M.-A. Gomez accurately describes that players are vulnerable to greater psychological forces in the last 5 minutes of the match, which can cause the accuracy of throws to decrease, even in well trained and stable players (Gomez et al., 2017).

The greatest analysis found in the literature concerns the throw angle of the ball, however it must be noted that authors do not link this parameter with others, which does not allow for conclusive findings regarding what has the greatest influence on establishing this angle, which evolves with time (Rojas et al., 2000; Nunome et al., 2002; Malone et al., 2002; Okazaki et al., 2015; Rodacki et al., 2002). This allows to put forward a hypothesis that other factors condition the value of the throw angle and its variability is caused by constant changes regarding the ideal or, most likely, multiple ideal ways of carrying out a free throw. This makes interpretation much more difficult for researchers and forces them to constantly monitor advancements in techniques.

A subsequent and often written about element is the stabilization of the trunk during a throw. However, the authors do not describe its interaction with other parameters. Many articles show stabilization of the trunk as a decisive factor, not only in terms of accuracy of a basketball throw, but also in other sporting disciplines. The amount of publications on this topic shows the weight of this parameter within sport and direct training efforts to focus on this element (Gomez et al., 2018; Verhoeven, Newell, 2016; Oancea, Ionescu, 2015; Cetin, Murati, 2014; Barbieri et al., 2017; Dong et al., 2013; Schmidt, 2012). The sole stabilization of the trunk is vastly influenced by many factors stated in this review of literature. This means that when planning stability training for basketball players, the possibility of training the greatest number of interchangeable factors ought to be taken into account. The literature lacks accurate research which analyzes elements impacting stability during a throw, which opens up the possibility of researching this parameter more closely.

Hence, the second aim was to state what the literature deems as factors conditioning good and proper stability of the trunk, which in turn impacts the effectiveness of the throw.

These factors are predominantly: proper breathing, motor control conditioned by the correct tension and strength generated by the appropriate muscles. Another important element appears to be the nervous system, which is responsible for the normal functioning of trunk stabilization.

The majority of authors within the analyzed literature states that correct activation of trunk muscles is the most influential factor in trunk stabilization (Szafraniec et al., 2018; Anderson et al., 2016; Whyte et al., 2018). This shows that today this parameter appears to be a priority when shaping a stable trunk. At the same time, it is important to highlight the fact that authors very widely direct attention to other elements influencing a stable trunk, such as breathing, which in 2013 was written on by Leon Chaitow (2013) and later in 2017 by B. Anderson and K. Biliven.

Second is the lumbar muscle and its activation about which we are able to read about in J. Peltonen and coworkers' paper (1998) (Jeon et al., 2015). All articles state a primary parameter responsible for the stabilization of the trunk, but it must be highlighted that none of the authors claims that it is one single factor. This means that the conclusions drawn from the literature agree with the fact that in order for good stabilization to be attained it is not possible to take into account only one factor. This is important when planning stability training in sport.

While providing such a large number of factors conditioning maintaining a stable trunk, the information from literature also provide a vast array of possibilities in terms of working with an athlete, in order for this important parameter to improve. There exist many forms of training the motor control which improves stability in athletes. N. Kofotolis proposes Pilates as a form of such training. He shows the impact of exercise of this kind on the positioning of joints, concentration, breathing and control of the trunk. He describes the possibilities of minimizing the pain, functional instability and asymmetricity during a 12-month training program. He also highlights the important role of peripheral mobility joints, not only the stability of the trunk as elements that increase the effectiveness of training (Kofotolis et al., 2016). However, M. Comerford states that the time period in which training should bring about effects is 3–4 months (Comeford, Mottram, 2017).

Analyzing and summarizing the above review of literature, it must be stated that seeking to introduce training that improves the quality and effectiveness of free throws must first and foremost focus on the stability of the trunk, which is conditional on a very large number of factors but allows for the sculpting of others that influence a throw, creating a foundation for improvement. This is why when planning stability training one should take into account the remaining elements influencing a free throw. Due to this, training this way increases the chance to change the quality of a free throw and the effectiveness of a player in an element of the game by improving the nerve and muscle control.

Conclusions

1. Many biomechanical and psychological factors exist, which impact free throws in basketball. Analyzing the performance of a throw and planning training that improves its quality and accuracy ought to take into account the number of these factors. It should be remembered that these factors are variable. This does not allow to clearly determinate the biomechanics of a perfect free throw. It is obvious that every researcher wants to find it, determine the most important factor and check interaction with other variables during research. With this interaction it will be possible to determine which factor will affect the largest number of variables, and will be considered crucial for the correct throw.

2. One of the most important factors in a free throw is good trunk stabilization, which is influenced by motor control resulting from tension, timing and strength of muscles which are located between chest and pelvis. It should be noted that today's stabilization training takes various forms. That is the main reason why it should be planned based on the movements which are made during the throw, in relation to possible research. Exercises proposed by researchers during possible tests, and when planning basketball training, should ideally be matched to the elements affecting the player during the throw. It could be concluded, based on this review, that the priority would be activation of the abdomen and maintaining it during the movement from squat to extension, as it happens during the throw.

3. The most important is the functioning of the nervous system, which ensures good nerve muscle control, and what comes with that is good stabilization and control of movement during a throw.

The conclusions of this review show how important it is to determine the factor that has the greatest impact on other factors, and generally on the free throw. According to this review, the stabilization of the torso is the factor that is the most trainable and crucial during the throw. In the scientific sense, this gives researchers the opportunity to determine the real significance of this element during the throw. In a practical sense, this article gives basketball trainers knowledge about important elements when planning and conducting shooting training.

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PURINE METABOLISM IN THE LIGHT OF AEROBIC AND ANAEROBIC CAPACITY OF FEMALE BOXERS – THE PILOT STUDY

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Abstract The aim of the work was to assess the intensity of purine nucleotide degradation during maximum physical exercise. 5 elite female boxers were the subject of the study. Each of them underwent two exercise stress tests in order to evaluate the level of $\dot{V}O_{2peak}$ and the level of anaerobic capacity during a Wingate test. The study involved collecting capillary and venous blood samples at rest and after the exercise test to determine the Acid-Base Balance (ABB), concentration of lactic acid (LA) and purine metabolism nucleotides. The average value of $\dot{V}O_{2peak}$ was 40.92 (SD = 4.087) ml/kg/min, the average anaerobic capacity Ppeak was 7.57 (SD = 0.380) Watt/kg. The workload resulted in significant changes in the level of ABB and LA after both of the exercise stress tests ($p < 0.001$). Concentrations of hypoxanthine (Hx), xanthine (X) and uric acid (UA) in the blood increased significantly after the Wingate test ($p < 0.05$). The level of plasma purine nucleotides at rest and after standard exercise may be a useful tool for monitoring the adaptation of energetic processes in different training phases and support the overload diagnosis.

Key words purine nucleotides, uric acid, Acid-Base Balance (ABB), Wingate anaerobic test, maximal oxygen uptake, anaerobic threshold (AT)

Introduction

Although boxing as a combat sport had its origin in ancient Greece, it was only included in the program of the Olympic Games at the beginning of the 20th century. Until quite recently the sport had been restricted to men. The first boxing World Championship for women was organized in 2001, with inclusion in the Olympic Games in 2012. Despite the many favorable conditions promoting the development of women's boxing, the sport has not been present much in studies devoted to physiology or biochemistry of sports-related effort. The nature of the training process, as well as the high intensity of a boxing match itself (11 total minutes, as 3 rounds of 3 minutes each and one-minute rest between rounds), require boxers to display a high level of anaerobic capacity and a medium level of aerobic capacity. A training session would be arranged in such a way as to make it possible to develop the aerobic capacity during the preparatory period, as it affects the speed of the athlete in the precomputation period. Time analyses of combat sports show that muscle energetics involve aerobic-anaerobic metabolism depending largely on the intensity of the effort. A high post-effort level of lactic acid in the blood indicates maximal and supramaximal loads (Hübner-Woźniak, Kosmol, Glaz, Kusior, 2006; Guidetti, Musulin, Baldari, 2002). Only an athlete with a high level of capacity is able to attain and maintain such a high level of load without experiencing intensification of fatigue symptoms, resulting in the loss of motor coordination.

The disturbance of the energy homoeostasis of the cell and aggressive hydrolysis of ATP particles during exercise contributes to the production of adenosine monophosphate (AMP), which may in turn, depending on the type of tissue, be subject to different decomposition mechanisms. In skeletal muscles, AMP deamination to inosine monophosphate (IMP) and ammonia involves AMP deaminase enzyme (AMP-d, EC 3.5.4.6). The activity of this enzyme is inhibited by indirect products of the glycolysis process: e.g., 2,3-BPG, a decrease in ATP concentration and reciprocally by those produced as a result of the described IMP reaction. IMP, in turn, is transformed into inosine. Inosine is degraded by purine nucleoside phosphorylase (PNP, EC 2.4.2.1) to hypoxanthine (Hx), which can efflux the muscle and be lost from the adenine nucleotide pool. It is also the only metabolite that is able to be returned to the pool of purine nucleotides of the cell, with the involvement of hypoxanthine-guanine phosphoribosyltransferase (HGPRT, EC 2.4.2.8). A post-exercise re-synthesis of the purine ring is very energy-intensive for the organism, which is why the efficiency of the discussed reutilization system is of great importance for the body. The indicator of the intensity of the purine nucleotide degradation is the hypoxanthine/xanthine (Hx/X) concentration ratio. A high value indicates an effective nucleotide reutilisation mechanism and an increase in the overall pool of available purine bases within the cell. Enzymatic transformation of Hx into X, and eventually into uric acid (UA) with the involvement of the xanthine dehydrogenase enzyme (XDH, EC 1.1.1.204), causes a loss of purine nucleotides from the functioning cell (Hellsten-Westing, Sollevi, Sjödin, 1991; Fox, Palella, Kelley, 1987; Murray, 1971). The final metabolite of nucleotide metabolism, as can be seen in Figure 1, is uric acid (UA).

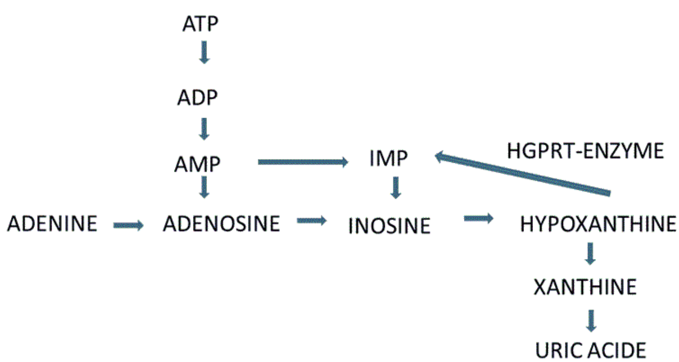

Figure 1. Pathway of purine nucleotide metabolism

Uric acid is a very important antioxidant that is excreted from the body with the urine, among others. The analysis of UA concentration in the blood in sports diagnostics has its limitations. Most likely, they may result from the fact that the lactic acid produced during exercise competes with uric acid over the secretion rate in the proximal tubule of the kidney, decreasing at the same time its excretion with urine (Fox et al., 1987). Therefore, an increase in muscle oxygen potential due to training, limits the rise in lactic acid in the blood during exercise under the same stress, and increases at the same time the excretion of uric acid in the urine. Hypoxanthine has been considered to be an indicator of histotoxic hypoxia over a long period of time. It is also regarded as a marker of adenine nucleotide degradation in the muscle, a marker of energetic stress during exercise, an index of exercise intensity, and may be used in the classification of physical exercise.

It has been indicated in research that hypoxanthine concentration in the blood during exercise depends largely on the exercise duration and intensity. In the study by F. Banaszak and Y. Hellsten-Westing on groups of rowers, swimmers, and long-distance and short-distance runners, they saw the occurrence of an abrupt increase in Hx concentration within the blood during sub-maximum exercises with an intensity above the threshold, maximum and supra-maximum levels (Hellsten-Westing et al.,1991; Banaszak, Rychlewski, 1989). On the other hand, data on the intensity of exercise-induced purine nucleotide degradation in combat sports, particularly in boxing, are very rare in literature.

The aim of the work was to assess the intensity of purine nucleotide degradation during maximum physical exercise as a metabolic response to the changing energetic homoeostasis of the cell.

Methods

Participants

The exercise stress study comprised a group of 5 female boxers – Polish Olympic Representatives of Women's Boxing – and was approved by the Polish Boxing Association. The athletes who qualified for the study form the elite in this sports discipline, having won numerous prizes and awards, including World and European Championship Titles. All examined women were during the follicular menstrual cycle phase. The exercises tests were conducted daily for two consecutive days.

The study was conducted in accordance with the Declaration of Helsinki and the National Statement and Human Research Ethics Guidelines and approved by the IRB (Institute for Research in Biomedicine) at the Poznań University of Medical Sciences (2010-03-04; Ethics Approval Number 232/10). An information sheet was provided to each boxer who was approached to participate in the study, and on agreement to participate, informed written consent was obtained.

Experimental design

Evaluation of aerobic capacity

In order to evaluate the levels of peak oxygen uptake ($\mathring{V}O_{2peak}$) and anaerobic threshold (AT), each of the athletes underwent an increasing-intensity physical effort to reach the level of individual maximum capacity or to arrive at the level of refusal. The test was performed using a Kettler cyclo-ergometer. The initial load was 50 Watts (70 RPM) increasing by 15 Watts every 3 minutes at a constant RPM until a maximum load was reached. The exercise stress test was carried out using a Jeager Oxycon Mobile Ergospirometer, and the following circulatory-respiratory parameters were monitored on a constant basis: heart rate (HR), oxygen uptake per minute ($\dot{V}O_2$), carbon dioxide production (VCO_2), minute ventilation (VE). The threshold load was determined using ventilation method on the basis of the analysis of effort-related changes in respiratory parameters (V-slope method).

Evaluation of anaerobic capacity

In order to evaluate the level of anaerobic capacity, a standard 30-second Wingate Maxima capacity test was carried out using a Monark 824 E cyclo-ergometer. The primary test was preceded by a 5 min warmup period at approx. 50 Watts, followed by a 5 min break. External loading was estimated individually at 7.5% of body weight. During the test the athletes were encouraged to maintain maximum effort for 30 secs. Recorded results were analysed using Monark Anaerobic Test Software (ver. 3.0.1, Sweden). The following values were marked during the test: mean power (Pmean), total work (Wtot), peak power (Ppeak), fatigue index (FI % decrease in the power output within 30 s), time to obtain peak power (Tpp), and time of maintaining peak power (Tmax).

Biochemical analysis

Venous and capillary blood samples were collected at rest and 10 minutes after the exercise was finished. Despite the fact that the maximum lactic acid (LA) concentration during the exercise occurred between the 3rd and 8th minute after the exercise was completed, the LA concentration in the 10th minute correlated to Hx increase during the exercise, which peaked 10−15 minutes after exercising.

Capillary blood was marked for Acid-Base Balance (ABB) measurement using a Roche Cobas b121. All values were measured immediately after collection. Lactic acid concentrations were assayed enzymatically spectrophotometrically, measuring the increase in the absorbance of NADH at a wavelength of 365 nm.

Blood plasma was used for the concentration of oxypurines (hypoxanthine, xanthine) and uric acid using high-performance liquid chromatography (HPLC) on a Hewlett-Packard 1050 equipped with a UV detector. A Hypersil ODS 100 × 4.6mm 5µm column and a Hypersil ODS 20 × 4 mm 5µm precolumn by Alltech was used for the marking process. The carrier phase included a buffer of the following composition: 1% methanol + 4% buffer – 100 mmol/L KH_2PO4 with a pH of 5.8. The flow velocity was 1.0 ml/min. The substances were identified by comparing the retention time of the sample under examination and reference compounds of a known composition. Leaching proceeded in the system in the following order: UA, Hx, X. Measurements were performed at a wavelength of 254 nm.

Statistical analysis

The obtained results were used as the average (M) and standard deviation (SD). All of the statistical analyses were performed while using Dell Statistica (data analysis software system), version 13, downloaded from www.software.dell.com The normality of the data distribution was verified by using the Shapiro–Wilk tests. The t-test was employed to evaluate the influence of the exercises on the assessed indices. The relationship between the variables was tested while using Pearson's correlation. A p-value < 0.05 was considered to be significant.

Results

The sample group comprised boxers from different weight categories, from flyweight (up to 54 kg) to heavyweight (up to 81 kg) aged from 23 to 29. A detailed anthropometric description of the boxers is presented in Table 1.

Table 1. Anthropometric characteristics of the boxers

Variable	n = 5	M ±SD	Min	Max
Age (y)		24.8 ±2.19	23	29
Body mass (kg)		68.8 ±9.04	52	78
Body high (cm)		170.6 ±6.94	159	177
BMI (kg/m^2)		23.5 ±1.39	20.5	24.9

Table 2 shows the evaluation of anaerobic capacity enabling performance of physical effort in a short period of time and of maximal or submaximal intensity, involving mostly the activity of fast-twitch muscle fibers. The phosphagen qualities in the sample group members were described using the following indicators (PP, MP, TOPP, TMPP), and the glycolytic qualities using (TW, FI) indicators.

Table 2. Evaluation of the anaerobic capacity of the boxers

Variable	n = 5	M ±SD	Min	Max
P_{mean} (Watt)		432.46 ±45.726	351.89	503.780
P_{peak} (Watt)		517.32 ±49.139	428.44	580.570
P_{peak} (Watt/kg)		7.57 ±0.380	7.01	8.230
T_{pp} (sek.)		6.83 ±1.719	4.44	9.580
T_{max} (sek.)		4.60 ±1.182	2.68	6.300
W_{tot} (J/kg)		192.28 ±8.879	180.99	203.019
FI (%)		14.82 ±2.155	12.47	18.910

P_{mean}: mean power; P_{peak}: peak power; T_{pp}: time to obtain peak power; T_{max}: time of maintaining peak power; W_{tot}: total work; FI: fatigue index.

Table 3 shows the parameters of aerobic capacity, i.e. peak oxygen uptake ($\dot{V}O_{2peak}$) and the percentage value of peak oxygen uptake at the AT (anaerobic threshold, %$\dot{V}O_{2peak}$). In addition, to show the body's reaction to the exercise stress test, the table contains the values of HR, VE and exercise load.

Table 3. Evaluation of aerobic capacity based on the analysis of $\dot{V}O_2$, VE, HR, and load with peak- and AT-level effort

Variable	n = 5	Peak exercise			Anaerobic threshold (AT)		
		M ±SD	Min	Max	M ±SD	Min	Max
$\dot{V}O_2$peak (ml/kg/min)		40.92 ±4.087	32.6	46.2	26.86 ±1.801	24.50	30.00
VE (l/min)		111.80 ±10.089	96.0	128.0	44.00 ±9.690	30.00	60.00
HR (beat/min)		187.00 ±6.300	176.0	197.0	146.40 ±9.040	131.00	159.00
Load (Watt)		257.00 ±20.120	230.0	275.0	158.00 ±27.928	125.00	200.00
% $\dot{V}O_2$peak (%)					66.30 ±6.57	54.11	75.15

$\dot{V}O_2$: oxygen uptake per minute; VE: minute ventilation; HR: heart rate.

Table 4 presents the biochemical reaction to the loads applied during both exercise stress tests. The change in the level of concentration of Acid-Base Balance and lactic acid in the blood proved to be statistically significant in both tests ($p < 0.01$). The second level of degradation of the AMP, measured by the post-effort concentration levels of Hx, X, and UA, showed statistically significant changes in biochemical parameters after the anaerobic capacity evaluation test ($p < 0.05$) and for the Hx ($p < 0.01$).

Table 4. Concentration levels of oxypurines, uric acid, lactic acid and Acid-Base Balance in both active and resting state in the blood of the female boxers undergoing aerobic and anaerobic capacity tests

Variable n = 5	WAnT		Incremental Stress Test	
	rest M ±SD	post-exercises M ±SD	rest M ±SD	post-exercises M ±SD
Hx (µmol/L) **/NS	7.22 ±2.799	13.32 ±1.87	7.18 ±1.734	15.70 ±6.354
X (µmol/L) */NS	0.89 ±0.452	1.44 ±0.673	1.69 ±0.469	2.16 ±0.721
Hx/X NS/NS	10.33 ±4.22	11.32 ±4.57	4.23 ±2.31	7.18 ±2.77
Hx+X (µmol/L) */*	8.12 ±3.04	14.77 ±2.36	8.87 ±1.48	17.89 ±6.71
UA (µmol/L) */NS	1 136.97 ±43.527	312.01 ±70.821	160.30 ±73.270	206.16 ±59.618
LA (mmol/L) **/**	1.5 ±0.561	11.91 ±1.32	1.49 ±0.175	10.88 ±1.299
BE (mmol/L) **/**	−0.58 ±1.539	−11.269 ±1.122	0.34 ±0.839	−12.24 ±1.560
HCO_3^- (mmol/L) **/**	23.82 ±1.218	15.58 ±0.794	24.24 ±0.722	14.92 ±1.116
pH **/**	7.41 ±0.016	7.25 ±0.022	7.42 ±0.010	7.26 ±0.022

LA: lactic acid; BE: acid-base balance; HCO_3^-: sodium bicarbonate; Hx: hypoxanthine; X: xanthine; UA: uric acid.
NS: not statistically significant, *$p < 0.05$, **$p < 0.01$.

Discussion

Women's boxing, as a relatively new sport discipline, is lacking an in-depth description of the physiological and biochemical responses in the body to training-related effort. A detailed analysis of the results of studies carried out among different population groups and among boxers of different ranks will make it possible to shape their physiological profiles in the future.

The authors of this paper obtained an oxygen capacity indicator ($\dot{V}O_{2peak}$) of 40.92 ±4.087 ml/kg/min with a HR of 187 ±6.3 beats/min, VE 111.80 ±10.089 l/min and AT 66.30 ±6.57 % $\dot{V}O_{2peak}$, which proves that the level of oxygen capacity is good. No correlation between the body mass nor weight category of the boxers and the $\dot{V}O_{2peak}$ value was observed in this research. The highest and the lowest value of peak oxygen uptake was observed for boxers in the super-middleweight category. It indicates that there are other factors determining the capacity of oxygen consumption by the body, apart from body mass. Chatterjee's study from 2006 showed that the average value of $\dot{V}O_{2max}$ for 45 women from the Indian boxing team fluctuated at approx. 48.6 ±6.8 ml/kg/min. (Hellsten-Westing Norman, Balsom, Sjodin, 1993; Imamura et al., 1999). This difference in the oxygen uptake is a result of the different testing procedure, where treadmill tests were used, and our tests were carried out using a cyclo-ergometer. From the physiological point of view, the activity carried out with the use of a cycle ergometer involves a much lower muscle mass, hence the lower level of oxygen uptake. A similar level of maximum oxygen uptake was described in a study by H. Imamura et al. (1999). The average level of $\dot{V}O_{2max}$ was 42.7 ±5.1 ml/kg/min. Furthermore, P. Chatterjee's studies from 2006 indicate that one 2-minute long round increased HR up to 197 ±7 beat/min. This points to a maximal, and sometimes even supramaximal, work intensity (Chatterjee, Banerjee, Majumdar, 2006). The energetics of muscle activity at such a level of intensity is based mostly on phosphagen and glycolytic-lactic metabolism. The 30-second Wingate test allowed us to assess a given boxer's predisposition to such intense effort. The maximum power level in the sample amounted to 517.32 ±49.139 Watts and 7.57 ±0.380 Watt/kg body mass, with the average power level of 432.46 ±45.726 Watts (6.41 ±0.296 Watt/kg). Maximum power was not correlated to the body mass. The highest and the lowest value of the studied indicator occurred among the women boxers in the super-middleweight category. Due to the limited number of studies and works on the capacity of female boxers, it was necessary to compare the obtained results with the findings of C. Doria et al. (2009). A comparative analysis involved juxtaposition of karate and boxing as the training patterns for both disciplines are similar. The average maximum power, describing the potential of ATP resynthesis, in the group of karate kata and kumite women was 6.5 ±0.3 Watt/kg on average and was comparable with the values attained by the women boxers. Moreover, metabolic reaction and effort-related concentration of lactic acid resulting from the applied exercise loads were quite similar (LA for karate was 12.4 ±2.2, for boxing, 11.91 ±1.32 mmol/L). Extensive studies by E. Hübner-Woźniak, A. Kosmol, A. Głaz, A. Kusior (2006), focusing on the body's reaction to exercise loads in combat sport athletes, enabled a substantive analysis of relationships existing between many biochemical and physiological indicators. These were carried out, however, in a group of men. The maximum exercise load applied in both tests triggered the development of tissue hypoxia, leading to an imbalance in the ATP/ADP relation and to a disturbance of the pace of ATP resynthesis. As a consequence, an increase in the amount of ATP decomposition metabolites in blood was noticed, such as: Hx, X, and UA. Moreover, statistically significant effort-related changes in biochemical parameters were observed during the Wingate test ($p < 0.05$). Moreover, statistically significant effort-related changes in biochemical parameters were observed during the Wingate test for LA, BE, HCO_3^-, pH, Hx ($p < 0.01$) and X, UA ($p < 0.05$). The analysis of correlation between the effort-related increase in the amount of Hx, and UA, and physical capacity indicators, show a high negative correlation between the maximum and average power and the effort-related increase of UA in the blood ($r = –0.9247$, $p < 0.05$), and time to obtain peak power and increase of Hx ($r = –0.8913$, $p < 0.05$). The post-exercise difference in the intensity of purine nucleotide degradation (Hx/X) is lower among the competitors subjected to the Wingate test, which may prove a higher loss of nucleotides from their entire pool available within the cell. On the other hand, a post-exercise higher total of nucleotides measured with the Hx+X sum occurred after the Incremental Stress Test, which may prove a faster and less energy-intensive re-synthesis of nucleotides with an involvement of the HGPRT enzyme. This confirms the theory that high training stimuli trigger an increased activity of the HGPRT enzyme and a return of Hx to the nucleotide pool. It is not leached from the muscles due to its transformation into UA. Similar findings were obtained by J. Zieliński and K. Kusy (2012) who carried out a study in a group of sprinters and triathletes – athletes of different physiological profiles – and demonstrated that athletes exposed to higher training loads display a higher increase in the concentration of Hx in the blood after exercise tests. At the same time, an analysis of purine nucleotide turnover and the measurement of HGPRT activity shows the development of more energy-efficient patterns of purine chain synthesis among sprinters, compared to athletes exposed to smaller training loads (Zieliński, Kusy, 2012). High training loads applied to running practice patterns triggered a development of beneficial adaptive changes and an increase of HGPRT enzyme activity. On the other hand, Y. Helleten-Westing, B. Norman, P.D. Balsom, B. Sjodin (1993) studies show that effort up to the level of refusal causes a loss of Hx and inosine, leading to a decrease in the cellular ATP pool by approx 9%. A total restoration of ATP to its rest level involves slow and energy-demanding *de novo* synthesis of purine rings (Tullson, Terjung, 1990). The created Hx may subsequently be included into the purine nucleotide pool or leached together with inosine and UA through the kidneys or intestines (Harkness, Simmonds, Coade, 1983; Sorensen, Levinson, 1975). The UA formed by means of decomposition is an antioxidant used as a substrate in the non-enzymatic reaction of oxidation to allantoin (Hellsten et al., 2001). The carried out tests demonstrated that a stronger effort-related degradation of purine nucleotides occurred among the athletes during the a 30-second maximal power test. This is also additionally supported by a higher effort-related increase in the UA concentration level in the blood. Comparing previous studies conducted by the authors involving a group of karate athletes who displayed a lower level of purine nucleotide degradation during a Wingate test (measured by the ratio of Hx/X) and a higher effort-related increase of the amount of Hx and X in blood, it may appear that the difference is most probably a result of a higher aerobic capacity of the karate athletes ($\mathring{V}O_{2max}$ 51.3 ml/kg/min) and their better anaerobic capacity (maximum power of 530.81 ±77.697 Watt) than the women boxers (Domaszewska, Laurentowska, Michalak, Kryściak, Rakowski, 2008).

Given the presented findings, an analysis of the activity of HGPRT would be reasonable, although it turned out to be impossible due to methodological constraints. In the light of studies conducted by T. Rychlewski and J. Zieliński focusing on the use of measurement of the Hx concentration level as a marker of cellular energy crisis, the introduction of biochemical diagnostics of such a type as a tool for marking post-exercise changes in skeletal muscles seems well-justified (Zieliński, Kusy, 2012; Rychlewski et al., 1997). A comparison of exercise-induced changes of ABB indicators and LA concentration provided evidence that the type of physical activity performed did not influence exercise-induced changes of these parameters; they were comparable in both of the studied tests. That is why LA concentration during exercise as an indicator of the intensity of ischaemic lesions occurring within the cell is not sensitive enough. Based on literature and our previous research, we claim that the measurement of Hx concentration within the blood after a completed exercise is a more sensitive marker of the described lesions. An analysis of the obtained results indicates a statistically significant increase in Hx after exercise with reference to the lack of a statistically significant change after the Incremental Stress Test. However, it should not downgrade the usefulness of traditional physiological and biochemical markers in sports diagnostics, but rather serve as an indicator that would allow for a more precise optimization of training loads and, in consequence, make it possible to prevent overtraining in combat sports, which is often conducive to injury. D.R. Howell et al. (2017) in their research, provided evidence that there are no serious body injuries during fights affecting physiological or cognitive functions of the body.

Conclusions

The level of aerobic and anaerobic capacity in the analyzed sample group of female boxers is similar to that found in world literature on the subject. The biochemical reaction to the applied test workloads was comparable to the reaction found among athletes practicing other combat sports.

The level of plasma purine nucleotides at rest and after standard exercise may be a useful tool for monitoring the adaptation of energy processes in different training phases and support the overload/overtraining diagnosis. These markers may expand traditional physiological and biochemical methods of diagnostic processes, e.g. lactic acid, HR_{max}, and HR_{AT}. In our opinion, the changes in plasma Hx and X concentration are sensitive metabolic indicators of the exercise's status. These parameters possibly provide indirect information about the potential energetic status of the muscle, especially in highly trained athletes in which no significant adaptation changes are detected when examined by means of commonly acknowledged biochemical parameters.

Acknowledgments

This statement is to certify that all authors have seen and approved the manuscript being submitted. We warrant that the article is the authors' original work. We warrant that the article has not received prior publication and is not under consideration for publication elsewhere. On behalf of all co-authors, the corresponding author shall bear full responsibility for the submission. All authors agree that author list is correct in its content and order and that no modification to the author list can be made without the formal approval of the Editor-in-Chief. The authors declare no conflicts of interest.

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