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THE OUTLINE OF THE HISTORY OF PHYSICAL CULTURE IN THE PROVINCE OF TERNOPIL IN THE YEARS 1920–1939

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Abstract The aim of the paper is to present the outline of the history of physical culture in the province of Ternopil in the years 1920–1939. The province of Ternopil was established on 23 December 1920, as one of the very first provinces on the South--Eastern Borderlands of the Second Polish Republic. In the interwar period, physical culture flourished in the province of Ternopil. In the twenties and thirties of the 20th century, new social and sports associations and sports clubs were being established. What is more, sports organisations gathering Polish, Ukrainian and Jewish citizens that had been active before the outbreak of WWI became active again. Football was the most popular sports discipline practised alongside boxing, gymnastics, cycling, athletics, archery, water sports, shooting, gliding, table tennis. A contest whose main prize was the State Sports Badge played an important role in propagating physical activity in society.

Key words province of Ternopil, the interwar period, physical culture, sport

Introduction

The aim of the paper is to present the outline of the history of physical culture in the province of Ternopil in the years 1920–1939. It should show various forms of participating in physical culture, such as physical education, sport, physical recreation and matters concerning military training.

The province of Ternopil was established on 23 December 1920, as one of the very first provinces on the South-Eastern Borderlands of the Second Polish Republic. Likewise, the date of its establishment constitutes the starting point of this work. The final point is the year 1939 – the outbreak of WWII. On 1 September 1939, Poland was invaded by Germany, and on 17 September 1939 the Soviet Union followed suit. In the aftermath of these events, the territory of the province of Ternopil was occupied by the Soviet Union.

The province of Ternopil covered the territory of 16,533 km^2 and counted 1,600,400 inhabitants (*Mały Rocznik Statystyczny, 1939)*. The eastern border of the province was the border with the Soviet Union; the southern border of the province was also the border with Romania; from the western side, the province of Ternopil was adjacent

to the provinces of Stanisławów and Lviv; in the north it neighboured the province of Wolhynia. The province of Ternopil included the following districts: Borshchiv, Brody, Berezhany, Buchach, Chortkiv, Kamianka, Kopychyntsi, Pidhaitsi, Peremyshliany, Radekhiv, Skálat, Ternopil, Terbovlia, Zalishchyky, Zbarazh and Zolochiv (*Mały Rocznik Statystyczny, 1939*).

Polish citizens constituted the majority in the province of Ternopil – 49.3% (789,100), while there were 45.5% (728,100) people of the Ukrainian origin, 4.93% (78,900) of Jews, and 0.17% (2,700) of Germans (https://pl.wikipedia.org/wiki/Wojew%C3%B3dztwo_tarnopolskie [Entry: Województwo tarnopolskie]). The cities were inhabited by 16.8% of people, whereas 83.2% lived in the rural region (Gradowski, 1989).

As far as the former research is concerned, the work by Stanisław Zaborniak entitled *Physical Culture of the Ukrainians on the territory of Poland (1868–1939)* (*Kultura fizyczna ludności ukraińskiej na ziemiach polskich (1868–1939))* (Zaborniak, 2007a) is of the biggest scientific importance. The author presented physical culture of the Ukrainian minority on the territory of the following provinces: Ternopil, Wolhynia and Lviv, located in the Second Polish Republic. The publication used various research methods such as: synthesis, written sources analysis, induction, deduction and comparative method. The following research questions were discussed:

1. Which sports clubs and youth and social organizations were active in the area of physical culture in the province of Ternopil in the years 1920–1939?
2. Which physical activity types were developed in the province of Ternopil in the interwar period?

The activity of clubs and societies in the area of physical culture

In the ranks of the Shooting Association (SA) – on the territory of the province of Ternopil – the 6th Lviv region was active (together with Ternopil sub-region). The SA Ternopil sub-region was established in 1930 (Zakrzewska, 2007). The territory of the SA Ternopil sub-region activity overlapped with the territory of the province. In 1936, the SA Ternopil sub-region counted about 31,000 members and 4,823 eaglets (as of 1937). In the years 1935–1939, 8 members of the sub-region took part in SA courses. The commanding officer of the SA Ternopil Sub-Region was colonel J. Lachowicz (Zakrzewska, 2007). Members of the Polish Teachers Association were engaged in the sub-region's activity. In the school year 1937/1938, there were 564 of them. The SA Ternopil Sub-Region possessed some infrastructure, among all, as of October 1938, it had 20 shooting houses, 11 other ones under construction, and 600 youth clubs. Only in the districts of Kopychyntsi, Ternopil (land one) and Zboriv shooters did not have any shooting houses that would be fully developed or under construction. In the training year 1932/1933, two shooting and archery courses were attended by 38 members of the sub-region (Zakrzewska, 2007).

"Sokół" Gymnastics Society (GS) on the territory of the province of Ternopil ran its activity within the structures of Lesser Poland Area of the following regions (as of 31 December 1925): Brody (6 nests and 454 members), Berezhany (4 nests and 661 members), Chortkiv (9 nests and 387 members) and Ternopil (9 nests and 703 members) (The report of the Management of "Sokół" Gymnastics Societies Association in Poland). In particular regions (as of 31 December 1925) the following nests were active: in Brody region – Olesko (15 members), Brody (230 members and 56 teenage members), Busk (88 members and 27 teenage members), Lopatyn (35 members), Dubno (45 members), Zaliztsi (41 members); in Berezhany region – Berezhany (216 members and 76 teenage members), Rohatyn (133 members and 152 teenage members), Pidhaitsi (107 members and 59 teenage members), Peremyshliany (205 members); in Chortkiv region – Khorostkiv (60 members), Husiatyn, Buchach, Chortkiv (207 members), Kopychyntsi, Melnytsia (50 members and 9 teenage members), Zalishchyky (70 members and

126 teenage members); in Ternopil region – Pidvolochysk (130 members and 36 teenage members), Mykulyntsi, Skálat, Zbarazh, Zolochiv, Ternopil (352 members and 38 teenage members), Terebovlia (96 members), Zbarazh (125 members and 40 teenage members), Krugiv.

In another written source (Kłoś, 1926) we find information on the number of "Sokół" nests in the province of Ternopil, as of 1 January 1925. In Brody region, these were the following places: Olecko (founded in 1903; 25 members – 21 men and 4 women); Brody founded in 1891; 210 members – 143 men and 67 women); Busk (founded in 1904; 86 members – 63 men and 23 women); Lopatyn (founded in 1904; 37 members – 26 men and 9 women); Dubno (founded in 1922; 44 members – 31 men and 14 women). As for the region of Berezhany in Lesser Poland Area, the numbers were as follows: Berezhany (founded in 1892; 227 members – 192 men and 35 women), Rohatyn (founded in 1881; 144 members – 106 men and 38 women); Pidhaitsi (founded in 1898; 112 members – 83 men and 29 women); Peremyshliany (founded in 1904; 215 members – 163 men and 52 women). The region of Chortkiv hosted the following "Sokół" nests: Khorostkiv (founded in 1908; 46 members – 41 men and 5 women); Husiatyn (founded in 1906; 64 members – 42 men and 22 women); Chortkiv (founded in 1891; 217 members – 173 men and 44 women); Kopychyntsi (no information on the date of nest foundation and number of members); Melnytsia (founded in 1906, no information on the number of members); Zalishchyky (founded in 1892; 93 members – 84 men and 9 women). The region of Ternopil had the following "Sokół" nests: Pidvolochysk (founded in 1903; 172 members – 120 men and 52 women); Mykulyntsi (founded in 1900; 59 members – 48 men and 11 women); Skálat (no information on the date of nest foundation and number of members); Strusiv (no information on the date of nest foundation and number of members); Ternopil (founded in 1885; no information on the number of members); Terebovlia (founded in 1892; no information on the number of members); Zbarazh (founded in 1893; 150 members – 120 men and 30 women). What is more, Lesser Poland Area (on the territory of the province of Ternopil), as of 1 January 1925, comprised the region of Zolochiv with the following nests: Zolochiv (founded in 1892; 189 members – 163 men and 26 women); Krugiv (founded in 1924; 24 members – men only); Zboriv (founded in 1903; 54 members – 30 men and 24 women); Zaliztsi – founded in 1892, 72 members – 52 men and 20 women (Kłoś 1926). 183 "Sokół" members from the region of Brody, Berezhany and Zolochiv participated in a military training activity (including 39 persons who took part in summer military training camps) (Kłoś 1926).

The Ukrainian Gymnastics Society (UGS) "Sokił" was very active in the area of physical culture, tourism and cultural-educational activities in the province of Ternopil. As of 1928, the province of Ternopil hosted 158 nests belonging to the UGS "Sokił" and the biggest number of them was located in the districts of Chortkiv (22), Peremyshliany (19) and Pidhaitsi (22) (Zaborniak 2007a). "Sokił" was active in 14 districts of the province of Ternopil; it gathered 11,567 members, including 8,319 men, 2,648 women and 630 teenage members.

A year later (1929), there were 228 UGS "Sokił" nests in the province of Ternopil (Trofimiak, 2001). The province of Ternopil prided in the biggest number of "Sokił" nests, whereas the province of Lviv had 189 nests and the province of Stanisławów – 91.

On the territory of the province of Ternopil, the following rural youth organizations were promoting physical activity: Central Association of Young Villagers (1935–1939), Lesser Poland Youth Association at Lesser Poland Agricultural Society (1919–1931), "Wici" Rural Youth Association of the Republic of Poland (1928–1939) (Małolepszy, 2004).

In the province of Ternopil, Ukrainian sports associations and clubs propagated physical activity, too. Among them there were "Podilla" ("Podolia") Ukrainian Sports Association (USA) in Ternopil (1908–1939); "Meta" Ukrainian

Sports-Workers Association (USWA) in Ternopil (1928–1937); "Radostawka" Ukrainian Sports Club (USC) in the village of Kriva near Radekhiv (1928–1939); "Skała" Ukrainian Sports Club in Dobromirka, district of Zbarazh (1934–1939); "Rusałka" Ukrainian Sports Association in Zolochiv (1937–1939) (Zaborniak, 2007a). Among the aforesaid organizations, "Podilla" USA in Ternopil displayed a wide range of activities and ran the following sports sections: boxing, women's sports games, ice hockey, swimming, football, volleyball, chess, table tennis. "Podilla" USA members were also active in the area of tourism and culture and education (choir, theatre, library). There were also other organizations active on the territory of the province of Ternopil, e.g. "Płast" Ukrainian Scout Organisation, "Łuh" Gymnastics and Firefighting Society, "Kameniari" Ukrainian Society (Trofimiak, 2001).

As far as Lviv Regional Football Association (RFA) is concerned – in the years 1921–1939 – football sections from the following sports clubs and associations participated in the league: "Kresy" Military-Civil Sports Club (MCSC) from Ternopil, "Janina" Zolochiv (it was founded under the name "Złoczovia" – Zolochiv), "Gwiazda" Brody, "Jehuda" Ternopil, "Kresowiacy" Polish Sports Club (PSC) from Zbarazh, "Legion" Ternopil, "Lubicz" Brody, "Sokół" Gymnastics Society (GS) from Chortkiv, "Sparta" Trembovla, "Podilla" USA Ternopil, Military Sports Club (MSC) from Ternopil, Jewish Workers Sports Club (JWSC) Ternopil, Jewish Workers Sports Club (JSC) Zolochiv (Goksiński 2012). Apart from the aforesaid organizations, Lviv RFA included as well: "Strzelec" SC from Chortkiv, "Trembowelski" SC from Trembovla, "Strzelec" Polish Shooting Team (PST) from Zolochiv, "Gordon" JSC from Ternopil, "Trumeldor" JSC from Kopychyntsi (Hałys, 2020).

The best football teams were: "Kresy" MCSC from Ternopil, "Janina" Zolochiv, "Jehuda" Ternopil, JSC Zolochiv and "Podilla" USA from Ternopil. Beginning with the sports season of 1927, the footballers of "Janina" Zolochiv played in Class A matches of Lviv RFA (Goksiński, 2012). In the season 1927, they took a very good third place in Class A matches, and were defeated only by two Lviv clubs – Military Sports Club (MSC) and Lechia. In the sports season of 1930, in Class A matches of Lviv RFA, they took the last ninth place, winning 2 matches, drawing 1 and losing 13 of them (Mandziuk, 2016). They were moved to Class B matches of Lviv RFA. Class A matches of the sub-region of Ternopil (belonging to Lviv RFA) were organized for the first time in 1935. The matches were played by the teams of "Janina" Zolochiv, "Jehuda" Ternopil, "Podilla" USA and "Kresy" MCSC from Ternopil. The footballers of "Jehuda" Ternopil became the champions of Ternopil sub-region. In the following seasons, the best teams of Ternopil sub-region were: "Kresy" MCSC from Ternopil (season 1936/1937), "Jehuda" Ternopil (season 1937/1938), "Janina" Zolochiv (season 1938/1939) (Mandziuk, 2016). The team of "Kresy" Ternopil played in the league matches from the season of 1921, taking part in Class C matches. From 1934, the club was under the auspices of military circles and adopted the name of "Kresy" MCSC from Ternopil (Goksiński, 2013). Among other Ukrainian sports clubs with a football section, "Podilla" USA from Ternopil was the strongest one. It is worth mentioning that only two provinces of the Second Polish Republic lacked RFA structures. Among them were the provinces of Novogrudok and Ternopil.

Sport was practised in military units which were stationed in the province of Ternopil. Major Tadeusz Komorowski was an officer of the 9th Uhlan Regiment of Lesser Poland. The regiment was stationed in Chortkiv and Trembovla (Porada, 2021). In 1924, it qualified for the Polish national team in horse riding for the Olympic Games in Paris. Major Tadeusz Komorowski on his horse "Amon" took part in the Eventing Competition and was individually given the 26th place, whereas as a team they were 7th (Porada, 2021).

The province of Ternopil, together with the provinces of Lviv and Stanisławów, belonged to the structures of Lviv Regional Association of Athletics (Lviv RAA). "Sokół" GS from Zolochiv belonged to Lviv RAA (Król, 2015). On the territory of the province of Ternopil athletics events were held in e.g., Ternopil, Zbarazh and Zolochiv.

Lviv Regional Table Tennis Association had its sub-regions in Jarosław, Przemyśl, Rzeszów, Stanisławów and Ternopil (Pięta, 2008).

Towards the end of October 1935, there was a race for the championship of Ternopil. There were three contests within that competition. A 5-kilometre race was won by Branicki, who arrived at the finishing line before Solski; a 2.5-kilometre cycling race for junior competitors was won by Broszkiewicz who defeated Lautsch; whereas Solski and Nalepa won a 3-kilometre double race, overtaking Koszot and Branicki (Kieruzel, 2016). It is worth mentioning that "Rusałka" Ukrainian Sports Association in Zolochiv had a cycling section (Zaborniak, 2007b).

A strong boxing section could be found within the structures of "Podilla" USA from Ternopil. In the sports season of 1936/1937, the boxers of "Podilla" took part in Class B league matches of Lviv Regional Boxing Association (Lviv RBA). They were classified on the 2nd place and won their participation in play-offs for the team's promotion to Class A of Lviv RBA (Zaborniak, 2007a). In play-offs they were defeated by boxers from "Polonia" Przemyśl and "Czarni" Lviv Sports Club.

The region of Ternopil witnessed the development of gliding and water sports. There was Podolia Flying Club and Ternopil Rowers Society (Grabowski, Malinowski, 2013).

On the territory of the province of Ternopil, there were resort and sports centres. A resort of Post Military Training (PMT) was run in Zalishchyky (Kowieska, 1997). Moreover, holidays for teachers were organized in Zalishchyky, too.

Contribution of province of Ternopil inhabitants in gaining the State Sports Badge

In June 1930, Poland introduced the so-called qualifiers to obtain the State Sports Badge – SSB (Małolepszy, Drozdek-Małolepsza, 2020). It was a very important task in the interwar period, also in the province of Ternopil, to propagate and disseminate the idea of making effort to obtain the SSB. It is worth mentioning that a person rewarded with the SSB had to demonstrate fitness and skills not in one sports discipline or physical activity, but in a few ones – in six different groups (disciplines): I – gymnastics or swimming, II – jumps, III – running, IV – throws, fencing or sports games, V – marching, trips, ski runs, cycling, horse riding and rowing or sports games, VI – shooting (Małolepszy, Drozdek-Małolepsza, 2020). Meeting the minimum requirements in all the groups qualified an individual to obtain the SSB. A document authorizing this individual to carry the SSB was a certificate issued by the District Committee of Physical Education and Military Training (DCPEMT), on the basis of a decision of the Province Committee of Physical Education and Military Training (PCPEMT).

Table 1. A List of the numbers of SSBs obtained in Poland (in particular provinces) in the years 1931–1932

Province	Education		Army		Other organisations and associations		Total	
	1931	1932	1931	1932	1931	1932	1931	1932
1	2	3	4	5	6	7	8	9
Białystok	888	1,339	1,352	8,395	281	2,697	2,521	12,431
Kielce	426	2,765	–	2,278	147	1,885	573	6,928
Cracow	251	2,659	–	4,246	30	787	281	7,692
Lublin	355	1,712	316	5,268	193	4,025	864	11,005
Lviv	1,210	2,971	730	8,847	714	3,378	2,654	15,196
Łódź	282	2,528	195	2,324	50	3,200	527	8,052
Novogrudok	243	751	858	8,153	33	1,023	1,134	9,927

1	2	3	4	5	6	7	8	9
Polesie	297	768	564	4,076	80	1,443	941	6,287
Pomerania	554	2,653	203	6,657	385	4,335	1,142	13,645
Poznań	1,599	6,248	435	9,732	155	7,811	2,189	23,791
Stanisławów	49	1,270	–	1,420	4	980	53	3,670
Silesia	350	1,360	367	4,004	383	2,496	1,100	7,860
Ternopil	240	841	61	3,728	51	821	352	5,390
Vilnius	145	1,966	657	4,072	121	1,247	923	7,285
Volhynia	190	619	440	4,201	76	1,881	706	6,701
Warsaw (province)	472	2,620	158	7,874	156	3,955	786	14,449
Warsaw (city)	448	2,576	298	6,942	68	1,811	814	11,329
Total	7,999	35,646	6,634	92,217	2,927	43,775	17,560	171,638
Women							1,112	10,468
Men							16,448	161,170

Source: Małolepszy, Drozdek-Małolepsza (2020).

The number of SSBs obtained by the inhabitants of the province of Ternopil was still growing (e.g., Table 1). Next year (1933), the inhabitants of the province of Ternopil obtained 8,046 SSBs; where 814 of them were obtained by students, 4,443 by soldiers and 2,789 by members of organizations and societies (State Archives in Piotrków Trybunalski – APPT, Starostwo Powiatowe Piotrkowskie – SPP, sygn. 1258, no pagination). Taking into account the number of obtained SSBs, the district of Kopychyntsi was the leader, whereas the district of Zbarazh occupied the last place. In the following years, the number of SSBs obtained in the province of Ternopil grew; in 1934 it counted 11,121 SSB, and in 1935 – 11,126 SSB (APPT, SPP, sygn. 1872, no pagination). It should be emphasised that as for the number of obtained SSBs (as of 1935), the province of Ternopil was only outstripped by the province of Polesie (8,337) and Stanisławów (6,086). In the province of Ternopil, in the years 1934–1935, a number of organization and society members who obtained the SSB grew (5,330 and 3,839 accordingly). The biggest number of SSBs was obtained in the province of Silesia (40,970 – in 1935).

Conclusion

The interwar period witnessed the development of physical culture in the province of Ternopil. In the twenties and thirties of the 20th century, new social and sport societies and sports clubs were being established, and sports organizations that had been active before WW1 experienced their renaissance. Among all, "Sokół" Gymnastics Society, the Shooting Association, rural youth organizations, sports clubs and societies developed their activity. "Janina" Zolochiv and "Kresy" MCSC from Ternopil were the best sports clubs. Sports societies and clubs among Ukrainian citizens were also quite active. Among them one should mention "Sokił" Ukrainian Gymnastics Society and "Podilla" USA. The territory of the province of Ternopil was also home to sports societies and clubs run by Jewish citizens.

Football was the most popular sports discipline. Boxing, gymnastics, cycling, athletics, archery, waters sports, shooting, gliding and table tennis followed. SSB contests also played an important role in promoting physical activity. SSB competitions were organized in educational and military institutions, youth, social and sports societies and organizations.

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POSITION-SPECIFIC PHYSICAL PERFORMANCE OF PROFESSIONAL PLAYERS DURING FULL-SEASON MATCHES IN A GREEK SUPERLEAGUE ELITE TEAM

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

Abstract The aim of the present study was to examine how various playing positions and opponent team ranking affect the covered distances and the acceleration and decelerations profile of a team during 2018–2019 Greek *SuperLeague*. StatSport GPS system recorded in match-play real-time both the players' covered distances (m) and the number of acceleration/deceleration runs (n) in zones from 3 m/s^2 to 10 m/s^2. The descriptive statistics showed that the players' mean covered distances were 10,289 m per match. The *MANOVA* revealed significant differences of the players' covered distances in all intensity zones in relation to their playing positions ($F_{(12,\ 513.567)}$ = 41.862; p = 0.000) and the opponent team ranking *(*$F_{(3,189)}$ = 3.687; p = 0.013). Furthermore, no significant interactions were observed between the playing positions and the opponent team ranking ($F_{(12,\ 500.339)}$ = 1.149; p = 0.318). Moreover, no significant differences were recorded regarding the opponent team ranking with the amount of accelerations ($F_{(1,189)}$ = 0.501; p = 0.480) and decelerations ($F_{(1,189)}$ = 1.342; p = 0.248). Summarizing, the current study showed the high-demanding competitive performance of midfielders, full backs and forwards regardless the standing of the opponent teams. Hence, the team's training must include special stimuli of aerobic and high-intensity workouts according to the players' playing positions in the match.

Key words: soccer, speed, match status, championship

Introduction

The physical activity profile in soccer is intermittent, with the players regularly alternating between brief bouts of high-intensity exercise and longer periods of low-intensity exercise (Rampinini et al., 2007). In addition, the contemporary soccer match-play is characterized by high-intensity speeds in the covered distances by the players of the elite teams (Carling, Bradley, McCall, Dupont, 2016). Moreover, the total covered distances and the match-play intensity zones are representative of the overall severity of exercise and the players' contributions towards the total team effort during the competitive period matches. For the above reasons and aiming to improve competitive performance of soccer players, it would be helpful to identify the most important elements that could increase the success rate. Furthermore, for the entire evaluation of the playing loads, the number of accelerations and decelerations performed by the players, in both official matches and trainings, must be taken into account because they evoke great exertion to the soccer players due to the eccentric type of muscular contraction (Little, Williams, 2007; Tibaudi, 2011).

Nowadays, limited data exists regarding the players' internal and external loadings in relation to their playing positions during the training as well as in the official in-season match in elite soccer teams. In addition, each separate playing position has different technical and physical conditioning demands from the professional players (Dellal, Wong, Moalla, Chamari, 2010). One of the most prominent finding from the time-motion analysis studies was the great differences in the energetic and physical performance characteristics among the various playing positions of the elite players (Di Salvo et al., 2007; Bradley, Noakes, 2013). When comparing the five most-common players' positions, it is clear that central and wingers cover more distance than any other position, with the wingers and full backs also displaying superior high-intensity activity profiles while attackers and central defenders consistently show the lowest intensity-specific physical performance during a match (Ispirlidis, 2021).

Currently, several studies have attempted to detect the elements of internal and external loadings regarding the professional players' performance in both official matches and trainings (Casamichana, Castellano, Castagna, 2012; Payet et al., 2016; Goto, 2018), in order to highlight the necessary parameters for a more qualitative team and individual analysis. Especially in soccer, advanced technology offers the opportunity for a more qualitative match-analysis, through internal (*e.g* heart rate) and external exertion records [through the recordings of covered distances with different playing intensities, acceleration or deceleration, change of direction, energy cost, etc.]. The Global-Positioning-System (GPS) technology has been increasingly applied in both semi-professional and professional soccer (Gabbett, 2016). Worldwide, the top-soccer clubs use the GPS technology for the real-time performance monitoring, although each of them have their own approach in matches and simulate their overall training workouts in order for the elite players to receive the match-specific stimuli and simultaneously to practice their physical conditioning with a variety of tactical skills with the ball (Djaoui, Chamari, Owen, Dellal, 2017).

However, there are few studies regarding the elite professional players' physical performance in relation to their playing position in official match and the contextual parameters in elite teams that participate in top-level Greek league by applying the GPS soccer-specific technology (Smpokos, Mourikis, Linardakis, 2018a, b). This research hypothesis based on the assumption that the professional players match-play performance will differ regarding their playing position and their opponent team ranking. Thus, the aim of the present study was to examine how various playing positions and opponent team ranking affect the covered distances and the acceleration and decelerations profile of a team during 2018–2019 Greek *SuperLeague*.

Methods

Participants

Eighteen (n = 18) professional players aged 27 ±3.3 yrs., with body mass of 77.1 ±6.9 kg, stature 180.5 ±13 cm and 9.4 ±1.9 percentage (%) of body fat were recorded in the present study. Their match-play performance was analyzed during the Greek *Superleague* 2018–2019 regular season in 30 official matches (15 home & 15 away). The current study was carried out in a team which ranked in the top-3 of the above season, qualifying in the next period *UEFA Europa League* tournament (Group Stages). The experimental protocol was approved by the institutional review boards and was in accordance with the Declaration of Helsinki.

Data Collection

The external loads of the starting line-up outfield players who completed the 90 min in their team's full-season matches were recorded (goalkeepers excluded). The analyzed data was collected from the entire regular season of the Greek *Superleague* started on 25 August 2018 until 5 May 2019. During the national championship, each player wore a portable transmitter in a personal vest recording the match-play selected parameters during their official matches (National Cup matches excluded). The transmitter was the *FIFA* Approved StatSport GPS Tracker-Apex Athlete Series (*StatSports Group Limited, Newry, N. Ireland*) with high-frequency 18 Hz GPS (10Hz GNSS) which recorded the players' covered distances (m) in real-time, in the intensity zones of:

i. Z_1 = <4 $m.s^{-1}$
ii. Z_2 = 4–5.5 $m.s^{-1}$
iii. Z_3 = >5.5 $m.s^{-1}$

The number of accelerations and decelerations were counted from the GPS platform in the players' runs greater than 3 m/s^2 as a default. The assessed players' match-play accelerations and decelerations zones as a default were:

i. 3–4 m/s^2
ii. 4–5.5 m/s^2
iii. 5.5–7 m/s^2
iv. 7–10 m/s^2
v. Total 3–10 m/s^2

201 individual match-play observations were recorded. More specifically, the players' measurements per playing positions during the 2018–2019 *Superleague* matches were: 55 for central defenders, 33 for full backs, 38 for central midfielders, 26 for forward and 49 for wingers. The opponent team ranking was based on the division of the 16-teams' Greek *Superleague* from the 2018–2019 season teams' position from 1^{st} to 8^{th} and 9^{th} to 16^{th}.

Statistical analysis

The normal distribution of the data was verified by using the *Shapiro-Wilk* test ($p > 0.05$) and the homoscedasticity was confirmed by *Levene's test*. It is worth noticing, that, where the performance variables were not normally distributed or the homoscedasticity was violated, non-parametric test were conducted (*Kruskal-Wallis test*) to verify whether there were significant group differences. Descriptive statistics were calculated for each variable including means (M) and standard deviations (±SD). For the comparison of the independent variables

("playing position" and "team ranking" in relation to the players "match performance"), the multivariate analysis was used (GLM) and the effect size (η^2) was estimated [in accordance to Cohen (1988) the Effect Size (ES) graded as small (ES): 0.01; medium ES: 0.06; large ES: 0.13]. The pair-wise comparisons were performed by using the *Bonferroni* test *(post-hoc)*. The statistical significance was defined at 5% ($p < 0.05$). All statistical analyses were carried out by employing the IBM SPSS v26.0 statistics software for Windows (*SPSS Inc., Chicago, IL, USA*).

Results

The *MANOVA* results revealed significant differences in the match-play covered distances of the players in all intensity zones in relation to their "playing position" (*Wilks' Lambda* = 0.165*;* $F_{(12, 513.567)} = 41.862$; $p = 0.000$; $\eta^2 = 0.458$) and "opponent team ranking" *(Wilks' Lambda* = 0.945; $F_{(3,189)} = 3.687$; $p = 0.013$; $\eta^2 = 0.055$). In contrary, no significant interactions were observed between the categorical variables "playing position" of the players and the "opponent team ranking" *(Wilks' Lambda* = 0.931; $F_{(12, 500.339)} = 1.149$; $p = 0.318$; $\eta^2 = 0.024$). Table 1 illustrates the players' performance intensity zones in the official matches of their team according to their playing position and the ranking of the opponent team.

Table 1. Players' match performance in relation to their intensity zones and their playing position and opponent team ranking (mean ± SD)

Distance covered (m)		Total		Rank 1–8 (n = 103)		Rank 9–16 (n = 98)		F-values	Sig	η^2
		mean	SD	mean	SD	mean	SD			
Zones <4 m.s^{-1} – = >5.5 m.s^{-1}	Total (201)	10,289.2	728.8	10,160.0	706.4	10,425.1	730.8	$F_{(1, 189)} = 6.989$	0.009	0.035
	CD (55)	9,939.2	559.1	9,825.9	531.8.	10,048.5	572.4	$F_{(1, 53)} = 2.228$	0.141	0.040
	FB (33)	10,649.1	667.6	10,446.7	721.1	10,864.2	548.0	$F_{(1, 31)} = 3.473$	0.072	0.101
	CM (38)	10,961.5	697.1	10,907.6	722.5	11,005.1	690.7	$F_{(1, 36)} = 0.180$	0.674	0.005
	F (26)	9,728.8	586.6	9,628.0	571.2	9,866.3	606.1	$F_{(1, 24)} = 1.049$	0.316	0.042
	W (49)	10,215.7	497.6	10,138.2	398.7	10,310.8	593.4	$F_{(1, 47)} = 1.473$	0.231	0.030
Z1 = <4m.s^{-1}	Total (201)	8,229.5	515.4	8,105.5	479.2	8,359.8	522.3	$F_{(1, 189)} = 11.084$	0.001	0.055
	CD (55)	8,325.6	450.3	8,229.0	402.9	8,418.8	480.5	$F_{(1, 53)} = 2.510$	0.119	0.045
	FB (33)	8,245.3	463.2	8,128.5	471.2	8,369.4	434.8	$F_{(1, 31)} = 2.322$	0.138	0.070
	CM (38)	8,608.1	448.6	8,485.0	438.5	8,707.7	441.8	$F_{(1, 36)} = 2.402$	0.130	0.063
	F (26)	7,637.6	469.6	7,566.4	454.6	7,734.8	494.1	$F_{(1, 24)} = 0.810$	0.377	0.033
	W (49)	8,131.3	376.7	8,028.1	296.5	8,258.1	430.0	$F_{(1, 47)} = 4.884$	0.032	0.094
Z_2 = 4-5.5m.s^{-1}	Total (201)	1,453.7	321.6	1,432.5	321.0	1,476.1	322.5	$F_{(1, 189)} = 0.653$	0.420	0.003
	CD (55)	1,248.1	220.1	1,209.2	188.2	1,285.6	244.5	$F_{(1, 53)} = 1.677$	0.201	0.031
	FB (33)	1,527.4	229.0	1,491.6	205.6	1,565.5	252.7	$F_{(1, 31)} = 0.853$	0.363	0.027
	CM (38)	1,826.2	377.5	1,862.4	405.4	1,796.8	360.8	$F_{(1, 36)} = 0.278$	0.601	0.008
	F (26)	1,274.8	218.4	1,229.8	187.7	1,336.3	250.4	$F_{(1, 24)} = 1.542$	0.226	0.060
	W (49)	1,441.1	165.6	1,460.6	152.3	1,417.2	181.2	$F_{(1, 47)} = 0.829$	0.367	0.017
Z_3 = >5.5m.s^{-1}	Total (201)	606.0	236.9	621.9	222.1	589.3	251.6	$F_{(1, 189)} = 0.229$	0.633	0.001
	CD (55)	365.5	130.5	387.7	128.1	344.1	131.5	$F_{(1, 53)} = 1.550$	0.219	0.028
	FB (33)	876.4	161.8	826.6	149.2	929.3	162.2	$F_{(1, 31)} = 3.590$	0.067	0.104
	CM (38)	527.3	150.3	560.2	163.4	500.6	137.0	$F_{(1, 36)} = 1.495$	0.229	0.040
	F (26)	816.4	156.0	831.8	141.5	795.2	178.8	$F_{(1, 24)} = 0.340$	0.565	0.014
	W (49)	643.3	142.6	649.5	151.9	635.6	133.3	$F_{(1, 47)} = 0.114$	0.737	0.002

Note: Effect size (η^2): 0.01 = small effect, 0.06 = medium effect, >0.13 = large effect.
Abbreviations: Central Defender (CD), Full Backs (FB), Central Midfielders (CM), Forwards (F), Wingers (W).

In addition, the *ANOVA* presented that the total covered distances (m) by the players of the studied team during the Greek *Superleague* matches significantly differed in relation to the players "playing position" ($F_{(4, 191)}$ = 25.507; p = 0.000; η^2 = 0.348). Specifically, central midfielders covered a greater amount of distances during the matches in relation to central defenders, forwards and wingers (p < 0.001), as well as the full backs compared to the central defenders, forwards (p < 0.001) and wingers (p < 0.05). Moreover, statistically significant differences were recorded among the players' "playing position" and their match-play covered distances with intensity <4 m.s^{-1} ($F_{(4, 191)}$ = 19.502; p = 0.000; η^2 = 0.290), with central midfielders to cover a greater amount of distances in relation to the other playing position (p < 0.05), while full backs covered significantly more match-play distances only in relation to forward players (p < 0.001). Similarly, in the playing zone from 4 to 5.5 m.s^{-1} central midfielders covered significantly greater amount of distances compared to the other playing position ($F_{(4, 191)}$ = 34.702; p = 0.000; η^2 = 0.421). Furthermore, in the intensity zone >5.5 m.s^{-1}, the significantly greatest amount of distances were covered by full backs and forwards ($F_{(4, 191)}$ = 82.918; p = 0.000; η^2 = 0.635) during their team's official matches.

Analyzing the "opponent team ranking", the *MANOVA* revealed statistically significant greater amount of match-play covered distances by the players ($F_{(1, 189)}$ = 6.989; p = 0.009; η^2 = 0.035) against the weaker opponents of the Greek *Superleague* (Team Ranking 9–16). Hence, this team's players covered 10,425.1 m (±730.8 m) when they played against the above teams while they covered less distances (10,160 m ±706.4 m) when they played against the stronger opponents of this national league (Team Ranking 1–8). Furthermore, significant differences were recorded in the players' covered distances in all playing positions regarding the opponent team ranking ($F_{(1, 189)}$ = 11.064; p = 0.001; η^2 = 0.055) in the match-play intensity zone <4 m.s^{-1} (8,359.8 m ±522.3 m vs 8,105.5 m ±479.2 m.

Regarding the maximal match-play speed of the players that was recorded during the matches of the Greek *Superleague*, the *MANOVA* reported significant differences of the above variable among "playing position" of the players ($F_{(1, 196)}$ = 9.798; p = 0.000; η^2 = 0.167). Specifically, forwards performed with a maximal playing intensity of 32.3 ±1.4 m.s^{-1}, full backs with 31.4 ±3.5 m.s^{-1} while wingers were recorded with a max-speed of 30.6 ±1.4 m.s^{-1}, higher than the maximal playing intensity which was recorded for central defenders (29.9 ±1.9 m.s^{-1}) and central midfielders (29.4 ±1.4 m.s^{-1}).

Similarly, the *MANOVA* results revealed significant interaction between the "playing position" of the players' and the "accelerations" performed by the players during the match (*Wilks' Lambda* = 0.736*;* $F_{(16, 590.262)}$ = 3.901; p = 0.000; η^2 = 0.074). In particular, the multi analysis linear model verified significant differences between the number of accelerations in all zones during the matches and the playing positions of the players (p < 0.01). In match-play, central midfielders and full backs, in relation to the rest of the positions, performed a significant greater amount of accelerations >3 m/s^2 ($F_{(4, 196)}$ = 4.714; p = 0.001; η^2 = 0.088) in relation to the accelerations which were recorded from central defenders and wingers (p < 0.01).

Regarding the decelerations, the *MANOVA* results showed significant differences in relation to the "playing position" of the players in the amount of the analyzed deceleration zones during the matches of the studied team (*Wilks' Lambda* = 0.531; $F_{(16, 590.262)}$ = 8.489; p = 0.000; η^2 = 0.146). In deceleration runs >3 m/s^2 significant differences were recorded among the players playing positions ($F_{(4, 196)}$ = 16.458; p = 0.000; η^2 = 0.251) in which central midfielders and full backs presented a greater amount of match-play decelerations compared to the other playing position of the players. Table 2 presents the amount of the match-play accelerations and decelerations in relation to the players' playing position.

Table 2. Players' accelerations/decelerations (n) in the match in relation to their intensity zone and their playing position (mean ± SD)

	Total (201)	CD (55)	FB (33)	CM (38)	F (26)	W (49)	F-values	Sig	η^2
Accelerations									
3–10 m/s^2	196.5 ±28.9	190.8 ±30.0	203.0 ±28.5	210.8 ±27.6	191.5 ±34.2	188.6 ±28.9	$F_{(4, 196)} = 4.714$	0.001	0.088
3–4 m/s^2	86.3 ±26.4	92.3 ±26.3	75.2 ±15.7	98.8 ±27.3	74.8 ±23.8	83.6 ±27.4	$F_{(4, 196)} = 6.318$	0.000	0.114
4–5.5 m/s^2	51.1 ±10.7	49.0 ±10.5	54.2 ±10.5	56.1 ±11.4	49.8 ±11.5	48.0 ±8.3	$F_{(4, 196)} = 4.678$	0.001	0.087
5.5–7 m/s^2	43.1 ±19.1	37.3 ±17.1	51.3 ±13.7	42.8 ±22.0	48.1 ±20.5	41.8 ±19.2	$F_{(4, 196)} = 3.491$	0.009	0.067
7–10 m/^{2}	15.6 ±9.6	12.2 ±7.7	22.4 ±8.5	13.1 ±8.9	18.8 ±11.2	15.2 ±9.2	$F_{(4, 196)} = 8.285$	0.000	0.145
Decelerations									
3–10 m/s^2	203.5 ±33.5	196.5 ±32.1	217.3 ±32.3	230.6 ±29.4	179.3 ±28.7	194.0 ±23.5	$F_{(4, 196)} = 16.458$	0.000	0.251
3–4 m/s^2	82.8 ±24.9	86.6 ±26.4	73.3 ±14.8	99.5 ±24.2	67.2 ±17.7	80.1 ±24.5	$F_{(4, 196)} = 10.013$	0.000	0.170
4–5.5 m/s^2	48.8 ±10.4	48.1 ±9.8	48.1 ±8.9	55.9 ±9.8	42.4 ±10.3	47.8 ±9.8	$F_{(4, 196)} = 8.063$	0.000	0.141
5.5–7 m/s^2	45.3 ±15.8	40.9 ±15.3	53.7 ±14.2	49.1 ±18.4	44.2 ±16.7	42.3 ±12.0	$F_{(4, 196)} = 4.740$	0.001	0.088
7–10 m/s^2	26.7 ±14.4	20.9 ±9.5	42.2 ±14.0	26.1 ±13.5	25.5 ±14.8	23.7 ±12.5	$F_{(4, 196)} = 16.348$	0.000	0.250

Effect size (η^2): 0.01 = small effect, 0.06 = medium effect, >0.13 = large effect.
Abbreviations: Central Defender (CD), Full Backs (FB), Central Midfielders (CM), Forwards (F), Wingers (W).

Finally, the analysis of the amount of accelerations/decelerations which were performed by the players during the full-season official matches in relation to the opponent team ranking did not confirm any statistically significant interaction between the above match-play parameters in the studied team. In particular, no significant differences were observed among the opponent team ranking with the accelerations ($F_{(1, 189)} = 0.501$; $p = 0.480$; $\eta^2 = 0.003$) and decelerations ($F_{(1, 189)} = 1.342$; $p = 0.248$; $\eta^2 = 0.007$). Table 3 outlines the number of match-play accelerations/decelerations of the players in relation to their playing positions and the opponent team ranking.

Table 3. Players' accelerations/decelerations (n) in the match in relation to their playing position and team ranking (mean ± SD)

	Position	Rank 1–8 (n = 103)		Rank 9–16 (n = 98)		F-values	Sig	η^2
		mean	SD	mean	SD			
Acceleration >3 m/s^2	Total (201)	195	26.5	197	31.3	$F_{(1, 199)} = 0.420$	0.517	0.002
	CD (55)	185	29.6	196	30.0	$F_{(1, 53)} = 1.734$	0.194	0.032
	FB (33)	203	21.6	203	35.1	$F_{(1, 31)} = .004$	0.948	0.000
	CM (38)	217	22.5	205	30.5	$F_{(1, 36)} = 1.850$	0.182	0.049
	F (26)	189	24.1	195	45.6	$F_{(1, 24)} = 0.158$	0.694	0.007
	W (49)	1,881	20.3	90	21.0	$F_{(1, 47)} = 0.77$	0.782	0.002
Deceleration >3 m/s^2	Total (201)	203	31.7	205	35.5	$F_{(1, 199)} = 0.151$	0.698	0.001
	CD (55)	194	32.5	199	32.2	$F_{(1, 53)} = 0.319$	0.575	0.006
	FB (33)	219	24.6	216	39.6	$F_{(1, 31)} = 0.062$	0.806	0.002
	CM (38)	235	25.9	227	32.1	$F_{(1, 36)} = 0.728$	0.399	0.020
	F (26)	179	21.4	180	37.6	$F_{(1, 24)} = 0.017$	0.897	0.001
	W (49)	194	22.5	194	25.2	$F_{(1, 47)} = 0.000$	0.996	0.000

Effect size (η^2): 0.01 = small effect, 0.06 = medium effect, >0.13 = large effect.
Abbreviations: Central Defender (CD), Full Backs (FB), Central Midfielders (CM), Forwards (F), Wingers (W).

Discussion

The results showed that the players' average covered distances during the official matches of their team in the national league of 2018–2019 was 10,289 m per match. Regarding the team opponent ranking, the players covered a greater amount of distances when they played with the teams ranked from the 9th to 16th position (10,425 m) in relation to the matches against the teams ranked from the 1st to 8th position of the *Superleague* (10,160 m). This finding is in accordance with similar design studies, which analyzed the physical performance of the players from a top-club that participated in the *Superleague* and resulted in the fact that the players of an elite team cover more than 10,000 m per official match in the Greek league (Smpokos et al., 2018b; Mitrotasios, Ispyrlidis, Mantzouranis, Vassiliades, Armatas, 2021). More specifically and in conjunction with the bibliography, the present study confirmed that central midfielders/wingers and full backs recorded with a greater match-play performance, in relation to the rest of the playing positions, regardless the opponent team ranking (Elyakim et al., 2020). Thus, the covered distances during their matches were 10,901 m for central midfielders, 10,446 m for full backs and 10,138 m for wingers, when the opponent team ranked from the 1st to 8th position of the Greek *Superleague*. However, during the in-season matches the above players performed marginally better in the matches against the teams ranked from 9th to16th position in the national league. Hence, the match-play of the studied players was recorded 11,005 m for central midfielders, 10,864 m for full backs and 10,310 m for wingers, confirming that the matches against low position teams demand from the players a higher and a more qualitative performance in order to reach the winning outcome (Ispyrlidis, Gourgoulis, Mantzouranis, Gioftsidou, Athanailidis, 2020).

Furthermore, according to bibliography, in match-play intensity zones higher than 5.5 $m.s^{-1}$, which in modern soccer refers to the transition-to-attack phase, the studied players did not present any differences between their performance and the match status, such as the opponent team ranking. The above finding confirms that the elite teams focus on the winning match outcome regardless the level of its opponent (Brito, Hertzog, Nassis, 2016; Redwood-Brown et al., 2018). Hence, during the in-season matches with teams ranked from 1st to 8th position of the Greek *Superleague* the covered distances with sub-maximal intensities were recorded as high as 560 m for central midfielders, 827 m for full backs and 650 m for wingers. Similarly, in the matches against the teams ranked in the national league from 9th to 16th position, the match-play maximal zone (>5.5 $m.s^{-1}$) was 500 m for central midfielders, 929 m for full backs and 636 m for wingers.

Regarding the amount of players' acceleration and deceleration runs during this elite-team official matches in the Greek *Superleague* period of 2018–2019, no significant differences were detected between the accelerations/decelerations in the total intensity zones (3–10 m/s^2). This finding is in accordance with a similar design study which confirms that the number of match accelerations/decelerations in professional players are similar regardless their playing positions (Vigh-Larsen, Daglas, Andersen, 2018). As far as the differences between the players' positions are concerned, the amount of match-play accelerations for central defenders was 191, for central midfielders 211, for wingers 189, for full backs 203 and for forwards 192. Similarly, the number of the match-play decelerations during the full-season matches were, 197 for central defenders, 230 for central midfielders, 194 for wingers, 217 for full backs and 180 for forwards.

Interestingly, the analysis of the amount of accelerations >3 m/s^2 showed, like a similar study, no significant interactions between the players' position and the opponent team ranking (Russell et al., 2016). Thus, when this study's participants played in the national league with a high position ranking team (1–8), the number of accelerations were recorded 186 for central defenders, 218 for central midfielders, 188 for wingers, 203 for full backs and 189 for

forward players. Similarly, when this Greek *Superleague* team played against the low position ranking teams (9–16), the players' number of accelerations >3 m/s^2 were estimated 196 for central defenders, 205 for central midfielders, 190 for wingers, 203 for full backs and 195 for forwards.

Similarly with the accelerations, the number of decelerations >3 m/s^2 did not present any significant interactions in relation to the players' position and the opponent team ranking. So, when the players played in the Greek *Superleague* against a high position ranking team (1–8), the amount of decelerations were recorded 194 for central defenders, 235 for central midfielders, 194 for wingers, 219 for full backs and 179 for forward players. Similarly, when this team played against the low position ranking teams (9–16) the players' amount of decelerations >3 m/s^2 were estimated 199 for central defenders, 227 for central midfielders, 194 for wingers, 216 for full backs and 180 for forwards. The above findings are in agreement with relevant results highlighting the special demands of all playing positions regarding the eccentric mode of their muscular contractions (Ingebrigtsen, Dalen, Hjelde, Drust, Wisloff, 2015; Tibaudi, 2011).

Conclusion

Summarizing, this study showed that, regarding the standing of the opponent team, the players covered a greater amount of distances when they played with the low-ranked teams (10,425 m) in relation to the matches against the high-ranked teams (10,160 m) of the Greek *Superleague.* As far as the players' playing position is concerned, this study confirmed that central midfielders, full backs and wingers were the most performance-demanding positions in an elite team. Additionally, central midfielders covered greater distances in the playing zone 1 and 2, full backs in zone 2 and 3 and wingers and forwards in zone 3. Furthermore, the total of the studied players' accelerations/decelerations were as high as required for the match loads of this team that was focused on winning results regardless the opponent team status. Finally, in match-play, central midfielders and full backs, in relation to the rest of the positions, performed a significant greater amount of accelerations >3 m/s^2 due to their crucial role in the transition-to- attack phase in their team.

Practical applications

The findings of this research study could offer valuable information to the coaches of the professional teams in order to simulate the official match conditions in the training workouts during the competitive period. In addition, the contemporary coaches will be able to manage and sustain the high intensity loads in the periodization of the microcycle sessions in elite soccer teams. Future research could assess the possible effects of the elite players' match-play performance not only on the winning outcome of the match, but also on the risk of injuries and/or muscle damages in the highly demanding modern soccer.

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PLANTS, ALGAE, CYANOBACTERIA AND FUNGI IN DIET OF VEGAN AND VEGETARIAN SPORTSMEN-A SYSTEMATIC REVIEW

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Abstract Vegan and vegetarian diets have become increasingly popular in developed countries. The aim of the research presented here is to review publications referring to the role of plants, algae, bacteria and fungi in the diet of vegan and vegetarian sportsmen published in the period 2000–2021. The review of the literature was based on peer-reviewed original full-text articles and patents using the ISI Web of Science database, as well as the Google Scholar and Google Patents search engines. Factorial combinations of the following keywords were applied: ('plant' or 'alga' or 'fungus' or 'cyanobacteria') and ('athlete' or 'sport') and ('food' or 'nutrition' or 'diet') and ('vegan' or 'vegetarian'). The survey of the literature, carried out according to PRISMA statements, showed that many taxa canbe used in manufacturing products enhancing sport nutrition, athletic performance, mental alertness, physical health, preventing disorders and controlling body weight. Numerous authors found that the ingestion of plant constituents such as caffeine and proteins enhances muscle growth and recovery. Other investigations indicated the occurrence of beneficial effects, as well as imperfections, ofnon-animal diets. The performed investigations documented that acceptance of vegan and vegetarian diets flows from religious and ethical beliefs, as well as the advantages of sustainable eating practices.

Key words athlete, health, non-animal diet, nutrition, sport

Introduction

The increasingly popular animal-avoiding diets in developed countriesare classified into two main categories, vegetarian and vegan, with each category further subdivided by the inclusion or exclusion of processed or naturally occurring products. Vegetarian or vegan diets may be practised for a variety of reasons, including health, cultural, philosophical, religious, and ecological beliefs, or simply because of taste preferences (Phillips, 2005; McGirr, McEvoy, Woodside, 2017; Parker, Vadiveloo, 2019). Numerous nutritionists (Craig, Mangels, 2009; Melina, Craig, Levin, 2016; Agnoli et al., 2017) have highlighted that well-planned vegetarian diets that include a wide variety of plant foods and a reliable source of vitamin B12 provide adequate nutrient intake. The beneficial effects of vegetarian and vegan diets on health outcomes have been reported by numerous authors (Dinu, Abbate, Gensini, Casini, Sofi, 2017 and literature cited here).

According to other authors (e.g. Nieman, 1999; Trapp, Knez, Sinclair, 2010), athletes who consume diets rich in fruit, vegetables and whole grains receive high amounts of antioxidant nutrients that help reduce the oxidative stress associated with heavy exertion, whereas for athletes who are mostoften concerned with performance, vegetarian

diets also provide long-term health benefits and a reduction in risk of chronic disease. Moreover, well-designed plant-based diets provide adequate nutrient intakes for all stages of the life cycle and can also be useful in the the rapeutic management of some chronic diseases such as heart disease, hypertension, type 2 diabetes, obesity and some cancers. Low intake of saturated fat and high intakes of vegetables, fruits, whole grains, legumes, soy products, nuts, and seeds (all rich in fibre and phytochemicals) are characteristics of vegetarian and vegan diets that produce lower total and low-density lipoprotein cholesterol levels and better serum glucose control. Furthermore, a plant-based diet could make more conservative use of natural resources and cause less environmental degradation (Meyer, Reguant-Closa, 2017).

To date, several authors have reviewed investigations focusing on the benefits and disadvantages of vegan and vegetarian diet for sportspeople (Forbes-Ewan, 2002; Holmes, Willoughby, 2018; Lis, Kings, Larson-Meyer, 2019, D'Angelo, Cusano, 2020, Maziarz, Chojęta, Zygmunt, Wróblewski, Zimna, 2020; Wirnitzer, 2020; Devrim-Lanpir, Hill, Knechtle, 2021), the effect of plant-based diets on endurance performance, particularly inflammation, oxidative stress and immune responses (Pilis, Stec, Zych, Pilis, 2014; Craddock, Probst, 2015), as well as physical health, environmental sustainability, and exercise performance capacity (Lynch, Johnston, Wharton, 2018). Numerous researchers have focused on general nutritional considerations for athletes and exercisers (Grandjean, 1987; Venderley, Campbell, 2006; Laquale, 2006; Nieman, 1999; Barr, Rideout, 2004; Fuhrman, Ferreri, 2010; Rogerson, 2017; Larson-Meyer, 2018; Carlson et al., 2019; Heller, 2019; Vitale, Hueglin, 2021), including special ones for adolescent girls and young women (Schroeder, Sonneville, 2015). Others researchers concentrated on dietetic advice directed particularly for dancers (Brown, 2018), artistic gymnasts (Jakše, Jakše, 2018) and CrossFit athletes (Carbone, Candela, Gumina, 2020). Schoenfeld (2020) discussed the vegan diet as it pertains to the female athlete. Other authors reviewed the use of nutritional supplements (Kaviani, Shaw, Chilibeck, 2020) and proteins (Bătrînu, Tero-Vescan, Miklos, 2020) by vegetarian athletes.

Despite the growing number of publications summarising the effects of vegetarian and vegan diets on the health and performance of sportspersons, the current state of knowledge is still insufficient. As such, the presented studies were undertaken and their main objectives were to learn: (i) which taxa of plants, algae, cyanobacteria and fungi are used for the production of nutritional products for athletes; (ii) which organs of the aforementioned organisms are applied; (iii) what are the effects of particular constituentson athletes' health and performance; (iv) what are the advantages and disadvantages of a vegetarian/vegan diet (especially in comparison to other dietary regimens); and (v) what are the reasons for practising non-animal diets by athletes.

Material and methods

For this survey, a systematic approach for synthesising information through a dedicated step-wise process for selecting available peer-reviewed literature sources was applied. The author searched for peer-reviewed original full-text articles and patents regarding the application of plants in vegetarian and vegan diets using ISI Web of Science-indexed publications. This search engine was selected as it provides a comprehensive all-encompassing database for various interdisciplinary domains. The review focused on literature records published over the time interval from 2000 to 2021. Moreover, publications were searched by browsing the Google Scholar and Google Patents internet search engines. The author used factorial combinations of the following keywords in the searches: ('plant' or 'alga' or 'fungus' or 'cyanobacteria') and ('athlete' or 'sport') and ('food' or 'nutrition' or 'diet') and ('vegan' or 'vegetarian'). The selection terms were examined from the title, abstract and keywords of the articles. The literature

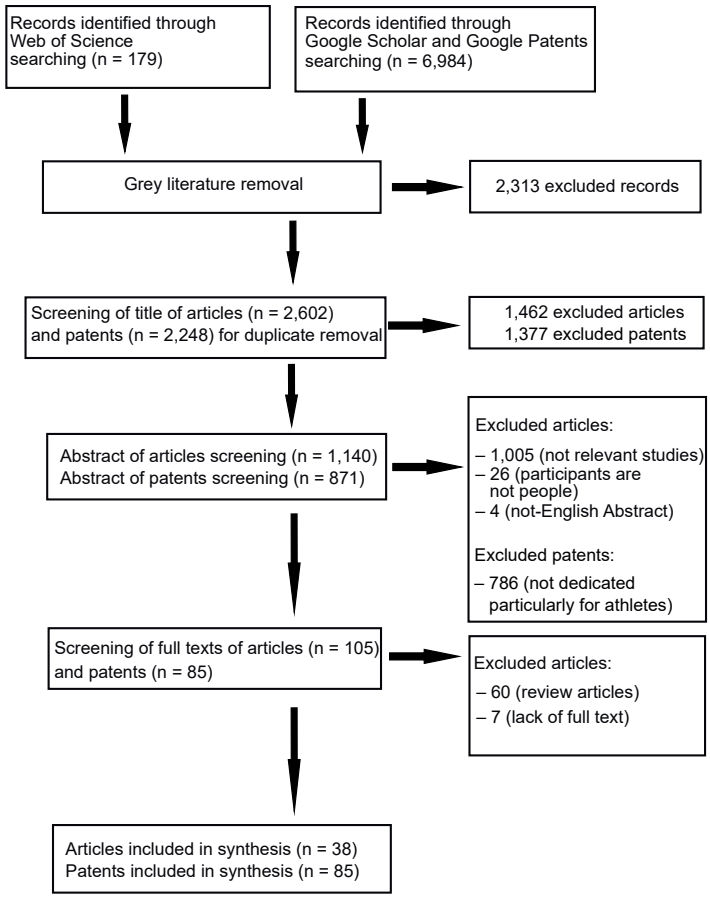

Figure 1. The procedure of literature search according Moher, Liberati, Tetzlaff, Altman (2009)

search was conducted from 20 March to 1 July 2021. The results included 179 hits from the ISI Web of Science, 4,740 from Google Scholar, and 2,244 from Google Patents. After the manual removal of grey literature (blog posts, letters, manuals, guides, bulletins, newsletters, editorials, commentaries, theses, dissertations, reports, conference proceedings, and meeting notes) from the lists of searches, the patents and peer-reviewed articles were selected. Following the removal of duplicates (publications indexed in at least two databases), the abstracts of patents and articles were screened for relevance and eligibility. The only inclusion criterion for patents was their usefulness for sport practitioners. The exclusion criteria for patents were: (i) patents irrelevant to the main subject; (ii) the abstract was not written in English. The inclusion criteria for articles were as follows: (i) investigations are relevant to the main subject of presented review; (ii) participants are people (clinical trials); (iii) no limits in age, weight, sex, nationality and number of participants; (iv) no limits in geographical location, or time period of investigations; and (v) the abstract was written in English. The exclusion criteria for articles were as follows: (i) studies irrelevant to the main subject; (ii) investigations conducted on non-human species; (iii) repetitive publications (different parts

of a single study were presented in two or more papers or studies based on a population that was part of an earlier publication); and (iv) the Abstract was not written in English. Finally, a full-text screening was performed. The only inclusion criterion for patents was their usefulness for sport practitioners. The inclusion criteria for articles were as follows: (i) observational, descriptive studies (case report/case series); (ii) observational, analytical studies (case–control studies, cross-sectional studies, cohort studies); and (iii) experimental studies (randomised controlled trials). The exclusion criteria for articles were as follows: (i) meta-analyses; (ii) systematic reviews; (iii) lack of full text; and (iv) lack of full text in English. A final total of 85 patents and 38 articles were selected to be reviewed. A chart detailing the search results is presented in Figure 1.

Results

The survey of patents/ inventions

The performed survey of literature showed that, altogether, 2 species of cyanobacteria, 6 species of fungi, 13 taxa of algae and 124 taxa of plants were used in the production of nutritional products for vegan and vegetarian athletes. The review of publications proved that the plants represented trees (20 species), shrubs (17), shrubs or trees (12), and herbaceous plants (75). The majority of herbaceous plants belonged to short lasting plants: annuals (37), annuals or biennials (2), and biennials (3). Alower number of species represented plants lasting at least two years (1) and perennials (32). In the case of cyanobacteria and algae, the whole organisms of individuals were mostly applied; in the case of fungi, the fruiting bodies were used; while in the case of herbaceous plants, awide spectrum of organs was applied from roots and tubers, toleaves, and to fruits and seeds. The aforementioned organs were used in the production of food ingredients (Table 1) and nutritional products (Table 2). Numerous authors invented nutritive compositions enhancing endurance (Table 3), improving mental alertness (Table 4), maintaining physical health and preventing disorders (Table 5), as well as controling body weight (Table 6).

Table 1. A review of patented nutritional products based on plant constituents used for products devoted for sportspeople on vegetarian or vegan diets in alphabetical order

Inventor(s)	Year	Patent/articletitle	Patent number or patent source	The raw material	Taxa
1	2	3	4	5	6
J.C. Bohlscheid, K.M. Fletcher, L.M. Huffman	2018	Potato protein powders	WO2018183770A1	Tubers	Potato
C.T. Cordle, S.T. Lubbers, L.W. Williams, J.H. Baxter, G. Duska-McEwan	2015	Nutritional products having improved organoleptic properties	CN103153095B	Seeds	Pea
M.L.F. Giuseppin, C. Van Der Sluis, M.Ch. Laus	2008	Native potato protein isolates	CA2669096A1	Tubers	Potato
N.T. Jakel, D. Kotowski, J. Ingvalson, F. Amore, M.J. Beaver, E.J. Fox, A. Patist, M.J. Tupy, J.F. Ulrich	2003	Corn oil processing and products comprising corn oil and corn meal obtained from corn	WO2003016441A1	Seeds	Corn
D. Janow	2014	Rice protein supplement and methods of use thereof	US20140205710A1	Seeds	Rice

1	2	3	4	5	6
L. Kizer, N. Renninger, A. Stiles	2017	Product analogs or components of such analogs and processes for making same	WO2017120597A1	Seeds	Pea, soy, almond, white bean
F.C. Lau, B.P. Daggy, E.P. Fakoukakis	2017	Composition comprising sacha inchi protein in combination with other plant proteins	WO2017027599A1	Seeds	Pea, soy, rice
				Tubers	Potato
T. Paeschke, A. Kozman, T. Rivera, B. Hitchcock	2012	Fiber obtained from fruit or vegetable byproducts	WO2012074959A1	Fruit peel	E.g. orange, grapefruit, lemon, lime
L.A. Scanlin, M.B. Stone, C. Burnett	2010	Quinoa protein concentrate, production and functionality	US20100184963A1	Seeds	Quinoa

Table 2. The review of nutritional supplements devoted for sportspeople on vegetarian or vegan diets in alphabetical order

Inventor(s)	Year	Patent/articletitle	Patent number or patent source	The raw material	Taxa
1	2	3	4	5	6
M. Barata, T.M. Guilleman, E. Moretti, E. Müller, M. Delebarre	2017	Nutritional formulations comprising a pea protein isolate	WO2017129921A1	Seeds	Pea
A.P. Biescas, J.A.T. Mari, P.T. Riera, A.A. Pons, N.C. Porcel, A.P. Florit	2009	Isotonic Energy Drink	US20090246323A1	Seeds	Almond
				Leaves	Tea
B. Boursier, E. Moretti, G. Ribadeau-Dumas, S. Belaid, A. Riaublanc, J. Gueguen, A. Lepoudere, J-J. Snappe, I. Colin	2017	Assembly of at least one vegetable protein and at least one dairy protein	EP2897474B1	Seeds	E.g. soy, pea, bean
A. Budemann, M. Veen	2016	Food composition containing amino acids and cocoa	US20160000133A1	Seeds	Soy, pea, lentil, bean, cocoa
W. Cain, S.M. Milazzo	2014	Nutraceutical formulation	US20140234515A1	Fruit	Coconut, goji, raspberry
				Seeds	Flax
				Tubers	Sweet potato
R.K. Dhillon-Gill	2010	Nutritional suplement	US20100029581A1	Seeds	Flax, chick pea, brown rice, wheat
J.L. Ho, L. Canzhen	2012	Tiger nut yogurt and preparation method thereof	CN102550686A	Tubers	Tiger nut
L. Hongtao	2005	Multiple element nutritive powder	CN1194633C	Seeds	E.g. soy, lotus, sesame, bean, rice, gorgon fruit
Z. Jicheng, L. Xianglin, Z. Jinming, Q. Yuhua, W. Lan, S. Yujie	2015a	Solid (functional) beverage synthesized from hibiscus esculentus, fungi and alga and preparation method thereof	CN104473286A	Fruits	Okra
				Fruiting body	Scarlet Caterpillar club, lion's mane mushroom, poria
				Whole organism	Spirulina maxima
Z. Jicheng, L. Xianglin, Z. Jinming, Q. Yuhua, W. Lan, S. Yujie	2015b	A method of preparing functional chocolate by an okra-fungus-algae plant composition	CN104472816A	Fruits	Okra
				Seeds	Soy
				Fruiting body	Scarlet Caterpillar club, lion's mane mushroom, poria
				Whole organism	Spirulina maxima
J. Lis, P. Marquilly, S. Lagache, L. Retourne	2015	Novel non-allergenic snacks containing vegetable proteins	CA2929948A1	Seeds	Pea, greenalgae

1	2	3	4	5	6
M-L. Mateus, M.G. Roy, Y.M. Thonney	2014	Bite-size nutritional products having a filling and methods for using same	US20140120208A1	Seeds	Peanut
				Fruits	e.g. grape, apple, apricot, banana, vanilla
				Leaves	Peppermint
R.A. Miller, T.B. Shelton	2016	Nutritional or dietary supplements containing fatty acids and nitrite	US20160081962A1	Seeds	e.g. grape, flax, lingoberry, canola, poppy
				Root	Beetroot
L.J. Minus	2012	Nutritional beverage formulation	US20120093981A1	Seeds	Oat, cacao, nutmeg
				Fruits	Banana
W. Qingge	2015	Nutritious porridge with black soybeans and pumpkin seeds and manufacturing method thereof	CN104256340A	Seeds	e.g. soy, pumpkin, rice, Job's tears, peanut
A. Schmidbauer, Ch. Leisser	2011	Iron-complexes extracted from curry leaves and their use	EP2298330A1	Leaves	Curry tree
L. Shaowei, H. Chenkang, K. Lina	2014	Puffed grain energy bar	CN103783121A	Seeds	Corn, soy, rice, buckwheat
J. Szilbereky, A. Jednákovits, A. Salgó, G. Barla Szabó, L. Szabados	2014	A novel raw material for functional foods and a process for the preparation thereof	WO2014060784A2	Seeds	Soy, rice, maize, oat, wheat, chickpea
S. Turner, K. Laporte, S. Al-Murrani, L. Hayward	2010	Controlled release food formulations	WO2010056957A1	Seeds	Flax, walnut, common wheat, rapeseed
R.S. Wilkes	2012	Omega-3 enriched cereal, granola, and snack bars	EP2429318A1	Seeds	e.g. soy, corn, canola, sunflower, millet, kamut
				Fruits	Raspberry, cherry
D. Venturi	2004	Whole meal replacer	WO2004017764A1	Fruits	Rose, apple
				Seeds	Pea
A. Zoia, M.M. Bargardi	2007	Vegetable origin food rich in proteins and nutritious	WO2007013109A1	Seeds	e.g. chick peas, almond, rice

Table 3. The review of nutritive products improving physical performance devoted for sportspeople on vegetarian or vegan diets in alphabetical order

Inventor(s)	Year	Patent/articletitle	Patent number or patent source	The raw material	Taxa
1	2	3	4	5	6
A. Bast, G.R.M.M. Haenen, L.C.R. Van Der Heyden, S.J. Rietjens	2009	Olive extracts for promoting muscle health	WO2008040550A2	Fruits, leaves	Olive
S. Bell, R. Forse, B. Bistrian	2001	Dietary supplement for individuals under stress	US20010022980A1	Seeds	e.g. walnut, peanut, cashew, hazel, flax, soy
W.H. Chou, V. Chou	2011	Herbal compositions and methods for enhancing vital energy and athletic performance	US7906159B2	Leaves	Maidenhair tree
				Roots	Common golden root
J. Cox	2014	Chocolate mass	EP2590514B1	Seeds	Cacao, corn, rice, sorghum, flax, pomegranate
B. Depta	2017	Composition containing aronia berry extract, red spinach extract and beetroot extract	US20170112886A1	Fruits	Aronia
				Roots	Red beet
				Leaves	Red spinach

1	2	3	4	5	6
J. Deshpande, K. Ghanam, V. Srivastava	2016	Macroalgae compositions, processes for preparation thereof, and uses in sports nutrition	US20160287646A1	Leaves	Brown algae e.g. bladder wrack, oarweed, egg wrack
S.E. Durkee, G. Dente	2008	Method and composition for increasing Erythropoietin	US20080241076A1	Roots	Dong quai
				Leaves	Duckweed
R.M. Ferrante, Ch.K. Cunningham	2015	Performance enhancing composition and method of delivering nutrients	US8999424B2	Fruits	E.g. pomegrate, goji berry, blueberry
				Roots	Carrot, beet
C. Germano	2008	Nutritional formula for recovery of athletes	US20080119386A1	Fruits	Blueberry, sour cherry, strawberry
				Seeds	Grape, raspberry
C.W. Hastings, D.J. Barnes, C.A. Daley	2012	Performance-enhancing dietary suplement	US8168241B2	Seeds	Soy, grape, black pepper
M.S. Hausman	2014	A nutritional approach to improving athletic performance and reducing injury with L-ergothioneine and/or vitamin D2	WO2014004647A1	Organism tissue	Mushroom, King trumpet mushroom
S.O. Hill, J.S. Minatelli, R.S. Moerck, U.E. Nguyen	2011	Chia seed composition	DE112009000124T5	Seeds	Chia
K. Khalil, O. Said	2008	Herbal energy-enhancing formulation	WO2008152624A2	Roots	Common chicory
				Leaves	Rocket
D.O. Lukaczer, G.K. Darland, D.J. Liska, T.A. Irving, J.S. Bland	2002	Dietary supplements for treating fatigue-related syndromes	US6352712B1	Leaves	Rosemary
				Root	Ginger
				Rhizome	Curcumin
J.A. Minatelli, W.S. Hill, R. Moerck, U. Nguyen	2009	Chia seed composition	US20090181127A1	Seeds	Chia
J.D. Moore, T.R. Hampton, R. Harrell	2015	Dietary supplements for promotion of growth, repair, and maintenance of bones and joints	US8968791B2	Seeds	e.g. apricot, avocado, blackcurrant, borage, coriander, cotton, kapok, meadowfoam, perilla, poppy, pumpkin
				Whole organism	Algae from genus: Eugena, Botryococcus, Dunaliella, Isochrysis, Nannochloropsis, Neochloris, Phaeodactylum, Pleurochrysis, Prymnesium, Scenedesmus, Spirulina
N. O'Kennedy	2016	Compositions	US20160375080A1	Fruits	Tomato
				Seeds	Groudnut, oat, common wheat
				Roots	Swiss chard
R. Petralia	2012	Nutraceutical beverage	US20120213756A1	Leaves	True aloe
D. Phillips, D. Phillips	2013	Caffeinated creamer	US20130129866A1	Seeds	Coffee
				Leaves	Tea, yerba mate, guayusa, yaupon holly
				Fruit	Guarana
Ch. Roumayeh, S. Bellestri, J.Ch. Jerebko	2015	Nutritional compositions and methods	US20150099032A1	Roots	e.g. Asian ginseng, cadonipsis, licorice
				Fruits	e.g. chestnut rose
N. Silver, M. Hamill, P. Samayoa, J. Hou, L. Hamm, D. Berry	2014	Nutritive polypeptides, formulations and methods for treating disease and improving muscle health and maintenance	WO2014134225A2	Fruits	e.g. apple, peach, pear, plum
				Seeds	Corn, anise
				Leaves	e.g. Peppermint
				Tubers	Potato
				Fruits	Red date, hawthorn
				Rhizomes	Chinese yam

1	2	3	4	5	6
B.D. Tuttle	2002	Dietary supplement for increasing energy, strength, and immune function	US6465018B1	Roots	Asian ginseng, American ginseng,Mongolian milkvetch
H-P. Wild	2016	Compositions for use in food products	WO2016150573A1	Fruits	Citrus, raspberry, blueberry
M. Veen, A. Budemann	2014	Food composition containing amino acids and cocoa	US20140154358A1	Seeds	Cacao, pea, bean, lentil
R. Xiu	2002	Rhodiola and used thereof	US6399116B1	Root	Golden root

Table 4. The review of nutritive products improving mental alertness suitable for sportspeople on vegetarian or vegan diets in alphabetical order

Inventor(s)	Year	Patent/articletitle	Patent number or patent source	The raw material	Taxa
S. Cheyene	2014	Health supplement using guarana extract	US8877258B1	Leaves	Green tea, peppermint, tulsi
				Fruits	Guarana
R.F., Gerardus, J. King, S. Lester	2003	Alertness bar	CA2480100A1	Seeds	e.g. soy, sesame, safflower, flaxseed
T. Stutzman	2017	Sweet tart energy tablet	US9549563B2	Fruits	e.g. orange, strawberry, black cherry, blue raspberry
K. Tao, L. Guanghua	2017	Sweet potato biscuit and preparation method thereof	CN104799317B	Tubers	Sweet potato
				Seeds	Rice
				Root	Kudzu vine, carrot
				Fruits	E.g.medlar

Table 5. The review of nutritive products improving physical health and preventing disorders suitable for sportspeople on vegetarian or vegan diets in alphabetical order

Inventor(s)	Year	Patent/articletitle	Patent number or patent source	The raw material	Taxa
1	2	3	4	5	6
D. Andrews	2006	Nutraceutical Moringa composition	US20060222682A1	Seeds, fruits, leaves	Horseradish tree
J. Ansell, P. Blatchford	2017	Gold kiwifruit compositions and methods of preparation and use therefor	US20170326190A1	Fruit	Kiwifruit
S. Bhardwaj, S. Saraswat	2019	Product development, nutrient and sensory analysis of sports drink based on chia seeds (Salvia hispanica L.)	International Journal of Physiology, Nutrition and Physical Education	Seeds	Chia
Z. Chunshan	2013	Nutrient eight-treasure soup formula and preparation process thereof	CN101797049B	Roots	Carrot, white turnip
				Leaves	White turnip
				Seeds	Barley
				Fruiting body	Wood ear mushroom
A. Jeukendrup, T. Stellingwerff, E. Zaltas	2009	Carbohydrate bar	EP2098126A1	Seeds	Pea, soy, rice,peanut
				Fruits	Vanilla

1	2	3	4	5	6
N.C. Loizou	2009	Health suplement	US20090110674A1	Seeds	e.g. pumpkin, guarana, grape, horse chestnut
				Leaves	e.g. acacia
				Roots	e.g. maca, nettle
M. Robertson	2006	Universal protein formulation meeting multiple dietary needs for optimal health and enhancing the human immune system	US20060280840A1	Seeds	Soy, quinoa, amaranth, millet, rice, safflower
W. Songyi	2015	Plant health solid drink and preparation method thereof	CN104323391A	Seeds	Tibetan goji, wheat, soy
				Fruits	Red date, hawthorn
				Rhizomes	Chinese yam
B.R. Vescovi	2016	Methods and formulations for enhancing hydration	US20160000131A1	Seeds	e.g. flax, chia
				Roots	Konjac, liquorice
				Bark	Slippery elm
				Leaves	e.g. aloe vera
M.J. Vadakkemuri, P.T. Kochery, P.T.J. Kocherry	2016	Optimized nutrient food	WO2016035095A1	Seeds	e.g. sunflower, sesame, soy, flax, fenugreek, cress

Table 6. The review of nutritive products contributing to weight loss suitable for sportspeople on vegetarian or vegan diets in alphabetical order

Inventor(s)	Year	Patent/articletitle	Patent number or patent source	The raw material	Taxa
1	2	3	4	5	6
G. Brooks, S. Franklin, J. Avila, S.M. Decker, E. Baliu, W. Rakitsky, J. Piechocki, D. Zdanis, L.M. Norris	2010a	Methods of inducing satiety	US20100303961A1	Leaves	Purple layer, dulse, sea lettuce
				Organism tissue	Spirulina, Green algae
G. Brooks, S. Franklin, J. Avila, S.M. Decker, E. Baliu, W. Rakitsky, J. Piechocki, D. Zdanis, L.M. Norris	2010b	Reduced-fat foods containing high-lipid microalgae with improved sensory properties	US20100297331A1	Organism tissue	Green algae
G. Brooks, S. Franklin, J. Avila, S.M. Decker, E. Baliu, W. Rakitsky, J. Piechocki, D. Zdanis, L.M. Norris	2012	Novel microalgal food compositions	US20120128851A1	Organism tissue	Green algae
G. Brooks, S. Franklin, J. Avila, S.M. Decker, E. Baliu, W. Rakitsky, J. Piechocki, D. Zdanis, L.M. Norris	2015	Food compositions of microalgal biomass	CN102271525B	Whole organism	Green algae
V.S.P. Chaturvedula, M.P. May, J.A. May, J.E. Zamora	2015	Compositions and methods for the solubilization of stevia glycosides	WO2015127297A1	Leaves	Candy leaf
G. Chunhu	2010	Coffee with weight reducing and antifatigue functions	CN101861903A	Seeds	Coffee, soy
				Leaves	Tea
				Tubers	Jerusalem artichoke

1	2	3	4	5	6
I. Daikeler, M. Wilson, M.L.N. Alamdari	2015	Dietary intervention with reduced daily caloric intake	US20150342237A1	Roots	e.g. maca, milkvetch
				Rhizomes	e.g. Yacon
				Leaves	e.g. horseradisch, green tea
				Fruits	e.g. goji,bilberry
				Seeds	e.g. flax, grape
J. Deaton, H.G. Dawson	2014	Proteolytic compositions for rapidly and extensively degrading protein supplements	WO2014130007A1	Stems	Pineapple
Q. Jian, Z. Junjie	2014	Preparation method of fat-fighting low-calorie full-nutrition meal replacement preparation	CN103494213A	Seeds	Rice, sunflower, maize
Z. Junling	2014	Health-maintaining and weight-reducing type blending oil	CN103651949A	Seeds	e.g. rice, sunflower, rapeseed, soy, sesame
D. Narasimhan, S. Narasimhan	2016	Hunger minimizing juice fasting system	US20160100615A1	Fruits	e.g. apple, orange, watermelon, grape
				Roots	E.g. carrot, beetroot
P. Oddenino	2014	Food composition with thermogenic function	EP2064961A1	Seeds	Coffee
H.W. Selby	2014	Cholesterol-reducing diet	US8821947B2	Fruits	Cocoa
				Seeds	Olive, canola, flax, walnut
T. Tao, L. Ting	2017	Quinoa nutritive meal replacement powder	CN106306993A	Seeds	Quinoa, soy, rice
N. Xuemei	2013	Weight-reducingand meal replacement protein type solid beverage	CN102687750B	Seeds	Soy

The survey of investigations on plant constituents suitable for sportspersons

The effect of ingestion of plant constituents

Senger, Bohlinger, Esgaib, Hernández-Cubero, Montes, Becker (2017) found, that the oil- and protein-rich kernels of the subtropical plant chuta (*Jatropha curcas* L.) can be exploited as a snack and as an ingredient for foodstuffs which can complement the diets of vegetarians and vegans, professional athletes, or persons who have to restrict their consumption of carbohydrates for medical reasons. Other authors confirmed the beneficial effects of caffeine (Vanata, Mazzino, Bergosh, Graham 2014), as well as soy, whey and pea proteins (Tang, Moore, Kujbida, Tarnopolsky, Phillips, 2009; Banaszak et al., 2019; Lynch et al., 2020) on muscle growth and athletic performance. Moreover, Naclerio, Seijo, Earnest, Puente-Fernández, Larumbe-Zabala (2020) evidenced that a post-workout vegan-protein multi-ingredient admixture speeds upthe recovery of muscular function in young males. At the same time, other authors (Earnest et al., 2004; Gallien, Bellar, Davis, 2017) found the lack of performance benefits of selected vegan products in cyclists (Table 7).

Table 7. A review of original articles devoted to the effects of plant constituents on health and athletic performance of sportspeople in alphabetical order

References	Physicalactivity	Treatement	Results
Banaszek et al. (2019)	High-intensity functional training	Consumption of 24 grams of whey vs 24 grams of pea protein	Increase instrength for maximum back squat and deadlift in both groups. No differences of body composition and muscle thickness
Earnest et al. (2004)	Cycling	14-days supplementation period of adapotogen formula (*Cordyceps sinensis* mycellium and *Rhodiola* extract) or placebo (methycellulose)	No difference between groups for any peak exercise variables including peak VO_2, time to exhaustion and peak heart rate (HR)
Gallien et al. (2017)	Cycling	Consumption 30 minutes prior to trial of vegan pre-workout supplement vs. zero-calorie placebo supplement	No difference in cycling performance between groups
Lynch et al. (2020)	Recreative training	Consumption of 19 grams of whey protein isolate vs 26 grams of soy protein isolate	Consumption of whey and soy protein increases total body mass, lean body mass, peak torque of leg extensors and flexors
Naclerio et al. (2020)	Resistance training	Consumption 10 min. after workout completion of workout protein-vegan multi-ingredient admixtures vs. maltodextrin admixtures	Lower contraction velocity of vastus medialis after maltodextrin admixture. Better vertical jump and squat performance after protein-vegan admixture
Tang et al. (2009)	Unilateral leg resistance exercise	Consumption of a drink containing an equivalent content of essential amino acids (10 g) as either whey hydrolysate, micellar casein, or soy protein isolate	Higher muscle protein synthesis at rest and after excercise after ingestion of whey and soy than casein
Vanata et al. (2014)	The sprint-distance swimming	Consumption 3 milligrams of caffeine per kilogram of body weight	Improvement of swim times. Greater excretion of urinary caffeine in females

The effect of vegetarian/vegan diets on health and athletic performance

Nebl, Schuchardt, Wasserfurth, Haufe, Eigendorf, Tegtbur, Hahn (2019a), Nebl, Haufe, Eigendorf, Wasserfurth, Tegtbur, Hahn (2019b), Nebl, Drabert, Haufe, Wasserfurth, Eigendorf, Tegtbur, Hahn, Tsikas (2019c), Nebl, Schuchardt, Ströhle, Wasserfurth, Haufe, Eigendorf, Tegtbur, Hahn (2019d), as well as Woodbridge, Konstantaki, Horgan (2020) suggested that a well-planned health-conscious lacto-ovovegetarian and vegan diet, including supplements,can meet the athlete's nutritional requirements. Numerous researchers claimed that plant-based diets are beneficial for muscle strength and endurance in women and men in different age groups (Haub, Wells, Campbell, 2005; Boutros, Landry-Duval, Garzon, Karelis, 2020; Hevia-Larraín et al., 2021). At the same time, Wirnitzer (2010) evidenced that athletes involved in heavy endurance exercise should ingest a higher amount of energy from carbohydrates to maximise muscle glycogen synthesis. Other authors argued that plant-based diets show a beneficial influence on heart morphology (Król et al., 2020), a reduction of risk of heart diseases (Chang et al., 2020; Śliż et al., 2021), as well as the improvement of cardiorespiratory fitness (Lynch, Wharton, Johnston, 2016). Further positive effects, such as the increase of blood testosterone level in men (Ciara, 2019) and body mass loss (Ciuris, Lynch, Wharton, Johnston, 2019; Wirnitzer et al., 2019; Hernández-Martínez, Fernández-Rodríguez, Soriano, Martínez-San, 2020; Davey, Malone, Egan 2021), were evidenced at the same time. In addition, Yadav, Mukhopadhyay, Yadav (2020) proved that lacto-vegetarians reported greater exercise duration and physical fitness than non-vegetarians. At the same time, it is worth mentioning that Veleba, Matoulek, Hill, Pelikanova, Kahleova (2016) observed a slight improvement in physical fitness after a training programme with a vegetarian diet as compared with a conventional hypocaloric diet in patients with type 2 diabetes.

On the other hand, some researchers pointed out the imperfections of a vegetarian and vegan diet, such as the rise of oxygen consumption during submaximal cycling (Hietavala, Puurtinen, Kainulainen, Mero, 2012), the increase of post-exercise oxidative stress (Nebl et al., 2019c), the low level of selected microelements and vitamins (Gröber, 2020), as well as the risk of osteoporosis and anaemia (Klimatskaya, Zaitseva, 2015). Khanna, Lal, Kommi, Chakraborty (2006) found that intakeof some nutrients, haemoglobin level, endurance time, and recovery were better in non-vegetarians than in lacto- or ovo-lacto- female athlete vegetarians. Gibson-Smith, Storey, Ranchordas (2020) proved that serum ferritin level is significantly lower in vegan/vegetarian than in omnivore climbers, while Potthast, Nebl, Wasserfurth, Haufe, Eigendorf, Hahn, Das (2020) observed that enzymatic activities of essential regulators of cellular energy metabolism increase during exercise in omnivores and lacto-ovo vegetarian runners, and decreases in vegans (Table 8).

Table 8. A review of original articles devoted to the effects of plant-based diets on health and athletic performance of sportspeople in alphabetical order

References	Sport discypline	Gender	Age (years)	Diet of participants	Main components of vegan/vegetarian diet	Results of plant-based diet
1	2	3	4	5	6	7
Boutros et al. (2020)	Recreative training	W	25.6 ±4.1	Vegan diet vs. omnivorous diet	.	↑ of estimated VO_2 max ↑ of submaximal endurance time to exhaustion
Chang et al. (2020)	Excercise	M, W	30–70	Vegetarian vs former vegetarian vs non vegetarian	.	↓ of high-density lipoprotein cholesterol (HDL-C)
Ciara (2019)	Rereational weight training	M	20–70	Omnivorous vs vegetarian diet	.	↑ of marginal mean testosterone
Ciuris et al. (2019)	Endurance sports (triatletlon, runnig, cycling)	M, W		Omnivorous vs vegetarian diet	Whey, soy, corn, bean, peas, peanuts, potato, sweet potato, rice, sunflower	↓ of body weight and body mass index
Davey et al. (2021)	Gaelic football	M	25	Omnivorous vs vegan diet	Banana, peanuts, rice, quinoa, apple, chickpea	↓ of lean body mass, Ø in fat body mass, Ø in running performance
Gibson-Smith et al. (2020)	Climbing	M, W	30.3 ±6.7	Omnivorous vs vegetarian/ vegan diet	.	↓ of mean serum ferritin level ↓ of protein intake level
Gröber (2020)	Swimming	W	29	Vegetarian	.	↓ of iron, selenium, vitamin D and vitamin B12
Haub et al. (2005)	Resistive exercise training	M	65 ±5	Plant-based food vs meat -based food	Soy	↑ of overall muscle strength and muscle power ↓ of total cholesterol ↓ of low-density lipoprotein cholesterol ↓ of high-density lipoprotein cholesterol
Hernández-Martínez et al. (2020)	Powerlifting	M		Vegan diet	Chickpea, soy, carrot, rice, pepper, lentil, bean, tomato, banana	↓ of body mass ↓ of fat mass ↑ of fat-free mass
Hevia-Larraín et al. (2021)	Resistance training	M	26	Omnivorous vs vegan diet	Soy	↑ of leg lean mass ↑ of rectus femoris and vastus lateralis fiber cross-sectional area

1	2	3	4	5	6	7
Hietavala et al. (2012)	Cycling	M	23.5 ±3.4	Omnivorous vs vegetarian diet	.	Ø in venous blood pH, Ø in strong ion difference, Ø total concentration of weak acids, Ø in partial pressure of CO_2 or HCO_3- at rest or during cycling, Ø exercise time to exhaustion, ↑ of VO_2 max until exhaustion
Khanna et al. (2006)	Athletes	W	16–25	Omnivorous vs lactovegetarian vs ovolactovegetarian diet	Cereals, luguminous	↓ of body mass in ovolactovegetarians Ø in energy and carbohydrate intake ↓ of protein intake in lacto- and ovolactovegetarians
Klimatskaya, Zaitseva (2015)	Yoga	W	31.9 ±7.4	Lactovegetarian	Rye, barley, buckwheat, wheat, beet, turnip, potato, onion, cabbage, peanut, berries	↓ of intake of calcium (Ca) and iron (Fe) ↑ of consumption of sodium (Na) ↓ of consumption of potassium (K)
Król et al. (2020)	Amateur running		32 ±5	Vegan vs omnivorous diet	.	Ø in excersise capacity Ø in maximal oxygen consumption ↑ of rate of oxygen consumption per kilogram of body mass ↑ of diastolic and systolic function ↓ of relative wall thicknes
Lynch et al. (2016)	Endurance athlets	M, W	21–58	Omnivorous vs vegetarian diet	.	↓ of protein intake level
Nebl et al. (2019a)	Recreative running	M, W	27.5 ±4.1	Omnivorous vs lacto-vegetarian vs vegan diet	Cereals, potato, legumes, coffee, tea	↑ of intake of carbohydrates, fiber and iron)
Nebl et al. (2019b)	Recreative running	M, W	27.5 ±4.1	Omnivorous vs lactovegetarian vs vegan diet	Cereals, legumes	↑ of intake of carbohydrates, fibre, magnesium, iron, folate and vitamin E ↓ of intake of dietary fat and vitamin B12 Ø in excersise capacity
Nebl et al. (2019c)	Recreative running	M, W	27.5 ±4.1	Omnivorous vs lactoovovegetarian vs vegan diet	Cereals, legumes	↑ of oxidative stress Ø in nitrate, nitrite and creatinine
Nebl et al. (2019d)	Recreative running	M, W	18–35	Omnivorous vs lactoovovegetarian vs vegan diet	Cereals, legumes	↑ of mean red blood cell folate ↓ of vitamin D
Potthast et al. (2020)	Recreational running	M, W	18–35	Omnivorous vs lactovegetarian vs vegan diet	Cereals, potato, legumes, coffee, tea	↑ of enzymatic activity of sirtuins (SIRT1, SIRT3, and SIRT5) during exercise in omnivores and lactoovovegetarians ↓ of enzymatic activity of sirtuins in vegans
Śliż et al. (2021)	Long-distance running	M	20–39	Omnivorous vs vegan diet	.	↓ of fat and protein intake ↑ of carbohydrates intake ↓ of body mass ↓ of C-peptide and total blood cholesterol levels

1	2	3	4	5	6	7
Yadav et al. (2020)	Recreative training	M, W	16–27	Omnivorous vs vegetarian diet	.	↑ of excercise duration ↑ of physical fitness index score
Veleba et al. (2016)	Recreative aerobic excersise	M, W		Omnivorous vs vegetarian diet	.	↑ of maximal performance ↑ of maximal oxygene consumption Ø in fasting oxidation of fat, carbohydrates and protein
Wirnitzer (2010)	Amateur cycling	W	30	Vegan	.	↑ of of energy consumption from carbochydrates
Wirnitzer et al. (2019)	Endurance running	M, W	>18	Omnivorous vs lactovegetarian vs vegan diet	.	↓ of body mass ↓ of prevalences of allergies
Woodbridge et al. (2020)	Recreational running	M, W	42.9 ±10.6	Vegan diet	.	↑ of nutritional defencies in intake of energy, protein, vitamin D and selenium ↓ of nutritional defencies in intake of iron, zinc, vitamin B12, calcium and iodine

↑ – increase, ↓ – decrease, Ø – no changes/no differences.

The acceptance of plant-based diets by athletes

Pelly and Burkhart (2014) studied the dietary regimens of athletes competing at the Delhi 2010 Commonwealth Games. They discovered that a vegetarian regimen was followed by 7% of athletes, with women in the majority. Significantly more athletes from non-Western regions followed a vegetarian diet, particularly athletes from non-Western regions of Africa, the Caribbean, India and Sri Lanka, South East Asia, and the PacificIslands. Similarly, athletes from weight category sports were more likely to follow a vegetarian/vegan dietary regimen than athletes from most other sports. Cramer, Sundberg, Schumann, Leach, Lauche (2018) found that a total of 1.7 million US yoga practitioners have used a vegetarian diet. Iwasa-Mange and Wegener (2020) investigated the knowledge and perceptions of plant-based diets among competitive and recreational athletes recruited from Canadian post-secondary institutions. The authors found that athletes have the potential to be important advocates of healthy and sustainable eating among peer groups and the general public (Table 9).

Table 9. A review of questionnaire surveys on the use of plant-based diets by sportspeople in alphabetical order

Reference	Number of respondents	Sport discipline/ category	Gender	Age	Country or region	Use of products	
						number/percent of users or use frequency	purpose
Pelly, Burkhart (2014)	351	Weight category, endurance, racquet, power/sprint, team, aesthetic and figure	M, W	24 ±6	Australia and New Zealand, British Isles, Canada, SE Asia and Pacific, India and Sri Lanka, Caribbean and Africa	7% of respondents	Religious beliefs
Cramer et al. (2018)	34,525	Yoga	M, W	>18	United States of America	8.3% of yoga practitioners	Ethical beliefs
Iwasa-Mange, Wegener (2020)	48	Competitive and recreational activity			Canada		Health and sustainable eating

Discussion

The performed literature survey seems to confirm the statement of Diazgranados et al. (2020), who suggested that numerous taxa representing kingdoms of plants, algae, bacteria and fungi are essential to human wellbeing and provide a broad spectrum of benefits to society, offering vital solutions to some of the world's major challenges including, among others, human nutrition. According to the aforementioned authors, more than 7,000 species might serve as components of human food; moreover, these edible species are frequently renowned for their health qualities. Due to the irnutritive and therapeutic effects, numerous species are frequently used in athletes' diets. Sellami, Slimeni, Pokrywka, Kuvačić, Hayes, Milic, Padulo (2018) proved that numerous species are used by athletes to enhance muscle strength and body mass, relieve muscle and joint pain, as well as activate the nervous system. According to the aforementioned authors, the group of most commonly used species is represented,among others, by ginseng (*Panax ginseng* and *Panax quinquefolius*), goat's-head (*Tribulus terrestris*), ginko (*Ginkgo biloba*), golden root (*Rhodiola rosea*), guarana (*Paullinia cupana*), green tea (*Camilla sinensis*), mate (*Ilex paraguayensis*), and caterpillar fungi (*Cordyceps sinensis*). Furthermore, previous investigations also showed that soybean (*Glycine max*) (Kostrakiewicz-Gierałt, 2020a), maize (*Zea mays*) (Kostrakiewicz-Gierałt, 2020b), as well as coneflower (*Echinacea* sp.) (Kostrakiewicz-Gierałt, 2020c) represent the base of many sport supplements and meal replacements in a variety of forms such asbars, beverages, tablets, and powders. On the other hand, several authors (Maughan, King, Lea, 2004; Garthe, 2019) pointed out that many challenges, such as contamination, undefined ingredients, and variable content of biologically active substances in herbal supplements are of great concern for athletes who are tested regularly for banned substances.

The performed review of the literature confirmed the frequent use of numerous taxa representing trees, shrubs and herbaceous plants in the preparation of many food products especially dedicated for vegan and vegetarian athletes. The evidenced most frequent use of herbaceous species corresponds with their popularity as edible plants in several regions of the world (e.g. Dénes, Papp, Babai, Czúcz, Molnár, 2012; Hong et al., 2015; Landor-Yamagata, Kowarik, Fischer, 2018; Yeşil, İnal, 2019). Contrary to the obtained results, the investigations of many authors showed that in many regions the majority of edible herbaceous plants are represented by perennial species, while annuals are rather rare. Such a tendency was observed, among others, in Estonia (Kalle, Sõukand, 2012), Poland (Łuczaj, Szymanski, 2007), and Slovakia (Łuczaj, 2012). Moreover, the presented survey shows that roots, tubers, leaves, fruits and seeds are the most frequently used parts of plants. These findings correspond with studies proving that the aforementioned parts are mostly used in the production of food from plants in numerous regions of the world (e.g. Tardío, Pascual, Morales, 2005; Della, Paraskeva-Hadjichambi, Hadjichambis, 2006; Leonti, Nebel, Rivera, Heinrich, 2006; Rivera, Bocanegra-García, Monge, 2010; Teklehaymanot, Giday, 2010; Parada, Carrió, Vallès, 2011; Turner et al., 2011; Dogan, 2012; Łuczaj et al., 2012; Vallès et al., 2017; Xu, Liang, Wang, Wen, Wang, 2020; Monti, 2021). Several authors evidenced the occurrence of nutritive compounds (sugars, proteins, fats) and antioxidants (polyphenols, carotenoids, flavones, chlorophylls, ascorbic acid) in roots and tubers (e.g. Zhao, Wu, Wang, 2015; Chandrasekara, Kumar, 2016; Chandrasekara, 2018; Xu et al., 2017), fruits and seeds (e.g. Xu et al., 2017; González-Aguilar et al., 2008; Fidelis et al., 2019; Dhalaria et al., 2020; Jideani et al., 2021), as well as leaves (e.g. Xu et al., 2017; Mateos-Maces et al., 2020) of taxa widely applied in food products used by vegan and vegetarian athletes.

The performed review evidenced that plant-based diets offer numerous desirable nutritional and health benefits. The obtained results correspond with the findings of numerous authors showing the beneficial effects

of plant-based diets on cardiovascular safety and performance in endurance sports (Barnard et al., 2019). The aforementioned authors pointed out several advantages of such diets, such as a leaner body mass, facilitating of glycogen storage,improved tissue oxygenation, reduced oxidative stress, and reduced inflammation. At the same time, it should be mentioned that Craddock and Probst (2015) documented no discernible differences in athletic performance between people using vegetarian or omnivorous mixed diets. The aforementioned authors concluded that consuming a predominately vegetarian-based diet did not improve or hinder performance in athletes. Moreover, the performed overview of literature showed the occurrence of several imperfections of a vegan diet.

The performed investigations showing the reasons forchoosing plant-based diets by athletes are consistent with the investigations of Cliceri, Spinelli, Dinnella, Prescott, Monteleone (2018), who showed that positive attitudes toward plant-based dishes were positively related to empathic sensitivity towards humans and animals, as well as to attitudes towards healthy and natural products, highlighting theimportant role of food consciousness in determining eating habits.

Conclusions

1. The performed survey of patents and original articles showed the wide use of cyanobacteria and algae (organism tissue), fungi (fruiting bodies), as well as plants (roots, tubers, leaves, fruits and seeds) in manufacturing food ingredients, as well as products supplementing the diet, enhancing athletic performance, ameliorating mental alertness, improving physical health, preventing disorders, and controlling body weight.

2. The performed research indicated the occurrence of beneficial effects (e.g. the enhancement of muscle strength and endurance, reduction of risk of heart diseases, and improvement of cardiorespiratory fitness), as well as the imperfections (e.g. increase of post-exercise oxidative stress, greater risk of anaemia and osteoporosis) of non-animal diets.

3. The acceptance of vegan and vegetarian diets in athletes flows from religious and ethical beliefs, as well as the advantages of sustainable eating practices.

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THE EFFECTS OF AN ALTERNATIVE TRAINING METHOD ON PHYSICAL AND TECHNICAL ABILITIES OF ADOLESCENT SOCCER PLAYERS: A PILOT STUDY

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Abstract This study examined the effects of an alternative strength training method during soccer training on the development of physical and technical abilities of youth soccer players. 17 soccer players (age: 15 ±0.5 years) were divided in a control

group (CG) and an experimental group (EG). The players of the EG wore a "weight shorts", with 300 gr of additional weight on each thigh, while they participated into 3 regular soccer training sessions per week, for 12 weeks. The CG followed the same training program without wearing the "weighted shorts". Before and after 12 weeks of training, anthropometric characteristics, 10- and 30-m speed, the Arrowhead change-of-direction test, the Illinois agility test with ball, the countermovement jump, and the 5-repetition maximum (5RM) load at the split squat, leg extension and leg curl were measured. The EG improved significantly ($p < 0.05$) more in comparison with the CG in countermovement jump, leg extension and split squat (left leg) 5RM load. The addition of weights on the thighs using special shorts during soccer training sessions leads to increased jumping ability and lower limbs maximal strength in youth soccer players.

Key words youth, additional weight, lower limbs, vertical jump, strength

Introduction

Successful soccer players are characterized by strength, power, and their derivatives (acceleration, sprinting, jumping, and changes of direction) (Hammami, Negra, Aouadi, Shephard, Chelly, 2016). This is in accordance to the activities involved in soccer which are intense and of intermittent nature, with changes in the actions executed every 3–5 sec, resulting in repeated high-intensity spells of play (Karakoç, Akalan, Alemdaroğlu, Arslan, 2012). High-intensity actions such as sprinting, jumping, change of direction, kicking (Negra et al., 2018), dribbling, accelerations and decelerations, tackling and turning (Michailidis et al., 2013) represent major performance determinants not only in elite but also in youth soccer players. Likewise, elite youth soccer players are characterized by greater power, speed and acceleration capabilities than non-elite players at various youth age groups, including U13–U18 years (Murtagh et al., 2018) and they outperformed their sub-elite counterparts in various tests of physical performance (Waldron, Murphy, 2013). Consequently, power production of the lower extremities is necessary for a good athletic performance in soccer (Križaj, Rauter, Vodičar, Hadžić, Šimenko, 2019). Any improvement of youth soccer players' strength and power that can help them to improve their performance in short-lasting efforts during a game (Wong, Chamari, Wisløff, 2010) could be crucial to achieve sporting success in their future career (Negra et al., 2018). Thus, young soccer players should participate not only in regular soccer practice, but also in strength sessions.

Numerous studies have examined the effects of different types (e.g., machine based, free weights or combined, functional/complex/plyometric training) and durations of strength training programs in youths, with some of them finding a positive effect on selected parameters of general and soccer specific performance while others did not (Lesinski, Prieske, Granacher, 2016). Among them, some applied resistance training in addition to soccer training (Christou et al., 2006; Hammami, Negra, Shephard, Chelly, 2017), plyometric exercises into the regular soccer training (Söhnlein, Müller, Stöggl, 2014) or a combined resistance and plyometric training program added to regular soccer training (Zghal et al., 2019). Improvements were observed in maximal strength of the upper and the lower body (Christou et al., 2006), in sprint times from 5- to 40-meters (Christou et al., 2006; Söhnlein et al., 2014; Hammami et al., 2017; Zghal et al., 2019), in vertical jump height (CMJ, SJ or DJ) (Christou et al., 2006; Hammami et al., 2017; Zghal et al., 2019) and in agility (Christou et al., 2006; Söhnlein et al., 2014). However, no study examined how the effects of strength training applied by performing specific soccer movements with additional weight during regular training.

Strength training for the improvement of muscular force production remains a key component of any training program for the adolescences both for performance and injury prevention reasons (Lloyd et al., 2015). It has

been stated, though, that strength training must be integrated with sport specific skills training to improve skill performance (Maio Alves, Rebelo, Abrantes, Sampaio, 2010). In this context, portable and relatively inexpensive training devices can provide positive training effects. To the best of our knowledge, no study has examined the effects of an on-field combined strength and power training for the lower limb's using a portable training equipment such as additional weights on the thighs. Relevant studies could provide scientific rationale for soccer coaches and strength and conditioning specialists to include a strength training program using portable training equipment, which could be used by any team as a feasible and cost-effective on-field strength training program while performing regular soccer training. Thus, the aim of the current study was to examine the effects of an on-field lower limbs' strength and power training program using a portable equipment on physical and technical abilities of youth soccer players. It was hypothesized that wearing a special portable, short-construction shorts with additional weight on each thigh, while participating for 12 weeks in soccer training sessions, would improve maximal strength, jumping ability, speed and agility of youth soccer players.

Methods

Participants

Seventeen adolescent, male regional soccer players voluntarily participated in the current study. The training age of the players was 7.2 ±2.05 years and the regular soccer training sessions took place 3 times per week. The players and their parents were informed about the nature and the aim of the study, its benefits and the risks. Afterwards, the parents of the participants signed an informed consent form which was approved by the University's institutional review board and ethics committee. All the procedures were in accordance with the Helsinki's Declaration. The participants were separated into a control group (CG; N = 7) and an experimental group (EG; N = 10) (Table 1).

Table 1. Mean and standard deviation of the participants' anthropometric characteristics before the intervention

	Control Group (N = 7)	Experimental Group (N = 10)
Age (years)	15.1 ±0.3	14.9 ±0.7
Training Age (years)	6.8 ±2.4	7.6 ±1.7
Height (m)	1.75 ±0.03	1.71 ±0.06
Weight (kg)	62.2 ±2.48	58.7 ±8.56
BMI (kg/m^2)	20.34 ±1.31	19.94 ±1.92
Waist Circumference	68.17 ±1.94	66 ±4.39

Training program

Both the control and the experimental groups trained together, as one team, 3 times per week (Tuesday, Wednesday and Friday) for 12 weeks performing the same training sessions. Each training session lasted 80–90 min. In addition, all participants took part, as one team, once a week in an official regional soccer-match, usually on Sunday, lasting 80 minutes (2 × 40 minutes/half time). The aim of the training sessions was to improve the players' technical, tactical and physical abilities. Table 2 presents analytically the training contents applied throughout the 12-week intervention program.

Table 2. Training contents applied throughout the 12-week intervention program

Training contents	Weeks											
	1	2	3	4	5	6	7	8	9	10	11	12
Warm up, Rondo games (i.e., 5vs2)	■	■	■	■	■	■	■	■	■	■	■	■
Practice games		■		■	■	■	■					
with goals (large or small)												
for retaining possession												
and passing the ball as a group												
Small side games								■	■	■	■	■
Pressure games		■	■	■	■	■		■	■	■	■	■
frequent 2vs2, 3vs3												
and 4vs4 sitiuations												
Multiple actions			■	■	■	■		■	■	■	■	■
with goal shooting												
large goals												
Games			■	■	■	■	■		■	■	■	■
with tactic elements/												
guided games												
Final games				■	■	■	■	■	■	■	■	■
free play (freedom of expression, spontaneity)												
Creativity												

(a) (b) (c)

Figure 1. (a) Additional weight case of 300 gr; (b) Socket for the additional weight; (c) Additional Weight Shorts (AWS) (Photographs: Efthimios Bogiatzidis)

The only difference between the two training groups was that the players of the experimental group wore in each training session special shorts constructed for the purposes of the current study, the Additional Weight Shorts (AWS). In these shorts the additional weight for each leg was 300 gr (Figure 1a). The additional weight was added in a special socket at the height of the thighs (Figures 1b and 1c). The soccer-players wearing these shorts were

able to run, jump, pass, shoot and take part in soccer training without any discomfort. To fit well each participant, there were different sizes (XL youth-size, S-L adult-sizes) of shorts. There was a gradual increase in the time they wore the AWS, starting with a minimum of 10% up to a maximum of 80% of the total training time. Table 3 shows the training time wearing the AWS during the 12 weeks training period.

Table 3. Minutes in each training session wearing the AWS throughout the 12-week intervention program (minutes)

Week – Intervention	Training session 1	Training session 2	Training session 3
1	13	15	8
2	21	40	18
3	13	40	33
4	21	45	45
5	21	45	45
6	25	50	47
7	25	55	50
8	42	55	55
9	48	59	57
10	32	62	60
11	32	62	60
12	35	65	63

Testing procedures

The jumping and strength abilities were evaluated one week before and one week after the 12 weeks intervention training period and the follow-up evaluation was performed 4 weeks after the post measurement. Due to Covid-19, speed, agility and technique were assessed only pre- and post- the 12-week intervention training period.

The tests were executed at an outdoor soccer field with natural grass, where the participants wore soccer shoes, and at a gym with fitness equipment, where they wore indoor shoes. The week before testing there was a familiarization with the execution of the physical and technical ability tests and proper form and technique of each test was practiced according to the instructions of the research assistants. Before testing, the soccer players abstained from physical exercise for 1 day. Verbal encouragement was used throughout all tests to achieve maximum effort. The same researcher measured all the participants.

Sprint testing. 10-meters sprint time was measured with 2 photocells using the New Test Powertimer 300-series (Oy, Finland). A photocell was placed at the start and at 10 m. The players started 50 cm behind the first photocell to avoid an early activation of the timing mechanism. The photocells were placed at a height of 80 cm from the ground. The participants run as fast as possible, reaching the finish point of the final photocell, which was placed at 10 meters. Timing was performed at the distance of 10 meters. After 1 practice trial, 2 sprint tests were performed, separated by a 3-min recovery period, and the fastest trial was used for further analysis. 30-meters sprint time was measured with 2 photocells. One photocell was placed at the start and one at 30 m. The players followed the same procedure as in the 10 m sprint. Timing was performed at the distance of 30 meters. After 1

practice trial, 2 sprint tests were performed, separated by a 5-min recovery period, and the fastest trial was used for further analysis.

Change of direction (COD) ability. The Arrowhead test was used to evaluate COD ability. The New Test Powertimer 300-series portable photocells were used (Oy, Finland). The players started 50 cm behind the starting point, where the first photocell was placed, to avoid an early activation of the timing mechanism. The second photocell was placed at the finish line. Both photocells were placed at a height of 80 cm from the ground. The participants run as fast as possible until reaching the finish line. The test was conducted both turning left and right. After 1 practice trial, 2 trials for each left and right turning were performed, separated by a 5-min recovery period, and the fastest trial was used for further analysis.

Technical – agility. For the evaluation of technical agility the Illinois test was used. The New Test Powertimer 300- series portable photocells were used (Oy, Finland). The participants performed the test in the current study with a soccer ball. The players started 50 cm behind the starting point, where the first photocell was placed, to avoid an early activation of the timing mechanism. They started in the prone position with the chin touching the ground and the hands at shoulder level. The soccer ball was placed on the starting line. The second photocell was placed on the finish line. Both photocells were placed at a height of 80 cm from the ground. The participants run for the best possible time while dribbling a soccer ball with their feet without losing the control until reaching the finish line. After 1 practice trial, 2 trials were performed, separated by a 5-min recovery period, and the fastest one was used for further analysis.

Vertical jump performance. Vertical jump ability was assessed using the countermovement jump (CMJ) and the squat jump (SJ). Vertical jump height was calculated by the flight time measured with a contact mat (New Test Powertimer 300-series, Oy, Finland). For the execution of the CMJ, each participant placed his feet in the center of the contact mat and his body was in an upright position with the arms akimbo. The researcher gave a verbal signal and the participant moved from an upright position down to a semi-squat and performed a maximal vertical jump (stretching-shortening cycle), taking care to land on approximately at the same part of the contact mat with the legs kept outstretched during the jump. For the SJ, the participants placed their feet in the center of the contact mat with the arms akimbo, adopted the semi-squat position (knees angle at 90°) and without any pre-stretch performed a maximal vertical jump. The researcher was taking care that participants were descending at each jump until a knee angle of 90° was formed, landing with the toes and approximately at the same part of the contact mat.

Maximum strength. Maximum strength of the lower limbs was measured at the exercises leg extension, leg curl and split squat (single left and right leg). As an index of maximum strength, the maximum load that could lifted for 5 repetitions (5RM load) at each exercise was considered. As a warm-up, one set of 8 repetitions was performed with a load 50% of the estimated 5RM load and one set of 5 repetitions with a load 75% of the estimated 5RM load were executed. After those 5 repetitions with the load estimated to be the 5RM load were performed. If the trial was successful, the load was increased by 10% until the participants were unable to successfully perform 5 repetitions, which occurred within two to four attempts. The rest interval between sets was 3 min.

For the execution of the leg extension exercise the participants were seated on a leg extension machine (Super Sport, Athens, Greece) with their hands grasping handles. From this position they extended their legs until a full knee extension was achieved. Leg curl testing was performed on a leg curl machine (Super Sport, Athens, Greece) with the participants laying with face down, the hands grasping handles and performing a full knee flexion. The split squat testing was executed using a smith machine (Sfitness, Shanghai, China). The test started with the

participants standing upright on one leg. The top of the foot of the leg not participating in the movement was placed on a standard gym bench, positioned behind the participants, to ensure that the working leg was isolated to perform the attempt. The participants had to execute a single-leg squat until a 90° angle was formed between the thigh and the shank.

Statistical analysis

Two-Way repeated measures ANOVAs were used for the statistical treatment of the data, with "Group" as between and "Time" as within factor, along with the post hoc test Bonferroni. The statistically significant level was set as $p < 0.05$. All results are reported as mean ± SD.

Results

Seventeen participants successfully completed the study, without reporting any injury due to the intervention or the overall soccer training program. The control group and the experimental group did not differ significantly in any of their anthropometric characteristics before the beginning of the intervention program ($p > 0.05$).

Analysis of variance for repeated measures revealed statistically significant interactions between the two factors ("Group" and "Time") in the Countermovement Jump [$F_{(2, 30)} = 3.763$; $p = 0.035$], the Leg Extension [$F_{(2, 26)} = 17.120$; $p = 0.001$] and the Left-leg Split Squat test [$F_{(2, 26)} = 3.499$; $p = 0.045$]. The experimental group showed statistically significant greater improvement in the above variables in comparison with the control group (Table 4). The analysis of interaction revealed significant differences between the control and the experimental group in the Leg Extension in the follow up measurement [$F_{(1, 13)} = 5.124$; $p = 0.041$] and in the Left-leg Split Squat both in the post intervention measurement [$F_{(1, 13)} = 4.305$; $p = 0.048$] and the follow up measurement [$F_{(1, 13)} = 4.131$; $p = 0.043$]. In the countermovement jump a significant simple main effect of the within factor "Time" was observed only in the experimental group [$F_{(2, 14)} = 6.856$; $p = 0.008$], and the post hoc Bonferroni test revealed significant differences between the pre intervention and the follow up measurement (Table 4).

In Leg Extension a significant simple main effect of the within factor "Time" was observed both in the experimental [$F_{(2, 12)} = 73.222$; $p = 0.001$] and the control group [$F_{(2, 12)} = 10.205$; $p = 0.003$]. However, in the experimental group the post hoc Bonferroni test revealed significant differences between all measurements, while in the control group significant differences were found between the post intervention and the follow up measurements in comparison with the pre intervention measurement (Table 4).

Regarding the Left-leg Split Squat test a significant simple main effect of the within factor "Time" was observed both in the experimental [$F_{(2, 12)} = 66.890$; $p = 0.001$] and the control group [$F_{(2, 12)} = 19.837$; $p = 0.001$], and the post hoc Bonferroni test revealed significant differences between all measurements (Table 4).

A statistically significant main effect of the within factor "Time" was observed in the Right-leg Split Squat test [$F_{(2, 26)} = 62.583$; $p = 0.001$] and in the Leg Curl test [$F_{(2, 26)} = 69.323$; $p = 0.001$], regardless of "Group", and the post hoc Bonferroni test revealed significant differences between all measurements. As far as the Squat Jump is concerned, a significant main effect of the within factor "Time" was also found [$F_{(2, 30)} = 6.489$; $p = 0.005$], regardless of "Group". The post hoc Bonferroni test revealed significant differences between the pre intervention and the follow up measurement (Table 4).

Table 4. Mean and SD values of the vertical jump and 5RM strength test variables pre-intervention, after 12 weeks of the training intervention, and after a 4 week follow up period in the control and experimental groups

	Control Group (N = 7)			Experimental Group (N = 10)		
	pre	post	follow up	pre	post	follow up
Countermovement Jump (cm)	34.43 ±5.96	33.57 ±3.69	34.29 ±5.93	31.30 ±3.68	33.40 ±4.88	35.60 ±4.88 ŧ
Squat Jump (cm)	28.71 ±3.81	28.86 ±3.67	30.00 ±3.36 ŧ	28.60 ±4.88	31.00 ±3.33	32.70 ±3.43 ŧ
5RM Leg Extension (kg)	38.83 ±3.43	44.33 ±3.26 ŧ	45.00 ±3.09 ŧ	37.67 ±5.91	47.89 ±6.54 ŧ	53.11 ±8.31 ŧ§*
5RM Leg Curl (kg)	36.33 ±5.16	45.17 ±5.38 ŧ	47.50 ±6.68 ŧ§	36.56 ±7.68	46.56 ±7.29 ŧ	51.78 ±7.34 ŧ§
5RM Split Squat Right-leg (kg)	22.50 ±3.39	31.67 ±8.50 ŧ	39.50 ±13.23 ŧ§	25.11 ±4.85	37.33 ±5.36 ŧ	49.11 ±10.15 ŧ§
5RM Split Squat Left-leg (kg)	21.67 ±3.26	29.50 ±6.53 ŧ	37.00 ±10.46 ŧ§	25.33 ±6.26	37.00 ±7.05 ŧ*	48.78 ±11.31 ŧ§*

* Significantly different from the control group.
ŧ Significantly different in comparison with the pre-intervention measurement.
§ Significantly different in comparison with the post-intervention measurement.

No significant differences were found in all the sprint and agility variables neither between the two groups, nor between the pre- and post-intervention measurements (Table 5).

Table 5. Mean and SD values of the sprint test pre-intervention, after 12 weeks of the training intervention, and after a 4 week follow up period in the control and experimental groups (sec)

	Control Group (N = 7)		Experimental Group (N = 10)	
	pre	post	pre	post
10 m sprint time	1.97 ±0.40	2.04 ±0.24	1.92 ±0.36	2.01 ±0.16
30 m sprint time	4.82 ±0.65	4.84 ±0.38	4.80 ±0.59	4.77 ±0.30
Arrowhead COD right	8.93 ±0.57	9.10 ±0.61	8.78 ±0.53	8.74 ±0.30
Arrowhead COD left	9.08 ±0.60	9.10 ±0.63	8.86 ±0.65	8.89 ±0.33
Illinois test	22.96 ±2.24	23.17 ±2.74	21.75 ±2.18	21.23 ±1.07

Discussion

This study examined the effects of using a specific strength training tool, a weighted shorts with 300 gr on each thigh worn while participating in regular soccer training sessions, on the development of physical abilities of youth soccer players. The main findings of the current study were that strength of the lower limbs and vertical jumping ability of the young soccer players were improved while sprinting speed, change of direction (COD) and technical - agility abilities were less or not affected.

In the current study the EG achieved a higher performance compared to the CG after 12 weeks of training in the split squat only with the left-leg. This can probably be interpreted by the fact that 8 of the 10 players had the right leg as the dominant leg and due to the use of the AWS they improved more the strength of their left leg. They did not show significant differences compared to the control group in other tests, maybe because there were residual effects of the training period on the lower limbs, since the post-training evaluation was performed the following week. However, in the follow-up measurement, 4 weeks after the end of the training period, although the EG-players did not wear the AWS during training for 4 weeks, they improved significantly compared to the

CG in maximal strength in the split squat left-leg and the leg extension, and the countermovement jump. This was probably due to the physical adaptions that occurred during the 12-week training period. Probably, a tapering period of reduced stress, training without additional load on the thighs, was necessary for the positive outcomes of this specific training method to appear. This aspect is further supported by the fact, that also the squat jump, maximum strength in the right-leg split squat and the leg curl improved from post- to follow-up measurement, although not significantly compared to the control group. On the other hand, the improvement of the CG in the follow-up period in the squat jump, leg curl, split squat (single right and left leg) may be due to growth of the participants who were in adolescence but also from the participation in soccer training alone that leads to improvements in the performance of the lower body. In this context, Christou et al. (2006) showed significant increases in lower-body strength (leg press) after 8 and 16 weeks of strength/soccer and soccer training but in a control group as well, in males aged 13.8 ±0.4 years.

There are controversial results regarding the effectiveness of strength training on sprint performance. The current findings are in contrast with studies that observed an improvement in sprint performance in youths (Christou et al., 2006; Hammami, et al., 2017) following a strength training period but in agreement with other studies that found no effect or even a negative effect of strength training on sprint performance (Gorostiaga et al., 2004; Buchheit, Mendez-Villanueva, Delhomel, Brughelli, Ahmaidi, 2010; Lopez-Segovia, Andres, Gonzalez-Badillo, 2010). In the current study the performance at 10 m sprint time remained unchanged in both groups. We speculate that this finding is explained by the age (15 ±0.5 years) and the growth period our players were at. Cavaco et al. (2014) reported, that in these ages' growth affects motor coordination. The intra/inter muscular coordination and the neural control of the movement are affected at these ages by the constant modification of the anthropometric structure. Also, the performance at 30 m sprint time remained unchanged in both groups. Christou et al. (2006) showed no significant improvements in 10 m sprint time but a significant improvement in 30 m sprint time after a combined strength/soccer training program. In addition, improvements in sprint performance were found in studies where the speed ability was specifically trained (Kotzamanidis, Chatzopoulos, Michailidis, Papaiakovou, Patikas, 2005; Spinks, Murphy, Spinks, Lockie, 2007; Dasteridis, Pilianidis, Mantzouranis, 2011; Lockie, Murphy, Schultz, Knight, Janse de Jonge, 2012), something that was not done in the current study.

Regarding the absence of changes in COD performance found in the current study, this is consistent with the findings of other studies, that found no positive effects after a strength training intervention (Maio Alves et al., 2010; Shalfawi, Haugen, Jacobsen, Enoksen, Tonnessen, 2013). However, some previous studies observed a positive effect of strength training on COD performance (Nimphius, McGuigan, Newton, 2012; Söhnlein et al., 2014; Negra et al., 2018). Brughelli, Cronin, Levin, Chaouachi (2008) stated that the training protocols reporting improvements in COD performance have utilized exercises that more closely mimic the demands of COD, which include horizontal/lateral jump training (unilateral/bilateral), loaded vertical jump training, sport-specific and general COD training. In the current study this wasn't separately targeted.

To the best of our knowledge this is the first study that examined the effects of the use of a weighted shorts during regular soccer training on the improvement of physical abilities of young soccer players and positive effects were found on the strength of the lower limbs and vertical jumping ability. This is of importance since the weighted shorts is: a) a portable training tool that can be easily added and removed, b) appears to be a safe alternative way of strength training, as no training-related injuries were reported, and c) it allows the execution of all soccer-specific movements and the coaches have nothing to change in their planning as wearing it, players can participate

normally in the soccer training sessions. However, a limitation of the present study is the small sample size of the participants. A bigger sample could have offered better results about the effect of AWS on the physical performance of young soccer players. Moreover, the results of the present study are restricted only on the particular age category of male adolescent soccer players. Future attempts should extend these findings in other age groups and even in females. In any case, it should be noted that in this study an alternative on-field strength training method was applied, using a new and practical tool into regular training sessions for improving soccer-specific performance, without any differentiation in the training plan and this make this study practically important.

Conclusions

Soccer is a demanding sport in terms of physical characteristics. Strength and power are essential for players during running or jumping or to catch the ball before their opponents. The findings of the current study revealed that young U-16 (age: 15 ±0.5 years) soccer players who carried an additional weight of 300 gr on each thigh with a progressively increasing duration of their use for 12 weeks during the in-season period and participating normally in regular soccer training sessions (passing, shooting, sprinting, jumping, games, tactic etc.), have a positive effect on some of the parameters of the physical abilities. The strength and power of the lower limbs and their jumping performance were increased, using a cheap, practical and portable equipment, without extra training time and without disturbing the training sessions. These findings have important and direct implications for coaches and sport scientists involved in the development and training of youth soccer players. However, the current study also showed that to improve abilities such as speed, change of direction and technique-agility, more targeted and specific intervention related to these skills should be organized and this could be a perspective for future studies.

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ASSESSMENT OF KNOWLEDGE AND ATTITUDE IN THE FIELD OF DOPING IN YOUNG ATHLETES OF TEAM GAMES

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Abstract Contemporary sport is becoming more and more commercialized, hence the players strive to win at all costs, and to achieve this goal, they consider all means to be allowed. In order to be constantly on top, competitors change their training methods, use various aids, and finally direct their interests towards doping. Doping is considered to be the use of substances and all means intended to artificially increase physical fitness during sports competitions, which may be harmful to the ethics of sport or cause mental and physical harm to athletes.

The aim of the research is to assess the knowledge of the problem and attitudes of young people practicing sports games towards the dangers of doping. Assessment of knowledge on the effects of the use of illicit means, and analysis of opinion on the use of doping and strengthening mechanisms for the adoption of pharmacological agents.

Research on the knowledge about the use of support measures and doping in sport was carried out among talented youth practicing team sports games in randomly selected clubs of Małopolska, Silesia, Podkarpacie and Opole. Continuation studies were conducted in 2018–2020, they covered 60 girls and 60 boys, aged 16 years. The research was carried out using a questionnaire, the questions of which concerned the following problems: knowledge of the essence of sports doping, the relationship between doping and the principle of fair play in sport, support used in physical recreation, reasons for the use of doping, moral and criminal liability in the use of doping.

When analyzing the results of the research, it should be noted that the use of doping in sport is negatively perceived by the examined youth. However, it can be assumed that the knowledge about the support and the problem of doping in sport is insufficient. Setting the main goal – sports success and the related financial rewards, as well as the willingness to be the best in the opinion of the respondents may narrow the boundaries, which may facilitate the decision to use support and doping. These observations seem to be very disturbing, as the analysis of research data concerns young people practicing sports at the stage of education and the utilitarian nature of physical activity.

Key words doping, youth, sports games, knowledge

Introduction

Playing sports is a way of shaping not only physical, physical and mental fitness, but also shaping positive interpersonal relations. Sport is an ideal means of developing social bonds, a way of creating an integrated society. By its meaning, goals and values, sport transcends the purely bodily dimension and plays an important role in strengthening the health and character of the young generation, giving them the basic tools to meet the challenges of life.

However, despite its values, today's competitive sport slightly changes the beauty of the idea of sport, because in the era of commercialization it becomes a type of activity aimed at extending the limits of fitness and physical endurance of an individual, even at the cost of one's own health. Quite often nowadays, competition, and thus the essence of sport, has become the driving force behind the search for easy paths to success at various levels, especially since victory brings not only satisfaction, but also awards, honors, fame and, most importantly, big money. Hence, the contestants strive to win at all costs, and to achieve this goal, they consider all means permitted. In order not to fall out of the "carousel of sports successes", the players look for various ways out. They change training methods, use various aids, and finally turn their interests towards doping. The word doping was first introduced to sports vocabulary in 1889. It was then used to denote illegal measures used to increase the performance of racehorses. In the same year, the word appeared in the English lexicon as a designation of a mixture of opium and drugs administered to horses during races. From 1935, doping functioned in English as a common term (Yesalis, Bahrke, 2002) Doping is considered to be the use of substances and all means intended to artificially increase physical fitness during sports competitions, which may be harmful to the ethics of sports or harm athletes, both mentally and physically (Rewarski, Nazar, 1995).

Taking into account the disastrous effects of doping on health and sport at work, an attempt was made to test the awareness of this problem among young people, because according to Lipiec (1994), the effectiveness of the fight against doping depends on the one hand on the use of more and more perfect methods of detecting doping agents in the body of athletes, and on the other hand, on the progress in the field of education and prevention from an early age.

Aim of the study and basic assumptions

The aim of the research is to assess the knowledge of the problem and attitudes of young people practicing team sports towards the dangers of doping. Assessment of knowledge about the effects of using illegal substances, and analysis of opinions on the use of doping and the mechanisms of taking fortifying drugs.

Research questions were asked in the work:

1. Do young people practicing sports have optimal knowledge about the use of support measures?
2. Is there any awareness of the dangers of doping among young people?

Research hypothesis

Due to the nature of practicing sports, young people have a negative attitude towards the threat posed by the use of prohibited support measures.

Material and research methods

Research on the knowledge about the use of support measures and doping in sport was carried out among talented youth practicing team sports games in randomly selected clubs of Małopolska, Silesia, Podkarpacie and Opole. Continuation studies were conducted in 2018–2020, they covered 60 girls and 60 boys, aged 16 years. The research was carried out using a questionnaire, the questions of which concerned the following problems: knowledge of the essence of sports doping, the relationship between doping and the principle of fair play in sport, support used in physical recreation, reasons for the use of doping, moral and criminal liability in the use of doping. The validation of the survey carried out by experts in the field of sport ethics in terms of accuracy was tt = 0.96, and the reliability in the mock test was tr = 0.99 (Hermer, 1985; Brzeziński, 1996).

Presentation and discussion of research results

When discussing the research results, the first step was to analyze the knowledge of the essence of doping in sport. Attempts were made to assume that the knowledge of the problem that was discussed in the research is the starting point for this issue. According to the compiled data, both girls and boys have an advantage in the full knowledge of this problem. However, a large percentage of incorrect answers can be noticed (Table 1).

Table 1. Knowledge of the definition and essence of doping in sport

Type of response	Girls	The boys
	n = 60	n = 60
Correct	31 = 51.6%	34 = 56.6%
Incorrect	29 = 48.4%	26 = 43.4%

It seems that the problem of doping in sport should be presented more precisely among young people. In the era of support and treatment with pharmacological agents, there is a fluid limit in the selection of strengthening agents and drugs that may have a doping effect (example: Kuzniecowa, Maradona, Armstrong) – sport.tvp.pl.

The presentation of further research results concerns the non-compliance of doping with the principle of fair play (Table 2). and opinion polls on the admissibility of doping in sport (Table 3).

Table 2. Opinion research: is the use of doping consistent with the principle of fair play in sport?

Type of response	Girls	The boys
	n = 60	n = 60
Yes	0 = 0%	1 = 1.6%
No	58 = 96.6%	55 = 91.7%
I don't know	2 = 3.4%	4 = 6.7%

Table 3. Opinion on: Should doping in sport be allowed?

Type of response	Girls	The boys
	n = 60	n = 60
Definitely not	54 = 94%	52 = 86.7
Definitely yes	0 = 0%	0 = 0%
Depending on the situation	4 = 6.7%	8 = 13.3%
I have no opinion	2 = 3.3%	0 = 0%

It should be noted that over 90% of the respondents indicate the correct direction in their opinion on these issues. It is a good prognostic of the opinion of the respondents on these issues, nevertheless almost 10% of the respondents show a different opinion or a lack of decisiveness on the topic that seems so obvious.

The opinion on the problem of penalties for doping in sport is presented in Table 4.

Table 4. Opinion on: How to punish doping in sport?

Type of response	Girls	The boys
	n = 60	n = 60
Only a financial penalty	1 = 1.6%	3 = 5%
Only the suspension of the rights of the player for a specified period	12 = 20%	15 = 25%
The suspension of the competitor's rights and a financial penalty	24 = 40%	27 = 45%
Lifetime disqualification	22 = 36.7%	13 = 21.7%
I have no opinion	1 = 1.7%	2 = 3.3%

The results of the research illustrate quite diverse penal sanctions that would be imposed by both girls and boys. It seems that these opinions may illustrate an extended boundary of responsibility, which is not a good prognosis for the future attitude of the surveyed youth in the issue of doping in sport.

Table 5 presents the opinion of the surveyed youth on the harmfulness of doping in sport.

Table 5. Does doping harm your health?

Type of response	Girls	The boys
	n = 60	n = 60
Probably yes	4 = 6.6%	5 = 8.3%
Yes	53 = 88.4%	45 = 75%
Probably not	3 = 5 %	8 = 13.4%
No	0 = 0.0%	2 = 3.3%

Research data show that girls, more than boys, have a precise opinion about the harmfulness of doping to health. This condition may be due to the fact that boys may play down the dangers of doping to a greater extent, or that they have such a high health indicator at the moment that they do not feel such a threat.

Important information in the field of knowledge about the importance of support on sports results is provided by the studies in Table 6.

Table 6. Does the sports result depend to a large extent on support – doping?

Type of response	Girls	The boys
	n = 60	n = 60
Yes	39 = 65%	47 = 78.4%
No	18 = 30%	12 = 20%
I do not know	3 = 5%	1 = 1.6%

These data clearly show that both girls, and especially boys, have a specific opinion on the importance of supporting in achieving a high sports result. It seems that such a phenomenon is disturbing, as it may narrow the line in the mild perception of the problem of sports doping.

When looking for a tendency to change their image – physical fitness, an attempt was made to find out whether the subjects could be open to using any support.

Table 7. Do you feel a great desire to change the image of your physical fitness?

Type of response	Girls	The boys
	n = 60	n = 60
Yes	30 = 50%	41 = 68.4%
No	28 = 46.7%	18 = 30%
I do not know	2 = 3.3%	1 = 1.6%

The data in Table 7 show a high percentage of disturbed self-esteem process in terms of physical fitness of the examined girls and boys. Therefore, taking into account the high rank for support in achieving a sports result (Table 6), it can be assumed that most of the respondents could use support to improve their physical fitness. Such a phenomenon may be disturbing, and the reason for such an attitude can be seen in the high dynamics and commercialization of social life, which requires striving for excellence, sometimes at any cost (an example of the widespread use of amphetamines among young people learning).

The data in Table 8 in the aspect of a possible decision to accept doping presents us with a very diverse position. Although the analysis of the data shows that in both girls and boys, opinions negating this precedent prevail, some respondents show some tendency to use unauthorized support (girls approx. 11.7% – boys approx. 24.9%).

Table 8. Would you decide to take illegal support measures to achieve high sports success?

Type of response	Girls	The boys
	n = 60	n = 60
Definitely yes	2 = 3.3%	4 = 6.6%
Yes – if it was certain that they would not be detected	5 = 8.4%	11 = 18.3
No	43 = 71.7%	37 = 61.8%
I have no opinion	10 = 16.6%	8 = 13.3%

On the other hand, Table 9 presents the position of the respondents in a specific situation of choosing a decision to use doping.

Table 9. Reason why you could take illegal support measures?

Type of response	Girls	The boys
	n = 60	n = 60
Only to achieve a high sports result	17 = 28.4%	15 = 25%
For high sports results and financial benefits	38 = 63.3%	44 = 73.3%
I have no opinion	5 = 8.3%	1 = 1.6%

Presented in Table 9, the questions refer to the studies in Table 6–8 and indicate the disturbing position of young athletes to the possible adoption of doping depending on complex circumstances. The content of the data shows that the desire to achieve a high result, sports success and thus financial benefits could change their position in the approval of the use of sports doping.

Discussion

When discussing the presented research results, it should be noted that the use of doping in sport is generally negatively perceived by the examined youth. However, knowledge about the support and the problem of doping in sport is unstable and insufficient. These results are also confirmed by the research conducted by Duda (2005).

Setting the main goal – sports success and the related financial rewards, as well as the willingness to be the best in the opinion of the respondents may narrow the boundaries, which may facilitate the decision to use support and doping. These observations seem to be very disturbing in sports education, as the analysis of research data concerns young people practicing sports at the stage of education and the utilitarian nature of physical activity.

This stage is very significant in the development of a young athlete, because due to the great disinterestedness (the autotelic nature of the action prevails) – Naglak (2005), Duda (2012), he/she should develop a disinterested and ethical attitude in sports competition. However, an analysis of selective studies points to a different trend. So one can wonder about the cause of this phenomenon. It seems that in modern sport, even in the initial stages of training, considerable commercialization can be noticed (Paluszek, 2010), instrumental goals are becoming more and more dominant (valuable rewards, domination and too high expectations of parents in the process of training children), which distort the healthy and objective competition. Young athletes want to win at all costs, thus disturbing their self-esteem, which lowers the norms of values in sports competition (Duda, Wisłocki, 2013). At this point, you should consider what else is causing it. It seems that high tolerance to the use of doping results from the high popularity of doping already in recreational activity. This is called mild doping used in gyms and fitness clubs to improve psychophysical condition (Wichstrom, Pedersen, 2001; Rachon, Pokrywka, Suchecka-Rachon, 2006). Also, from the psychological point of view, this aspect is related to a specific well-being, which, if misunderstood, may allow for self-satisfaction, which alleviates the responsibility of doping (Seligman, Steen, Paarks, 2004). It also seems that modern doping, through the use of hardly detectable adjuvants (Barroso, Mazzoni, Rabin, 2008), may also encourage the use of this type of drugs. Another reason for such a state of affairs may lie in the danger of explaining the unethical attitudes of "sports champions" – the example of "God's hand" performed by the Argentine footballer Maradona (Liś, Olszański, 2014), or tolerance in anti-doping tests for American basketball players of the "Dream Team" at the Olympics in Barcelona in 1992 (Lipoński, 1996). It seems that such cases, mainly related to the commercialization of sport, can to a large extent "mitigate" the negative phenomenon of sports doping, which in its

form, despite the large social disapproval, is still a problem for fair play sports competition. At the end, the author would like to point out that the aim of the study was to selectively identify knowledge in the field of doping, its health hazards and the attitude itself towards the possibility of its application among young people practicing sports. The analysis of data and previous research in this aspect (Duda, 2005) shows that the topic related to the risk of doping among adolescents is still relevant and indicates a tendency to look at this problem gently. According to the authors, this phenomenon is significant not only in ethical sports education, but can significantly affect the pro-health dimension of sport, rationalization of training and future attitude in competition in line with the Olympic spirit.

Conclusions

1. There is an insufficient level of knowledge of doping in sport among the examined youth.

2. Increasing the requirements, the rush for perfection narrows the boundaries of the mental attitude towards the problem of doping in sport.

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CHANGES IN THE BLOOD PRESSURE, HEART RATE AND BODY MASS OF PHYSICALLY ACTIVE MEN IN RESPONSE TO THERMAL STRESS

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Abstract **Background:** Finnish sauna is presently the most popular type of thermal therapy in Europe. Saunas are widely available in aquaparks, SPA centers and hotels. In Scandinavian countries sauna is regarded not only as a form of treatment, but as a part of the national lifestyle.

Objective: The aim of this study was to evaluate sauna-induced changes in systolic (SBP) and diastolic blood pressure (DBP), heart rate (HR) and body mass in healthy men.

Methods: Thirty healthy men aged 20–49 years (mean age: 31.2 ±11.3 years) attended four 12-minute Finnish sauna sessions (temperature: 90°C, humidity: 14–16%) with 6-minute breaks in between sessions, including cold water immersion for 1 minute. The participants' physical activity (PA) levels were evaluated with an IPAQ questionnaire. Sauna bathers' body composition, BP and HR were measured before the first and after the fourth sauna session.

Results: A significant ($p < 0.001$) decrease in SBP and DBP values was noted in response to sauna regardless of the bathers' body mass, age and PA levels. The average HR increased significantly in younger, slimmer and more physically active participants. Sauna treatment induced a significant decrease in body mass loss regardless of all independent variables.

Conclusions: Repeated 12-minute Finnish sauna sessions have a beneficial influence on the cardiovascular system. Finnish sauna can be recommended for healthy men with average and high PA levels as a means of decreasing BP. Body mass loss, on the other hand, is related to the loss of body fluids as a result of sweating.

Key words dry sauna, blood pressure, heart rate, body mass loss, physical activity

Introduction

Finnish sauna is presently the most popular type of thermal therapy in Europe. Saunas are widely available in aquaparks, SPA centers and hotels, and the average admission fee is not high. In the Scandinavian countries, sauna is regarded not only as a form of treatment, but as a part of the national lifestyle (Perasalo, 1988). A visit to the sauna is a social and recreational activity during which the participants enjoy the company of others (Leung, 2017). There is evidence to indicate that regular sauna users have a longer life expectancy than sporadic sauna-goers (Laukkanen, Khan, Zaccardi, Laukkanen, 2015). According to bathers, the main benefits of sauna include stress reduction, improved sleep quality and decrease in chronic pain (Hussain, Greaves, Cohen, 2019). Regular sauna bathing minimizes the risk of modern lifestyle diseases, including overweight and cardiovascular diseases (Hannuksela, Ellahham, 2001; Kukkonen-Harjula, Kauppinen, 2006; Borysławski, Szaliłow, Bielec, Omelan, Podstawski, 2021).

Sauna bathing induces changes in circulation by enhancing blood flow to subcutaneous tissues. Heat accumulated in the body is released during sweating, which lowers blood pressure and increases the heart rate (HR) (Crandall et al., 2008; Pippi, Bini, Reginato, Aiello, Fanelli, 2021). Despite the fact that sauna is not recommended for individuals with cardiovascular diseases, it seems that sauna bathing improves hemodynamic parameters, clinical symptoms and cardiac function in patients diagnosed with congestive heart failure (Blum, Blum, 2007). A review of the literature suggests that controlled exposure to high temperature with low air humidity improves other cardiovascular functions by increasing left ventricular ejection function and considerably decreasing systolic blood pressure (SBP) (Crinnion, 2011). Regular sauna use also enhances the protective functions of the skin by maintaining a healthy pH and water holding capacity of the stratum corneum (Kowatzki et al., 2008). Sauna's effect on body mass loss is ambiguous. A single 30-minute session in a Finnish sauna did not induce significant changes in the body mass of healthy young men with both high and low PA levels (Żychowska, Półrola, Chruściński, Zielińska, Góral-Półrola, 2017). In young and physically active men, significant changes in body mass, body fat and BMI were not reported after ten Finnish sauna sessions (Gryka, Pilch, Szarek, Szyguła, Tota, 2014). In contrast, two 10-minute sauna sessions were found to decrease body mass in young sedentary women and men (Podstawski et al., 2014). The same study also revealed that individuals with high BMI values and high body fat percentage lost more body mass during sauna than lean bathers. The aforementioned studies present different protocols concerning the time of heat exposure in the sauna and the recovery mode. To the best of our knowledge, this is the first study to examine the effect of four 12-minute sauna sessions with a mixed recovery protocol.

Therefore, the aim of this study was to evaluate changes in selected physiological parameters in 30 young and middle-aged healthy men subjected to repeated thermal stress in a sauna. The authors hypothesized that sweating and thermoregulation processes during repeated sauna sessions would increase the HR, promote the loss bodily fluids and therefore decrease the participants' body mass.

Methods

Participants

The study involved 30 men aged 20–49 years (mean 31.2 ±11.31 years) with average and high physical activity (PA) levels. They were selected from a pool of volunteers (47 men) who were informed about the purpose of the study. The candidates were notified by e-mail and text message whether they met the inclusion criteria and were provided with the date of final recruitment. In order to adapt to a relatively high physiological load caused by thermal stress, the candidates visited the sauna 10 times (twice a week) in the period preceding the experiment. During each visit, they attended three 10-minute sauna sessions (temperature: 90°C, relative humidity: 14–16%) with 6-minute breaks in between sessions.

The participants were asked to complete a health questionnaire before the study. Thirty men meeting the below inclusion criteria were recruited for the study. The participants confirmed that they did not take any medications or nutritional supplements, were in good health and had no history of blood diseases or diseases affecting biochemical and biomechanical factors. The evaluated subjects presented medical certificates confirming that none of them had respiratory or circulatory ailments. Their PA levels were evaluated using the standardized and validated International Physical Activity Questionnaire (IPAQ) (Lee, Macfarlane, Lam, Stewart, 2011). In the overall group of 30 participants, 21 men were characterized by moderate PA levels (>600 METs per week) and 9 men – by high (>1,500 METs per week) PA levels based on self-reported activity levels in the short IPAQ form covering the last 7 days preceding the study (Craig et al., 2003).

Ethics approval

The study was conducted upon the prior consent of the Ethics Committee of the University of Warmia and Mazury in Olsztyn (10/2020), Poland, and it was consistent with the provisions of the Declaration of Helsinki developed by the World Medical Association. The participants were volunteers who signed an informed consent statement.

Research protocol

The participants received comprehensive information about sauna rules during the meeting preceding the study. They were asked to drink at least 1 L of water on the day of the test and 0.5 L of water 2 hours before the sauna session. The participants did not consume any foods or other fluids until after the final body measurements.

All participants visited a dry sauna in the same location and in the same time of the day (between 8:00–10:00) to minimize the effect of diurnal variation on the results. Every participant attended four sauna sessions (temperature: 90°C; relative humidity: 14–16%) of 12 minutes each and remained in a sitting position during each session. Every 12-minute sauna session was followed by a 6-minute recovery period. The participants recovered in a neutral room (temperature of 18°C and humidity 40–50% in a sitting position) for five minutes. Then, the participants remained immersed in a cold paddling pool (water temperature: +10–11°C) for 1 minute. The entire experiment lasted 72 minutes (72-ME). Air temperature and humidity inside the sauna cabin and the neutral room and water temperature in paddling pool were measured with the Voltcraft BL-20 TRH + FM-200 hygrometer (Germany) and confirmed with the Stalgast 620711 laser thermometer (Poland).

Body height was measured to the nearest 1 mm with a calibrated Soehlne Electronic Height Rod 5003 (Soehlne Professional, Germany) according to standardized guidelines. Body mass (measured to the nearest 0.1 kg), BMI and body composition parameters (weight, total body water – TBW, body fat mass – BFM, fat-free mass – FFM, waist-hip ratio – WHR) were determined by bioelectrical impedance with the InBody 720 body composition analyzer (InBody Co., South Korea) (Gibson, Holmes, Desautels, Edmonds, Nuudi, 2008). Blood pressure (BP) and heart rate HR were determined with an automatic digital blood pressure monitor (Omron M6 Comfort. Japan) immediately before the first session and immediately after the fourth cool-down break (the entire experiment lasted 72 minutes – 72-ME) in the neutral room. Due to high temperature in the sauna, the estimated values of physiological parameters, including heart rate ($HR_{min.\ avg.\ peak}$), recovery time, energy expenditure, oxygen uptake ($VO_{2\ avg.\ peak}$), excess post-exercise oxygen consumption ($EPOC_{avg.\ peak}$), respiratory rate ($_{avg.peak}$) and physical effort (easy, moderate, difficult, very difficult, maximal), were measured indirectly with Suunto Ambit3 Peak Sapphire heart rate monitors (Suunto Oy, Finland) which are widely used in studies of the type (Podstawski, Borysławski, Laukkanen, Clark, Choszcz, 2019). Physiological parameters were measured between the first sauna entry and the end of the fourth 12-minute session (66-ME). Pulsometers were placed on the wrist, and HR monitor sensors were attached to the chest. Every pulsometer was calibrated to sex, year of birth, body mass, and PA level before sauna exposure.

Statistical analysis

Grouping variables (excluding age) were applied to split the analyzed physiological parameters into two separate groups based on the median values of:

- Age: 1) younger – 20–26 years (N = 19) and 2) older – 39–49 years (N = 11),
- PA levels (MET): 1) lower – up to 1,166 (N = 15) and 2) higher – above 1,166 (N = 15),
- BMI (kg/m^2): 1) slimmer – up to 26.7 (N = 15) and 2) more obese – above 26.7 (N = 15),
- FFM (kg): 1) lower – up to 70.1 (N = 15) and 2) higher – above 70.1 (N = 15),
- BFM (kg): 1) lower – up to 16.6 (N = 15) and 2) higher – above 16.6 (N = 15),
- WHR: 1) lower – up to 0.91 (N = 15) and 2) higher – above 0.91 (N = 15),
- Frequency of sauna use: 1) often – every two weeks or more frequently (N = 16) and 2) rarely – once a month or less (N = 14).

The significance of differences between categories was determined by Student's *t*-test for dependent variables. All analyzed parameters had normal distribution. Normality was verified with the Shapiro-Wilk test. The asymmetry coefficient (As) was also calculated.

Results

The average PA level in the studied group was 1,322.2 MET, and it approximated the upper limit of moderate PA levels (600–1,500 MET). Based on WHO standards, the participants' average BMI (26.7 kg/cm^2) was within the overweight range. The average WHR (0.9) was indicative of gynoid body type (Table 1).

A significant ($p < 0.001$) decrease in SBP (by 9.7 mmHg), DBP (by 6.9 mmHg) and body mass (by 1.0 kg), and a significant ($p < 0.003$) increase in HR (by 7.4 bpm) were noted in the studied population during sauna treatment (Table 2).

Table 1. Descriptive statistics of grouping variables before sauna treatment (N = 30)

Variable	Mean	*Me*	*SD*	min–max	*As*
Age (years)	31.20	24.00	11.31	20–49	0.64
MET, ml/kg BM/min	1,322.20	1,166.00	407.10	870–2045	0.62
TBW, l	51.43	50.90	6.04	40.2–62.8	–0.01
Body mass, kg	86.62	89.00	13.02	58.7–110.7	–0.29
Body height, cm	180.26	179.15	6.25	169.3–196.2	0.38
BMI, kg/cm2	26.66	26.70	3.76	17.4–34.1	–0.50
BFM, kg	16.74	16.60	6.66	4.0–32.9	0.23
FFM, kg	70.32	70.10	8.34	54.7–85.9	–0.04
WHR	0.90	0.91	0.07	0.72–1.03	–0.55

Table 2. Descriptive statistics of physiological parameters in the studied group (N = 30) before and after sauna treatment

Variable	Before sauna			After sauna			Difference	
	mean	*SD*	min–max	mean	*SD*	min–max	*t*	*p*
SBP, mmHg	134.63	12.95	107–155	124.93	12.04	105–156	6.61	<0.001
DBP, mmHg	78.20	12.05	53–113	71.27	9.76	50–91	4.85	<0.001
HR, bpm	74.57	12.99	50–111	82.00	13.59	61–119	–3.26	0.003
Body mass, kg	86.62	13.02	58.7–110.7	85.62	12.92	58.0–109.9	20.04	<0.001

Younger (Y) and older (O) men responded similarly to sauna (Table 3). In both age groups, the smallest changes were noted in HR values which increased significantly ($p < 0.004$) only in younger participants (by 9.2 bpm). The remaining physiological parameters decreased significantly in both age groups. A greater decrease in the absolute values of DBP (Y – 5.89 mmHg, O – 8.73 mmHg), SBP (Y – 9.31 mmHg, O – 10.36 mmHg) and body mass (Y – 1.38 kg, O – 1.74 kg) was observed in older men, but the differences in SBP and body mass were significant among younger participants due to a higher number of individuals in that group (Table 3).

Table 3. Descriptive statistics of physiological parameters in younger (N = 19) and older (N = 11) participants before and after sauna treatment

Variable	Age	Before sauna		After sauna		Difference	
		mean	*SD*	mean	*SD*	*t*	*p*
SBP, mmHg	Y	133.84	13.05	124.53	13.19	7.98	<0.001
	O	136.00	13.29	125.64	10.32	4.05	0.002
DBP, mmHg	Y	76.00	13.82	70.11	10.40	2.79	0.012
	O	82.00	7.20	73.27	8.64	6.54	<0.001
HR, bpm	Y	75.58	12.84	84.79	15.74	–3.28	0.004
	O	72.82	13.68	77.18	7.04	–1.12	*NS*
Body mass, kg	Y	85.88	15.42	84.50	15.34	22.24	<0.001
	O	87.90	7.77	86.18	7.67	10.74	<0.001

Notes: Y – younger, O – older, *NS* – no significant difference.

Greater changes in the analyzed parameters were generally noted in more physically active men (Table 4). The directions of the evaluated changes were consistent with the general trend regardless of the participants' PA levels. Heart rate values increased significantly (by 8.2 bpm, $p < 0.004$) in more physically active men (H), whereas the increase noted in less active men (L) was not significant ($p > 0.05$). The decrease in the measured values of SBP (L – 8.53 mmHg, H – 10.87 mmHg) and DBP (L – 7.74 mmHg, H – 7.13 mmHg) was significantly greater in participants characterized by higher PA levels, whereas the decrease in body mass was significant and highly similar in both groups (approx. 1.5 kg, $p < 0.001$).

Table 4. Descriptive statistics of physiological parameters in participants with lower (N = 15) and higher (N = 15) PA levels, before and after sauna treatment

Variable	PAL	Before sauna		After sauna		Difference	
		mean	*SD*	mean	*SD*	*t*	*p*
SBP, mmHg	L	135.00	12.93	126.47	13.52	3.82	0.002
	H	134.27	13.41	123.40	10.61	5.61	<0.001
DBP, mmHg	L	79.27	14.84	72.53	10.37	2.66	0.019
	H	77.13	8.82	70.00	9.30	5.00	<0.001
HR, bpm	L	78.00	14.28	84.67	13.10	–1.69	*NS*
	H	71.13	10.96	79.33	13.99	–3.39	0.004
Body mass, kg	L	88.31	12.55	86.78	12.55	15.21	<0.001
	H	84.93	13.69	83.45	13.51	12.90	<0.001

Notes: PAL – physical activity level, L – lower, H – higher, *NS* – no significant difference.

Table 5. Descriptive statistics of physiological parameters in slimmer (N = 15) and more obese (N = 15) participants before and after sauna treatment

Variable	BMI	Before sauna		After sauna		Difference	
		mean	*SD*	mean	*SD*	*t*	*p*
SBP, mmHg	S	127.67	8.79	118.00	8.98	6.21	<0.001
	F	141.60	12.89	131.87	10.80	3.82	0.002
DBP, mmHg	S	76.07	12.43	69.87	9.55	2.32	0.036
	F	80.33	11.68	72.67	10.10	6.85	<0.001
HR, bpm	S	70.00	10.21	79.93	12.13	–3.76	0.002
	F	79.13	14.16	84.07	15.05	–1.33	*NS*
Body mass, kg	S	77.29	9.98	75.93	9.89	19.45	<0.001
	F	95.95	8.06	94.30	8.21	13.19	<0.001

Notes: S – slimmer, F – fatter, *NS* – no significant difference.

The directions of changes in the values of BMI and FFM in more obese and slimmer men (BMI, Table 5) and in participants with low and high fat-free mass (FFM, Table 6) were also consistent with the general trend. With the exception of HR ($p > 0.05$) in more obese (F) individuals and subjects characterized by high FFM values (H), the noted changes were significant, but they were more pronounced in slimmer participants (Table 5 – S, Table 6 – H). Heart rate values increased significantly in men with lower BMI (S: increase of 9.93 bpm, $p < 0.002$) and lower FFM (L: increase of 11.6 bpm, $p < 0.001$). A greater decrease in the measured values of SBP, DBP and body mass was

observed in more obese individuals (F): SBP – decrease of 9.73 mmHg; DBP – decrease of 7.66 mmHg; body mass – decrease of 1.65 kg; Table 5) and in individuals with lower fat-free mass (L: SBP – decrease of 11.13 mmHg; DBP – decrease of 7.46 mmHg; body mass – decrease of 1.58 kg; Table 6).

Table 6. Descriptive statistics of physiological parameters in participants with low (N = 15) and high (N = 15) values of FFM, before and after sauna treatment

Variable	FFM	Before sauna		After sauna		Difference	
		mean	*SD*	mean	*SD*	*t*	*p*
SBP, mmHg	H	125.53	10.28	117.27	10.04	4.38	<0.001
	L	143.73	8.01	132.60	8.58	4.94	<0.001
DBP, mmHg	H	74.87	14.01	68.47	10.05	2.41	0.030
	L	81.53	8.98	74.07	8.92	6.34	<0.001
HR, bpm	H	68.07	10.44	79.67	13.69	–4.46	<0.001
	L	81.07	12.24	84.33	13.54	–0.93	*NS*
Body mass, kg	H	76.99	9.91	75.56	9.75	14.36	<0.001
	L	96.25	7.35	94.67	7.43	14.03	<0.001

Notes: FFM – fat-free mass, L – lower, H – higher, *NS* – no significant difference.

The directions of changes in the analyzed parameters were also consistent with the general trend regardless of the participants' BFM (Table 7) and WHR values (Table 8). The observed changes were highly significant, excluding HR in men with lower values of BFM and WHR. Heart rate values increased significantly in men with higher BFM (increase of 7.66 bpm, $p = 0.023$) and higher WHR (increase of 9.87 bpm, $p < 0.009$). A greater decrease in the measured values of SBP was noted in participants with lower BFM (decrease of 10.34 mmHg) and WHR (decrease of 10.94 mmHg). The decrease in DBP was more pronounced in men with lower BFM (decrease of 7.0 mmHg) and higher WHR (decrease of 8.47 mmHg), whereas a greater decrease in body mass was noted in participants with higher BFM (decrease of 1.7 kg) and higher WHR (decrease of 1.5 kg).

Table 7. Descriptive statistics of physiological parameters in participants with low (N = 15) and high (N = 15) BFM values, before and after sauna treatment

Variable	BFM	Before sauna		After sauna		Difference	
		mean	*SD*	mean	*SD*	*t*	*p*
SBP, mmHg	L	129.27	10.48	118.93	11.05	5.36	<0.001
	H	140.00	13.26	130.93	10.05	4.00	0.001
DBP, mmHg	L	77.13	14.08	70.13	10.88	2.67	0.018
	H	79.27	10.00	72.40	8.74	5.41	<0.001
HR, bpm	L	72.07	13.62	79.27	12.84	–2.04	ns
	H	77.07	12.26	84.73	14.20	–2.54	0.023
Body mass, kg	L	78.31	11.18	76.98	11.10	19.19	<0.001
	H	94.93	8.84	93.25	8.99	14.05	<0.001

Notes: FFM – body-fat mass, L – lower, H – higher, *NS* – no significant difference.

Table 8. Descriptive statistics of physiological parameters in participants with low (N = 15) and high (N = 15) WHR values, before and after sauna treatment

Variable	WHR	Before sauna		After sauna		Difference	
		mean	*SD*	mean	*SD*	*t*	*p*
SBP, mmHg	L	130.47	13.17	119.53	11.49	4.75	<0.001
	H	138.80	11.69	130.33	10.28	4.59	<0.001
DBP, mmHg	L	74.60	11.78	69.20	11.68	3.99	0.001
	H	81.80	11.58	73.33	7.20	3.38	0.005
HR, bpm	L	70.33	14.92	75.33	10.31	–1.60	*NS*
	H	78.80	9.41	88.67	13.45	–2.99	0.009
Body mass, kg	L	80.08	11.45	78.60	11.34	15.38	<0.001
	H	93.17	11.32	91.63	11.24	12.93	<0.001

Notes: WHR – waist-hip ratio, L – lower, H – higher, *NS* – no significant difference.

Highly significant changes were noted in all analyzed parameters, excluding HR in men who used the sauna rarely (Table 9). A significant increase in HR values (by 9.6 bpm, $p < 0.006$) was observed in frequent sauna bathers. Frequent sauna users were also characterized by a greater decrease in the measured values of SBP (by 11.36 mmHg), DBP (by 7.78 mmHg) and body mass (by 1.5 kg).

Table 9. Descriptive statistics of physiological parameters in participants who used the sauna rarely (N = 16) and often (N = 14), before and after sauna treatment

Variable	FQS	Before sauna		After sauna		Difference	
		mean	*SD*	mean	*SD*	*t*	*p*
SBP, mmHg	R	136.94	11.01	128.69	11.89	4.54	<0.001
	O	132.00	14.84	120.64	11.09	4.82	<0.001
DBP, mmHg	R	81.31	12.47	75.13	8.37	2.63	0.019
	O	74.64	10.90	66.86	9.61	5.10	<0.001
HR, bpm	R	81.63	11.50	87.19	10.48	–1.62	*NS*
	O	66.50	9.61	76.07	14.64	–3.26	0.006
Body mass, kg	R	91.37	10.96	89.88	10.88	15.36	<0.001
	O	81.20	13.42	79.68	13.27	12.62	<0.001

Notes: FQS – frequency, R – rarely, O – often, *NS* – no significant difference.

Discussion

The aim of this study was to evaluate the effect of 72-ME of Finnish sauna bathing (four 12-minute sessions in a Finnish sauna, with 6-minute breaks in between sessions, including 1 minute of cold water immersion) on the body mass, HR and BP (SBP and DBP) in 30 adult men who were regular sauna users. Our findings seem to confirm the results of other studies demonstrating that the duration of exposure to high temperature play the key role in body mass reduction among sauna users. For example, Podstawski et al. (2014) examined 685 young women and men who attended two 10-minute sauna sessions (temperature: 90°C, humidity: approx. 35%) with a 5-minute cooling break in between. The average body mass loss was 0.30 kg, and the sauna-induced change in body mass was

not significant. Similar results were reported by Boraczyński, Boraczyński, Podstawski, Borysławski, Jankowski (2018), where the average body mass loss determined in 230 young men after two 10-minute sauna sessions (temperature: 95°C, humidity, 25–27%) reached 0.49 kg and was not significant. In the present study, sauna exposure was more than twice longer, which could explain the significant reduction in body mass (by 0.8–1.3 kg). In another study, 6 young women and 6 young men with high PA levels attended three 20-minute Finnish sauna sessions (temperature: 70°C, humidity: approx. 17%) (Gutierrez, Mesa, Ruiz, Chirosa, Castillo, 2003). The average body mass loss was also significant (1.4 kg in men, 0.8 kg in women), but no significant changes were reported in body fat percentage. A significant decrease in body mass was noted in 10 young sedentary men who participated in three 15-minute sauna sessions (temperature: 90°C, humidity: 26%) with two cooling breaks in between (Pilch, Szygula, Zychowska, Gawinek, 2003). In another experiment, three 12-minute sauna sessions (temperature: 115°C, humidity: 35%) held on the same day induced a significant decrease in the body mass and BMI of young men with high PA levels (Prystupa, Rzepka, Lara, 2010). The abovementioned phenomena may be explained by the fact that during hot sauna bath the sweat is secreted at a rate of 0.6 to 1.0 kg per hour (Heinonen, Laukkanen, 2018). As the participants of described studies did not drink any fluids during experiment, the body mass loss was substantial.

A review of the literature suggests that the duration of sauna bathing combined with the duration of breaks in between sessions influence cardiovascular function. In a study by Cernych, Satas, Brazaitis (2018), the HR of 18 young men who attended a sauna over a combined period of 45 minutes (one 15-minute session and three 10-minute sessions at a temperature of 90°C, humidity of 20%, with 15-minute breaks in between the sessions) increased significantly from 65.6 bpm to 151 bpm. In the current study, the average HR did not exceed 90 bpm despite a similar overall time of exposure to high temperature. These variations could be attributed to differences in environmental conditions during the breaks in between sauna sessions. In the work of Cernych et al., the participants remained in a room with a temperature of 23°C during the break, whereas in this study, men spent the 6-minute break in a room with a temperature of 18°C and entered a cold water pool (11°C). Similar conclusions can be drawn from a study of 12 healthy men aged 60 years who attended two 10-minute sauna sessions (temperature: 80°C, humidity: 35%) with 20-minute breaks ending with cold water immersion (Radtke et al., 2016). In the cited study, SBP and DBP values also decreased during sauna, but SBP values clearly increased after cold water immersion. In contrast, Podstawski, Borysławski, Clark, Laukkanen, Gronek (2020) reported decrease in SBP and DBP values in 55 young men after a single 16-minute sauna session regardless of cooling mode (immersion in a pool or cold shower). In another experiment, 19 middle-aged women and men attended a single 25-minute session in a sauna (temperature: 95°C, humidity: 13–20%) (Ketelhut, Ketelhut, 2019). Their average HR increased from 64 bpm to 116 bpm immediately after sauna, but it decreased to 87 bpm already five minutes after the treatment. The participants remained in a room with a temperature of 25°C after the sauna without whole body cooling. In the cited experiment, sauna bathing exerted a different effect on BP values than that noted in present study. Average SBP increased from 120 mmHg to 135 mmHg, and reached 118 mmHg on average in the fifth minute after sauna. In turn, DBP increased from 82 mmHg to 90 mmHg, but dropped to 73 mmHg after 5 minutes in a room with a temperature of 25°C. A single, shorter stay in a sauna appears to exert a different effect on cardiovascular function. A significant increase in HR values (59.3 bpm vs 65.0 bpm) and a non-significant increase in BP values (127.9/78.9 mmHg vs 127.6/79.3) were reported in nine young men after a single 15-minute session in a sauna (temperature: 100°C, humidity: 30–40%) (Zalewski et al., 2014). In the present study, completely different changes were observed in HR and BP values, which could be attributed to differences in anthropometric parameters as well as differences in the

duration of sauna bathing. In this study, considerable differences in SBP and DBP values were observed after four 12-minute sauna sessions regardless of the frequency of sauna use before the experiment. In a study analyzing 16 young men who attended two 8-minute sauna sessions (temperature: 90°C, humidity: 50–60%) with a 2-minute break in a cold shower and a 10-minute passive rest period outside the sauna, only a significant decrease in SBP values was reported during the first 8-minute sauna session (Gayda et al., 2012). The participants had not regularly used the sauna before the experiment, which suggests that cardiovascular function is more likely to be influenced by the number of sauna sessions during a single treatment, rather than previous sauna experience. Laukkanen et al. (2019) also reported a significant increase in the HR values of 93 middle-aged women and men who participated in a single sauna session (temperature: 75°C, humidity: 10–20%) with longer exposure to thermal stress (two 15-minute sessions with a 2-minute break in a warm shower). However, the results reported by Zaccardi, Laukkanen, Willeit, Kunutsor, Kauhanen, Laukkanen, (2017) in a group of 1621 men aged 40–60 years reveal a clear correlation between the frequency of sauna bathing and the risk of cardiovascular diseases. According to the authors, regular and frequent sauna use improves endothelial function in individuals with a risk of cardiovascular disease, whereas intermittent body warming and cooling stimulates the autonomic nervous system and, consequently, lowers blood pressure. For this reason, regular sauna bathers should be less exposed to the risk of cardiovascular disease than infrequent sauna goers and persons with a short history of sauna use. Similarly to the results reported by Zaccardi et al. (2017), our findings suggest that regular and frequent sauna bathing improves cardiovascular function. In this study, resting HR and BP values were lower in frequent sauna users than in men who had rarely visited the sauna before the experiment (HR: 66 bpm vs 81 bpm; BP: 132/74 mmHg vs 136/81 mmHg).

Strengths and Limitations

This paper makes a novel contribution to the literature by providing information about the influence of thermal stress on healthy men. The authors are aware of some limitations of the current study. Firstly, the control group was not created. We have reviewed many studies concerning sauna bathing and only a few of them involved the controls for comparisons. In the present study, multiple factors were analyzed in the context of sauna bathing, therefore the inclusion criteria for the control group would be ambiguous. Secondly, only the results of male participants were presented in our study. We invited healthy women to participate in the experiment, but the response rate was very low. Therefore, female participants were not included in this study. On the other hand, the findings of Kirby, Lucas, Cable, Armstrong, Weaver, Lucas (2021) suggest that the physiological effects of sauna bathing are similar in both physically active women and men. We conducted a multifactorial assessment of the effects of sauna bathing in a group of male participants, which is one of the strengths of this study. Nevertheless, studies involving a greater number of participants of both sexes could provide a basis for comparison with our findings.

Conclusions

The results of the present study generally confirm previous observations regarding the influence of thermal stress on cardiovascular function. Blood pressure decreased after sauna regardless of the participants' body mass, age and PA levels. Heart rate values increased in all studied subjects, but a greater increase was noted in younger and slimmer men who were frequent sauna users and were more physically active. Sauna induced a significant decrease in body mass regardless of the participants' age, PA level and body composition. The observed cardiovascular responses were induced by intermittent exposure to extreme thermal conditions: high air temperature in the sauna,

followed by low water temperature in the paddling pool. Therefore, repeated 12-minute sessions in a Finnish sauna can be recommended for healthy men with average and high PA levels as a treatment that enhances cardiovascular function and promotes body mass loss.

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A PILOT STUDY ON ITALIAN EVENTING PROSPECTIVE OLYMPIC HORSE RIDERS PHYSIOLOGICAL, ANTHROPOMETRICAL, FUNCTIONAL AND ASYMMETRY ASSESSMENT

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Abstract The purpose of the study was to measure anthropometry, isometric force, balance, functional movement quality and asymmetries and peak oxygen uptake of prospective Rio 2016 Olympic Games Eventing horse riders (five males and two females: age 26–41 years, height 173.0 ±8.9 cm, weight 66.4 ±11.1 kg, BMI 22.0 ±1.8 kg·m^{-2}, FEI ranking 33–409). Mean and maximal isometric of the hands were approximately 45 kg, and 50 kg, respectively. Total maximal isometric force of the lower limb resulted 372.6 kg for the extensor muscles, and approximately 58 kg for the adductor muscles. Mean composite functional movement score was 14.1, mean Bunkie score 3.4, Y-balance score 93.1 ± for the left side and 90.9 for the right one. $V'O_2$peak values ranged between 2.4 and 4.2 l·min^{-1} and 46.8 and 59.7 ml·kg^{-1}·min^{-1}. The oldest and more experienced athletes had a greater postural control on the anterior direction. The athletes with a superior FEI ranking had a greater postural control. Subjects had high maximal isometric strength of the hands and lower limbs, good physical functions parameters, balance and maximal aerobic power and few muscular strength and balance asymmetries.

Key words: elite athletes, physical evaluation, asymmetry, performance

Introduction

Many athletes show signs of skilled sporting potential and talent identification programs are intended to recognize those athletes who possess remarkable potential for success. Many attempts have been made to develop methods to identify remarkably gifted athletes at an early age so as to focus available resources on particularly promising individuals and to promote their development in a certain sport. This process can be considered most beneficial for sport disciplines with a small number of participants at highly competitive levels, that can only rely on a small pool of gifted individuals. Moreover, a systematic review on talent identification in sport revealed that only three sports (soccer, gymnastics, and rugby league) were represented more than once in literature. This lack of diversity makes it very difficult to draw inferences about the predictive utility of testing variables. Authors concluded that there remains a substantial amount of information that we have yet to learn in this field and that future work should include a greater diversity in study designs (e.g. variables, samples, etc.) to reflect the considerable diversity in high performance sport (Johnston, Wattie, Schorer, Baker, 2018).

This is even more true when it comes to horse riding disciplines for whom scarce is the information on physical and anthropometrical profiles of elite level riders. Indeed, neither the physical, physiological, nor biomechanical traits required by riders, nor the most beneficial type of training for this population of athletes have been extensively investigated.

Eventing originally evolved from the training of cavalry horses. The sport is rather like the pentathlon in that it combines different disciplines in one competition and is run on a cumulative penalty basis. Eventing is a three-phase competition. Phase 1 is the dressage (DR) test that comprises a set sequence of compulsory movements at a relatively low speed in an area that is 20 m wide and 40 m long (60 m at higher levels of competition). Phase 2 is the cross-country (XC) test, in which the horse and rider negotiate a series of solid natural obstacles while galloping across the country. Phase 3 is the show jumping (SJ) test, where the horse and rider combination is required to complete one round of jumping over approximately 12 coloured fences within a set time. There are 5 classes, increasing in length, speed and technical difficulty, in which horses may compete according to their level of skill and fitness from introductory level 1* to Olympic level 5*. The modern 3-day-event is conducted over 3 or more days and is run in accordance with rules set by the Fédération Equestre Internationale (FEI). The Cross-Country day is the most physically demanding of the 3 disciplines. It is the cornerstone of Eventing, and proves the speed, endurance and jumping ability of the horse over varied terrain and solid obstacles. This phase is ridden at a gallop over 7,400 m and features solid fences (up to 45) as well as natural obstacles such as water, ditches, drops and banks. The sport of Eventing is a great all-round test of horse and rider and a tremendous examination of horsemanship and is renowned for being one of the most challenging equestrian sports for both horse and rider (Roberts, Shearman, Marlin, 2009).

Even though physical fitness is required by the equestrian athlete for maintenance of balance and effectiveness, scientific research concerning the physiological demands of horse riding is very limited. In the interest of the horse, however, fitness and competence of the rider are regarded as essential. There is, indeed, uniqueness about equestrian sport as the horse has its own free mind. This combined horse-human partnership adds further complexity and variability to the control of extraneous variables and events in scientific investigations (Roberts et al., 2009). Bompa and Haff (2009) suggested that the dominant motor abilities horse riders should possess are strength, reaction time, balance, and endurance. However, the available studies were mostly conducted on female riders who were not at a competitive level. Therefore, research using male and competitive equestrians were suggested to be

beneficial to present a clearer picture of a competitive equestrian population (Douglas, Price, Peters, 2012). More recently, Sung and colleagues (Sung et al., 2015) investigated comprehensive ranges of parameters such as change of lactate, heart rate, calorie, $V \cdot O_2$max, skeletal muscle mass, body water, body fat, etc between male amateur and professional horse riders, emphasizing that more successful athletes possess a combination of physical attributes, talent, skill, technique, determination, strategy, and psychological preparedness.

Undeniably, sport practice constraints athletes to manage simultaneous sources of information to maintain postural stability in an efficient manner. Impaired balance is one of the several risk factors that have been associated with increased risk of lower extremity injuries. Research suggested deficits in static and dynamic balance discern between individuals with a history of ankle sprains, chronic ankle instability, anterior cruciate ligament deficiency, and anterior knee pain (Shaffer et al., 2013). The contribution of sensory information to postural control has been shown to differ according to the sport activity and the level of practice. In a recent review, Paillard (2017) concluded that repeated particular postures and movements, induced by sport practice, could generate robust postural adaptations. This would be especially the case when the sport practice induces a high level of postural balance as in horseback riding where, maintaining postural stability, is a critical constraint to ensure safety and avoid falls. At this regard, horseback riders exhibited greater stability during a dynamic balance test, compared to non-athletes. Authors suggested that horseback riding could help developing particular proprioceptive abilities on standing posture as well as better postural muscle tone during particular bipodal dynamic perturbations (Olivier, Viseu, Vignais, Vuillerme, 2019). On the other hand, anatomical, functional, and dynamical asymmetry in a large sample of riders has been reported. At this regard, authors suggested that the demands on horse riders competing at higher levels may predispose these riders to a higher risk of developing asymmetry and potentially chronic back pain rather than improving their symmetry (Hobbs et al., 2014). Indeed, riders frequently complain about orthopaedic problems, possibly related to musculoskeletal stress reactions. Low back, hip joint, and hamstring muscle pain are the most common symptoms among competitive riders. A cross-sectional survey among competitive athletes, members of the Italian Equestrian Sport Federation showed that low back pain had a prevalence of 91.6% and 74.2% for lifetime and 1-year, respectively (Ferrante, Bonetti, Quattrini, Mezzetti, Demarie, 2021). An evaluation of the orthopaedic problems encountered by elite horseback riders revealed that 88% of riders suffer of back pain. The predominant reason for back pain in the rider has been suggested to be functional, as attributed to muscular disbalance (Kraft et al., 2009). Asymmetric forces are suspected of having negative effects on rider-horse interaction through weight aids, athletic performance, and health of the horse. Analysis on saddle pressure pattern revealed that the asymmetric loading is influenced by various factors of functional and anatomical asymmetry of rider and horse; a possible explanation for the rider's lateral shift could be anatomical asymmetries of the horse related to its laterality (Gunst et al., 2019). Although the risk of musculoskeletal conditions and injuries is multifactorial, preliminary evidence suggests that neuromuscular and strength training programs may be beneficial for preventing the occurrence of these conditions (Teyhen et al., 2012).

A deeper knowledge of elite level horse riders' characteristics may be useful for coaches and athletes to gain better performance and to address health promotion issues. Therefore, the purpose of this study was to identify the anthropometric, ergonomic, functional, and physiological profiles of the prospective Eventing horse Italian riders for Rio 2016 Olympic Games and to evaluate any relationship between the measured parameters and their international ranking and years of competitions. Symmetry in ergonomic and functional outlines was also assessed.

Methods

Participants

Subjects were seven (five males and two females) Eventing horse riders being part of the prospective team for the Rio 2016 Olympics. Since Horse riding is the only Olympic discipline in which male and female competitions are not separate as gender, data were processed together as one group. Subjects were included in the study if they have participated in Eventing competition at international level regularly for at least 10 years and kept a consistent training schedule in the last year. Performance level was assessed through the Fédération Equestre Internationale on-line ranking (FEI rank). All subjects trained 4–6 hours a day on different horses and practiced 2–4 hours a week of other sport activities at leisure level such as jogging. Exclusion criteria included: if they had reported a recent (within the past 6 weeks) musculoskeletal or head injury that was likely to affect their motor performance. The research was conducted in accordance with the 1964 Helsinki Declaration.

Design and Procedures

The study was approved by the Italian Olympic Committee. All subjects were required to review and sign a consent form prior to participation.

Measures were undertaken at the end of June 2016, approximately 6 weeks prior the Rio Olympic Games. Each test was performed on separate days, with at least 24h rest in between. The subjects were instructed to avoid same-day exercise prior to testing and be in a euhydrated state with empty bladder and bowel at the time of the test.

Measures

Maximal Isometric Strength (MIS) has been assessed by three different tests: Handgrip test (Ht), Lower limb extensor muscles (Emf), Lower limb adductor muscles (Amf). Maximal isometric strength of the forearm muscles (Ht) was measured from both hands. The subject was sitting comfortably on a chair with the shoulder adducted and neutrally rotated, with the elbow against the body and flexed at 90°, and the forearm and wrist in a neutral position. The subject held the dynamometer (Jamar Hydraulic Hand Dynamometer, J.A. Preston Corporation, Clifton, NJ) in the hand to be tested. The handle of the dynamometer was adjusted if required. Three maximal attempts lasting 20 s were recorded one hand at a time. The subjects were provided with a rest period of 2 min to control for the effects of fatigue. The maximum reading for each hand was used for further analysis. Force was expressed as maximal value (Fmax), mean value (Fmean) and decrease in maximal force along the duration of the test (Decrease), representing the muscle endurance for each hand. Lower limbs maximal isometric strength was evaluated with an isometric squat. It was performed by having the subject stand on two force platforms (Desmotech D11 Version Sport Pro, Italy) at a 100° knee angle. The subject was linked at the waist to the assessment station to ensure no displacement during isometric contractions. His/her elbows were bent at 90°, hands on waist, eyes looking forward. On verbal command the subject performed a maximum knee isometric contraction of the extensor muscles for 3–5 s. A minimum of three maximal actions were recorded and the best maximum was taken for further analysis. Three-min rest was allowed between trials. The peak force of the lower limbs adductors was measured using a commercial strain gauge (Iso control, Globus, Italy) mounted on an adductor machine. The load cell was secured in series with the sliding axis of the adductor machine seat using two chains attached to the adductor machine frame, so that the direct line of force was registered. Before each trial, the load cell was reset to zero to

negate the force produced on it by the two tensed chains. The participants were required to exert force as hard and as fast as possible for 3–5 s. Three trails were performed interspersed with 3-minute of rest. Peak force (the highest force recorded) was calculated.

Three functional performance tests were performed: Functional Movement Screen (FMS), Bunkie test (Bt), Y-Balance test (YBT). The FMS consists of 7 fundamental movement component tests that are scored on a scale of 0 to 3, with the sum creating a composite score ranging from 0 to 21 points (Kraus, Schütz, Taylor, Doyscher, 2014). Athletes, after obtaining verbal instructions and a brief demonstration of each sub-test, were not 'coached' through the movement, and were blinded to the scoring criteria of each sub-test. Testers were blinded to the scores of subsequent stations. We established a-priori that a composite FMS score of ≤14 would be used as a cut-off, as previously reported (Bonazza, Smuin, Onks, Silvis, Dhawan, 2017). The Bt consists of 40 s isometric exercise in 5 testing positions with each test performed bilaterally (Ronai, 2015). The time that one was able to maintain the proper test position without pain was recorded in seconds using a stopwatch. A test was terminated when a subject was no longer able to maintain the proper test position. Between testing positions a rest interval of 2 min was granted (O'Neill, Tamjid, DeRevere, Kostelis, 2019). Order of testing was randomized per each subject. Test termination occurred when either (a) the subject stopped the test due to fatigue or (b) the subject was unable to maintain the correct position (Brumitt, 2015). A 4 score was given when the movement was terminated between 31 and 40 s, a 3 score was given when the movement was terminated between 21 and 30 s, a score of 2 was given when the movement was terminated between 11 and 20 s, a score of 1 was given when the movement was terminated between 1 and 10 s and a score of 0 was given when the subject could not maintain the position at all. According to YBT procedure, participants completed 3 consecutive trials for each reach direction and, to reduce fatigue, subjects altered limbs between each direction. Attempts were discarded and repeated if the subject failed to maintain unilateral stance on the platform, failed to maintain reach foot contact with the reach indicator on the target area while the reach indicator is in motion, used the reach indicator for stance support, or failed to return the reach foot to the starting position under control. Average reach distance in cm over 3 trials were calculated for both limbs in the anterior, posteromedial, and posterolateral directions, the composite score (CS) was computed by adding all 3 reach directions together and then normalizing to leg length. The asymmetry score assesses the difference between the right and left reaching (Shaffer et al., 2013).

Peak Oxygen Uptake ($V\dot{O}_2peak$) was determined through an incremental running test on a motorized treadmill (Run Race, Technogym, Italy), with continuous gas measurements breath by breath at the mouth by a miniaturized telemetric metabolimeter (K5, Cosmed, Italy) with a 15 s sampling rate. Heart rate was also continuously monitored (HRM-Dual™ Ant+, Garmin, USA). A warm-up of 10 minutes of running preceded the incremental test. Thereafter treadmill velocity was set at 9 $km \cdot h^{-1}$ and increased by 0.5 $km \cdot h^{-1}$ each minute until volitional exhaustion, i.e. when the subjects were unable to run at the required velocity. $V\dot{O}_2peak$ was calculated as the highest value attained at the end of the test with data averaged at 15 s interval and the maximal heart rate achieved during the test was defined as HRmax. $V\dot{O}_2peak$ was accepted if a proximity of ≤5 $beats \cdot min^{-1}$ to theoretical HRmax (208 – 0.7 × age) was attained.

Statistical Analysis

The analyses were performed using the software StatView version 5.0.1. Data were expressed as median ± IQR. Nonparametric tests were used because of the small sample size. Differences between limbs (left vs right)

were performed with Mann-Whitney U test. Cohen's effects size (ES) was also computed (Fritz, Morris, Richler, 2012). Spearman Rank Correlation analyses were used to understand possible relationships between physiological parameters and age, FEI ranking, and competition years. Statistical significance was set at $p < 0.05$.

Results

Anthropometric values, FEI ranking and years of competition are presented in Table 1. Age ranged from 26 to 41 years, height from 158 to 187 cm, weight from 47 to 80 kg and BMI from 18.8 to 24.2 $kg \cdot m^{-2}$. All athletes were young adults and normal weight. FEI ranking ranged from 33 to 409, while years of competition ranged from 12 to 20.

Table 1. Anthropometry, ranking and competition years

	Median ± IQR	Range (min–max)
Age (yrs)	31.4 ±4.8	26–41
Height (cm)	173.0 ±8.9	158–187
Weight (kg)	66.4 ±11.1	47–80
BMI ($kg \cdot m^{-2}$)	22.0 ±1.8	18.8–24.2
FEI ranking	210.7 ±160.3	33–409
Competition (yrs)	16.3 ±2.9	12–20

Values are expressed as median ± IQR.

Maximal isometric strength results are illustrated in Table 2. Left hands had greater maximal (+2.6 kg) and mean (+0.5 kg) forces than the right ones for all subjects, and force decrease was significantly higher for the right hands, with a large effect (+5.1 kg; $p = 0.048$; ES = 0.7). All subjects presented higher performance of the left hands even though differences were not statistically significant.

Total maximal force of the lower limb extensor muscles resulted 372.6 kg. Left extensor muscles expressed a maximal force 23.2 kg higher than the right ones, non-statistically significant. A 1.6 kg higher maximal force of the left adductor muscles was observed, non-statistically significant.

Table 2. Maximal Isometric Strength (MIS)

	Max L	Max R	Mean L	Mean R	Decrease L	Decrease R
Handgrip Test (kg)	51.9 ±26.8	49.3 ±22.7	45.5 ±19.8	45 ±20.1	14.4 ±9.3	19.5 ±5.7
	Max L		Max R		Range (min–max)	
Lower limb extensor muscles (kg)	197.9 ±102.0		174.7 ±95.7		94–227.9	
Lower limb adductor muscles (kg)	58.8 ±19.1		57.2 ±18.4		33.2–69	

Values are expressed as median ± IQR.

Functional performance tests results are displayed in Table 3. Mean Composite Functional Movement Score was 14.1 (median ± IQR: 14 ±1.75; range: min 13 – max 17). Left and right side had almost identical scores for all items, except for one subject who achieved higher values on the left side for hurdle step (HS) and active straight leg raise (LR). No statistical differences between L and R were detected.

Mean Bunkie score was 3.4. Left and right side had almost identical scores for all items, except for one subject who achieved higher values on the left side for anterior power line (APL) and another one on the right side for posterior power line (PPL). Difference between left and right Bunkie test results was not statistically significant.

According to the Composite Balance Score, left side had 2.2 cm higher values than the right one. Lowest values were displayed for the Anterior balance, highest values for the Posteromedial balance and intermediate values were exhibited in the Posterolateral balance. Anterior values were significantly higher for the left side, with a large effect ($p = 0.035$; ES = 0.8), participants exhibiting an anterior reach asymmetry of 3 cm.

Table 3. Functional performance tests

	Left	Right	Range (min–max)
Functional Movement Screen (FMS)			
Deep squat	2 ±0		1–2
Stability push-up	2 ±1		1–3
In-line lunge	2 ±0	2 ±0	2–3
Hurdle step	2 ±1	2 ±0.75	2–3
Shoulder mobility	3 ±0	3 ±0	2–3
Active leg raise	1 ±1.75	1 ±1	1–3
Rotary stability	2 ±0	2 ±0	2–2
Bunkie test (Bt)			
Posterior power line	4 ±1	3 ±1	3–4
Anterior power line	4 ±0	4 ±0	3–4
Posterior stabilizing line	3 ±0.75	3 ±0.75	3–4
Lateral stabilizing line	3 ±0	3 ±0	2–4
Medial stabilizing line	3 ±1.5	3 ±1.5	2–4
Y-Balance test (YBT)			
Anterior (cm)	63 ±3.3	60 ±1.8	56–67
Posteromedial (cm)	100 ±10.8	98 ±9.5	88–106
Posterolateral (cm)	93 ±7.8	92 ±11	82–103
Composite (cm)	93.1 ±9.2	90.9 ±7.4	82.8–100

Values are expressed as median ± IQR.

Peak Oxygen Uptake ($V \cdot O_2$peak) was meanly attained at a treadmill velocity of 13 km·h^{-1}; rate of perceived exertion, measured on a 6–20 Borg scale, was marginally lower than 17. Maximal heart rate during the treadmill test reached 190 beats·min^{-1} and 100% of the estimated maximal heart rate. $V \cdot O_2$peak values were raging between 2.4 and 4.2 l·min^{-1} (median ± IQR: 3.7 ±0.8), and between 46.8 and 59.7 ml·kg^{-1}·min^{-1} (median ± IQR: 51.1 ±4.5).

Because few differences between L and R limbs where found, correlation analyses were computed with a composite value of strength or functional performance tests. Correlating the physiological parameters amongst themselves, handgrip max and mean positively and strongly correlated with lower limb extensor muscles and adductor muscles and with Bt posterior power line and posterior stabilizing line. Firstly, grip strength seems to reflect lower limb strength. Furthermore, handgrip max and mean positively and strongly correlated with peak oxygen uptake. Other correlations between maximal isometric strength and functional performance tests were found for lower limb extensor muscles with Bt posterior power line and posterior stabilizing line. Secondly, trunk and

hip musculature seems to reflect maximal isometric strength of both upper and lower limbs. Lower limb extensor muscles positively and strongly correlated with peak oxygen uptake, too. In general, the strongest athletes had a superior cardiorespiratory fitness. Bt Posterior stabilizing line correlated with peak oxygen uptake. Lastly, no correlations were found between Functional Movement Screen and Y-Balance test and any other physiological parameters (Table 4).

Table 4. Spearman Rank Correlation (rho) for physiological parameters

	Htmax	Htmean	Emf	Amf	Bt PPL	Bt PSL	$V\dot{O}_2$peak
Htmax	1						
Htmean	0.964*	1					
Emf	0.929*	0.964*	1				
Amf	0.786	0.893*	0.857*	1			
Bt PPL	0.929*	0.929*	0.929*	0.857*	1		
Bt PSL	0.813*	0.813*	0.813*	0.563	0.670	1	
$V\dot{O}_2$peak	0.821*	0.857*	0.821*	0.679	0.643	0.813	1

Htmax – Handgrip max, Htmean – Handgrip mean, Emf – Lower limb extensor muscles, Amf – Lower limb adductor muscles, Bt PPL – Bt Posterior power line, Bt PSL – Bt Posterior stabilizing line.

* $p < 0.05$.

Table 5. Spearman Rank Correlation (rho) for physiological parameters and age, FEI ranking, competition years

	Age	FEI ranking	Competition years
Maximal Isometric Strength			
Handgrip max	0.259	–0.357	0.580
Handgrip mean	0.045	–0.321	0.402
Handgrip decrease	0.348	0.286	0.170
Lower limb extensor muscles	–0.063	–0.107	0.330
Lower limb adductor muscles	–0.116	–0.071	0.241
Functional performance tests			
FMS score	–0.250	–0.473	–0.446
Bt Posterior power line	0.152	–0.071	0.438
Bt Anterior power line	0.571	–0.063	0.696
Bt Posterior stabilizing line	0.196	–0.188	0.321
Bt Lateral stabilizing line	0.027	0.607	0.455
Bt Medial stabilizing line	–0.339	–0.036	0.18
YBT Anterior	0.830*	–0.714	0.545
YBT Posteromedial	0.161	–0.366	–0.071
YBT Posterolateral	0.402	–0.893*	0.259
YBT Composite	–0.188	–0.464	0.027
Peak Oxygen Uptake			
Treadmill velocity	–0.509	–0.313	–0.045
$V\dot{O}_2$peak ($l \cdot min^{-1}$)	0.045	–0.393	0.402
$V\dot{O}_2$peak ($ml \cdot kg^{-1} \cdot min^{-1}$)	–0.580	–0.179	0.134

* $p < 0.05$.

Table 5 showed the Spearman Rank Correlation results between physiological parameters and age, FEI ranking, and competition years. Age moderately correlated with competition years (r_s = 0.679) and strongly correlated with Anterior YBT (p = 0.0420). The oldest athletes had a greater postural control on the anterior direction. FEI ranking moderately correlated with Anterior YBT and strongly correlated with Posterolateral YBT (p = 0.0287). The athletes with a superior standing in the ranking had a greater postural control especially on the posterolateral direction. Only a moderate, non-significant, correlation was found between competition years and Bt Anterior power line. Conversely, maximal isometric strength, and maximal aerobic power did not result correlated with any other measured parameter.

Discussion

The aim of this study was to describe anthropometric and physiological characteristics of prospective Olympics Eventing horse riders and to assess force, balance and functional asymmetry, providing novel informative data for these athletes. Symmetry in ergonomic and functional outlines and relationship between the measured parameters and their International ranking and years of competitions were also assessed.

Functional and asymmetry assessment

Equestrianism has been identified as a sport that requires perfecting the conduct of different means of travel and has been compared to other travel sports such as motor sports and water events (e.g. sailing, yachting) (Bompa, Haff, 2009). It has been elucidated that these 'travel sports' require the development of complex skills that necessitate many hours of training, and as athletes will have to make quick decisions, they involve quick proprioceptive processing. Bompa and Haff (2009) suggest that the dominant motor abilities athletes should possess in these sports are strength, reaction time, balance and endurance.

Subjects presented good maximal (~50 kg) and mean (~40 kg) hand-grip force, with a % force decrease of ~20%, and a statistically significant difference between hands for the latter value. Previous studies on equestrian athletes reported much lower maximal handgrip force (~30 kg or less); however, most researches were conducted on female amateur riders (Meyers, Sterling, 2000). If only female results are taken into account, hand grip strength values of the female riders were in-line with those of the other female athletes (Cronin, Lawton, Harris, Kilding, McMaster, 2017; Roberts et al., 2009). A difference between hands values is commonly reported, even if one study registered a notably higher grip strength on the right hand (Hobbs et al., 2014), while another study registered higher hand grip forces for the left hand for the amateur riders, and comparable values for both hands in elite riders (Sung et al., 2015). The high hand grip force shown by elite equestrian athletes of each gender indicates that the repetitive high-intensity handgrip actions frequently executed during equestrian sessions, over the years of training, may lead athletes to develop good hand grip strength. Furthermore, both lower limb extensors and adductors muscles resulted remarkably stronger when compared with non-athletic subjects (Harbo et al., 2012; Stoll et al., 2000). Even if it is not possible to confirm the cause–effect relationship between training and development of strength performance, the high isometric force values reported in the present study reinforce the suggestion that strength development in elite 'travel sports' athletes can be induced by training on the horse also in the absence of other specific strength training sessions.

Functional performance tests (FPTs) "simulate sport and activity" assessing aspects of performance, functional abilities, and/or the presence of dysfunctional movement patterns (Brumitt, 2015). FMS is described as

an assessment of the quality of human movement for which a score ≤14 has a high specificity for predicting injury; therefore elite riders of our study can be defined as having poor functional abilities with an increased risk of injury or low back pain (Bonazza et al., 2017). Besides, the Bunkie test score of 3.3, accompanied by only two different scores between right and left side, can be considered representative of good core muscular endurance. Since the ability to train the horse to be ambidextrous is considered highly desirable, rider symmetry found in both FMS and Bunkie tests can be recognized as a positive trait (Hobbs et al., 2014). According to YBT, anterior values were significantly higher for the left side, with a large effect, participants exhibiting an anterior reach asymmetry of 3 cm. Previous evidences on the YBT for injury prediction identified that individuals with anterior left/right asymmetries greater than 4 cm on the YBT were 2.5 times more likely to sustain a lower extremity injury (Plisky, Rauh, Kaminski, Underwood, 2006). Therefore, elite riders balance asymmetries resulted lower than values predicting injuries proneness.

$V \cdot O_2$peak of Eventing elite horse riders was slightly above 50 $ml \cdot kg^{-1} \cdot min^{-1}$, in line with literature values. Actually, when $V \cdot O_2$max values are compared between elite, amateur and collegiate/novice riders, the first reach 51–55 $ml \cdot kg^{-1} \cdot min^{-1}$, while the second cut down at 44–47 $ml \cdot kg^{-1} \cdot min^{-1}$ and the latter restrict to 34–37 $ml \cdot kg^{-1} \cdot min^{-1}$ (Meyers, 2006; Meyers, Sterling, 2000; Sung et al., 2015). It is plausible to think that the regular and intense riding training of elite athletes, who typically ride several horses each day, cantering and jumping with all of them and compete almost every week in multiple phases competitions, seems to elicit much higher cardiovascular fitness than recreational horse riding. Some authors suggested that increased riding exposure may result in positive physiological adaptation among the trained group (Kiely, Warrington, Mcgoldrick, O'loughlin, Cullen, 2019).

Correlations

Correlating the physiological parameters amongst themselves, correlations between maximal strength and functional performance were found. Significant positive relationships between isometric strength tests and the directional reaching of the Y-Balance test were previously reported (Chtara et al., 2018). It has been speculated that a great lower limb isometric strength may allow a better overall dynamic balance performance. However, this latter statement should be checked throughout a training investigation regarding the effect of isometric strengthening on dynamic balance performance. Indeed, no relationships were found between isometric lower limbs muscles force and balance performance in the present study.

As it could be expected competition years was related to age, even though the relationship didn't reach statistical significance ($r_s = 0.679$). Age significantly correlated with Anterior YBT ($p = 0.0420$), the oldest athletes having a greater postural control on the anterior direction. Anterior YBT was moderately and non-significantly correlated with competition years. Conversely, maximal isometric strength, and maximal aerobic power did not result correlated with any other measured parameter. FEI ranking moderately correlated with Anterior YBT and strongly correlated with Posterolateral YBT ($p = 0.0287$). The athletes with a superior standing in the ranking had a greater postural control especially on the posterolateral direction. Since Eventing required a high cardiovascular effort (Roberts et al., 2009), a good aerobic capacity has been suggested to be a factor determining riding performance at competitive level. Nonetheless, in the present study no correlation had been found between maximal aerobic power ($V \cdot O_2$peak) and performance level (FEI rank), indicating that the combined horse-human partnership adds further complexity and variability to the performance factors, furtherly complicated by the horse having its own free mind.

Conclusions

The assessment of rider's physical characteristics may provide coaches and athletes with a reference physique and may aid in the development of strength and conditioning programs to optimize horses and riders potential and health (Kraus et al., 2014). In the present study, seven male and female prospective Italian Olympic Event riders had high maximal isometric strength, both in the hands and lower limbs, good physical functions parameters and balance and good maximal aerobic power. Even though no general conclusion can be made on such a small sample size, results show that these high-level horse riders attained good physical fitness level over various aspects. Moreover, the lack of important asymmetries between left and right side for muscular strength and balance could suggest that, at such high level of competition, multiple movement qualities and optimal movement patterns are needed. Lastly, results showed that, in this group of elite athletes, oldest horse riders had more years of competition experience and a greater postural control on the anterior direction and that postural control better correlated with FEI ranking, moderately on the anterior direction and strongly with posterolateral balance.

More quantitative measurements of anatomical, functional and dynamical asymmetry compared to ridden postural asymmetries are needed to understand the effects of riding on strength and posture. Due to the large variability between riders, further work should incorporate longitudinal within-rider monitoring, which may indicate better the cause and effect relationships between riding and changes in physical capacity.

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POPULARITY AND COMMON ISSUES OF TEACHING SPORTS GAMES AT ELEMENTARY SCHOOLS IN SLOVAKIA

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Abstract Within the article, we analyze and evaluate the popularity and common issues of teaching sports games in physical and sport education at elementary schools in Slovakia. A survey was the research instrument for collecting the primary data, aimed at male (620) and female (506) teachers of physical and sport education at the second elementary education stage of three regions of Slovakia. Detecting of teachers' perception was surveyed in period of three years (2017–2020). Each answer of male and female teachers was compared and evaluated by using the chi-square test (X^2), while the significance level (α) was .01 and .05. In general, the sports games were the most popular activities among the male and female teachers of physical and sport education (58.02%; n = 653). More than 41% of male and female teachers' answers about the most significant factors influencing the quality of teaching sports games were spatial and material conditions. The reason for that was partly due to the low time allowance of teaching sports games (28.86%; n = 152). The traditional sports games (football, volleyball, basketball) were the best secured, in terms of material conditions, in contrast to floorball (34,70%; n = 390).

Key words elementary schools, material and technical support, physical and sport education, selected regions of Slovakia, sports games

Introduction

The aim of school physical and sport education is to provide pupils (students) with basic information about the healthy lifestyle, to develop skills and ensure an adequate level of knowledge and most of all shaping the proactive, pro-health and pro-social attitudes. All these conditions should be developed not only during school attendance, but should also have a transfer to adulthood or to the area of leisure activities. Clemente, Rocha and Kargaokar (2012)

indicated that teaching of physical and sport education is a process that should bring pupils (students) a wide range of information. In order for the school physical and sport education to affect pupils (students) for life, it must use the most diverse range of interesting means and use such motivating forms and methods, which will appeal to the pupils (students) as best as possible (Skladaný, Feč, Zusková, 2002). The popularity of physical and sport education depends not only on the content of lessons, teaching style, pedagogical approach and teacher activity, but also on the organizational format of activities, and of course the quality of spatial and material conditions (Sigmundová, Frömel, Havlíková, Janečková, 2005). The realization of individual aims of physical and sport education assumes compliance and the highest possible level of all variables that affect the educational process. The basic factors of this process are the teacher, pupils (students), content and conditions. In terms of importance of individual factors entering the physical and sport education process, it is not clearly possible to determine their order and dominance. The dissatisfaction is often expressed, mainly with the conditions, in which the physical and sport education process takes place (Šimonek, 2011). These conditions can be understood from various perspectives, whether it is the space, in which the physical and sport education process takes place or equipment, but also the quality and frequency of teaching aids (Nemec, 2013). Other factors influencing the quality of educational process can include pupils' (students') lack of interest (Junger, 2006; Boruková, Yazarer, Izáková, Ivanov, 2017), insufficient staffing (Mesiarik, 2012), low time allocation (Lehocký, 2010). When evaluating the content of school physical and sport education, several authors (Görner, Starší, 2001; Egger, Kühnis, Nussbaum, Däniken, 2002; Annerstedt, 2008; Hoffmann, Brixius, Vogt, 2018) warned that its quality is significantly conditioned by personal preferences, gender and value system. Some issues also appear in various forms in the teaching of its individual thematic units (Hastie, Saunders, 1991; McNeill, Lim, Wang, Macphail, 2010).

In 2008, the Slovak education system reorganized the structure of the national education, taking into account the European education system and introduced the so-called *"State Educational Program"* in the hierarchy of the International Standard Classification of Education (ISCED). In 2015, its innovation took place in order to improve its clarity and more logical connection of individual learning elements. An important part of this material was also the definition of space, in which each school can complete its content of education according to specific regional and local needs and conditions. Pursuant to Act 416/2001 Coll. As of 1 July 2002, the founding powers of schools and school facilities were transferred from local state administration bodies to local government bodies. Some local government bodies have invested in schools, but some have not, because they did not have the means to do that, which created significant differences in their technical condition, quality of technology and, last but not least, in their equipment. The analysis of gyms showed that 37.49% of elementary schools in Slovakia with more than 150 pupils (students) did not have their own gyms (in 2016) and in 123 cases, € 11 million (€ 10,856,987) were allocated to deal with emergency situations.

The physical and sport education is one of the most popular subjects among the pupils (students), which is confirmed by several authors (Bartík, 2009; Antala et al., 2012; Biddle, Mutrie, Gorely, 2015; Adamčák, Nemec, 2015; Straňavská, 2015; Basar, Coskun, 2017). Among the most popular thematic units for pupils (students), as well as teachers are the sports games (Hubinák, 2009; Dismore, Bailey, 2011; Izáková, 2013; Nemec, Adamčák, 2013). The innovated *"State Educational Program"*, within the thematic unit of sports games, recommended teaching 4 sports games (football, basketball, handball and volleyball), while the individual schools may, according to their conditions and interest of pupils (students), appropriate qualification of teachers, also include lesser-known sports games, such as floorball, baseball, ringo and ice hockey. From the research of several authors (Krška, 2007;

Baránek, 2013; Kozaňáková, Adamčák, Kollár, 2015) conducted in recent years, we can state that the floorball is one of increasingly popular sports games among the pupils (students) of Slovak elementary schools.

Aim

The aim of study was to analyze and evaluate the male and female teachers' perception about the popularity and common issues of teaching sports games, within the school subject of physical and sport education at the second elementary education stage.

Methods

In terms of study aim, the survey group was chosen purposely and consisted of male (55.06%; n = 620) and female (44.94%; n = 506) teachers of physical and sport education at the second elementary education stage of three (n = 3) regions of Slovakia. Being active male and female teacher of physical and sport education at the second elementary education stage was the only inclusion criterion of the study. The survey group's range was not limited; 1,126 (100%) of male and female teachers of three regions of Slovakia participated in the study, while the incidence of involved male and female teachers was the following: a) Eastern Slovakia – 382; 33.92% (male – 64.92%; n = 248 and female – 35.08%; n = 134); b) Central Slovakia – 368; 32.68% (male – 51.35%; n = 189 and female – 48.65%; n = 179); c) Western Slovakia – 376; 33.40% (male – 48.67%; n = 183 and female – 51.33%, n = 193) (Table 1).

Table 1. Characteristics of survey group (n = 1,126)

Region	Male teachers		Female teachers		Total number	
Eastern Slovakia	248	64.92%	134	35.08%	382	33.92%
Central Slovakia	189	51.35%	179	48.65%	368	32.68%
Western Slovakia	183	48.67%	193	51.33%	376	33.40%
Total number	620	55.06%	506	44.94%	1,126	100.00%

When collecting the data, the research instrument of survey was used, which was created purposely (non-standardized survey) and consisted of two sections: a) demographic information; b) survey questions, which consisted of three closed questions, concerned with the popularity of sports games, common issues of teaching sports games and sports games equipment. The content of non-standardized survey was inspired by several authors (Nemec, Adamčák, 2013; Soares, Antunnes, Van Den Tillaar, 2013), while the average time of completing the face-to-face survey was approximately 7 minutes. The information about identity was not taken, so that the survey was answered objectively. In addition, the survey was given to each second elementary education stage teacher of physical and sport education who inscribed the answers in their native language, within the pre-printed forms. After inscribing the answers, the survey was given to authors of study. Detecting of survey group's perceptions was surveyed in period of three years (2017–2020).

In terms of three regions, each answer of male and female teachers was compared and evaluated by using the program of Tap 3 – Gamo, Banská Bystrica. The acquired data from the three regions were pooled after cleaning. The method of percentage frequency analysis (%), arithmetic mean ($\bar{x}$) and multiplicity (n) was used, while

the percentage values were used in the survey questions with the singe choice answer. The difference between each region (variable of location) of Slovakia was evaluated by method of inductive statistics – chi-square test (X^2), of which the significance level (α) was 0.01 and 0.05.

Results

In terms of study results, the first item of survey was dealing with what place do the sports games occupy in the teaching of physical and sport education among the survey group (n = 1,126). When inscribing the answer about the most popular activity, the survey group's highest percentage answer (average) was the sports games ($\bar{x}$ 58.02%; n = 653), while the incidence of three regions was the following: a) Eastern Slovakia (54.19%; n = 207); b) Central Slovakia (59.51%; n = 219); c) Western Slovakia (60.37%; n = 227). In contrast to previous incidence, the range answer of natural environment ($\bar{x}$ 8.96%; n = 303) was the least popular activity, while the answer incidence of survey group was in the range of 5.59% (n = 21; Western Slovakia) to 11.26% (n = 43; Eastern Slovakia) (Figure 1). Despite of that, the lowest percentage answer was the gymnastics, within the survey group of Central Slovakia (8.97%; n = 33).

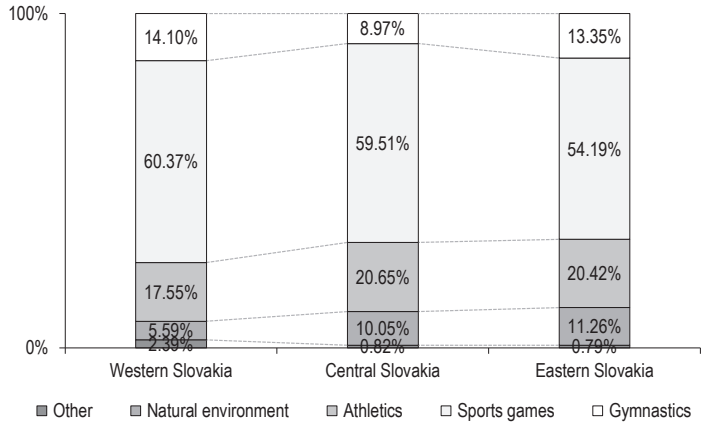

Figure 1. The most popular activity, within the survey group (n = 1,126)

Table 2. Survey group's answers about the most popular activity (n = 1,126)

Selected regions	Chi-square test (X^2)
Central Slovakia/Eastern Slovakia	0.35318⁻
Central Slovakia/Western Slovakia	0.01214*
Eastern Slovakia/Western Slovakia	0.01414*

* – Statistical significance of 0.05; ⁻ – Statistical insignificance.

In terms of statistical evaluation, the difference between the answers of survey group and variable of location was not significant at significance level of 0.05 (Eastern and Central Slovakia; p = 0.353). Yet, the statistical difference at significance level of 0.05 was recorded between the regions of Western and Central Slovakia (p = 0.012) and Western and Eastern Slovakia (p = 0.014) (Table 2).

An intention was to identify what male and female teachers of physical and sport education at the second elementary education stage of three regions of Slovakia (before the Covid 19) considered as the most common issues of teaching sports games (Figure 2). In general, the reason was the following: a) low time allowance of teaching sports games (28.86%; n = 325); b) insufficient spatial conditions (27.08%; n = 305); c) low interest of pupils (students) (25.64%; n = 288). In terms of variable of location, the survey group (n = 1 126) indicated the answers of low time allowance ($\bar{x}$ 28.86%; n = 325) and material support ($\bar{x}$ 14.58%; n = 164) as the common issues of teaching sports games. More than 21% of survey groups answers' about the insufficient material support of region of Western Slovakia created the most significant difference, compared to other regions (+7.97%; n = 29 – Central Slovakia; +11.32%; n = 42 – Eastern Slovakia). In general, the highest percentage survey group's answer was the insufficient time allowance, in particular of survey group of Eastern Slovakia (31.15%; n = 118). The answer of *"other"* was inscribed by $\bar{x}$ 3.83% (n = 43) of survey group (n = 1 126) who indicated the following issues of teaching sports games: a) organizational structure; b) exception of pupil (student) from physical and sport education.

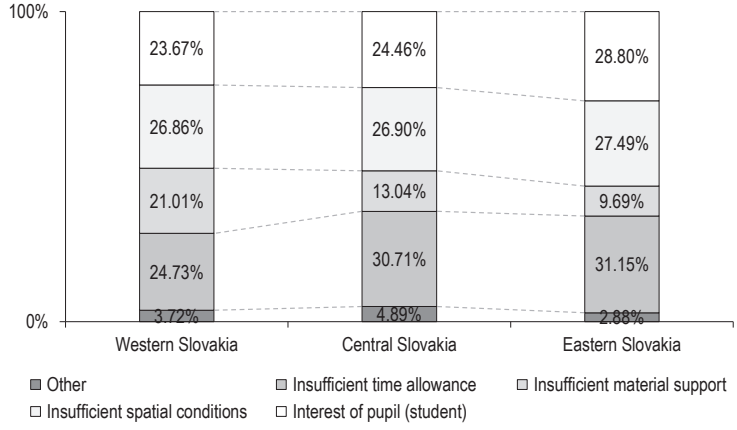

Figure 2. The most common issues of teaching sports games, within the survey group (n = 1,126)

In terms of statistical evaluation, the difference between the answers of survey group and variable of location was not significant at significance level of 0.05 (Eastern and Central Slovakia; p = 0.268). Yet, the statistical difference at significance level of 0.05 was recorded between the regions of Western and Central Slovakia (p = 0.041) and 0.01 between the regions of Western and Eastern Slovakia (p = 0.0003) (Table 3).

Table 3. Survey group's answers about the most common issues of teaching sports games (n = 1,126)

Selected regions	Chi-square test (X^2)
Central Slovakia/Eastern Slovakia	0.26880⁻
Central Slovakia/Western Slovakia	0.04128*
Eastern Slovakia/Western Slovakia	0.00031**

** – Significance level of 0.01; * – Statistical significance of 0.05; ⁻ – Statistical insignificance.

Within the survey, the last item was dealing with the material and technical support of teaching sports games (floorball, handball, volleyball, basketball and football), which was considered as an important indicator for fulfilling the aims of education. In general, we indicated that volleyball (71.93%; n = 810), basketball (71.31%; n = 803) and football (71.04%; n = 800) had the best (sufficient) equipment, within the selected sports games. When inscribing the answer about the insufficient equipment, the survey group's lowest percentage answer was floorball ($\bar{x}$ 27.81%; n = 313), while the incidence of three regions was the following: a) Eastern Slovakia (26.44%; n = 101); b) Central Slovakia (27.45%; n = 101); c) Western Slovakia (29.52%; n = 111). The range answer of not teaching the sports game of handball was the most frequent answer ($\bar{x}$ 35.21%; n = 396), while the least frequent answer was the sports game of football ($\bar{x}$ 1.16%; n = 13) (Figure 3). In terms of variable of location, we can state that the survey group's answer about the insufficient equipment of teaching sports games was in particular inscribed by survey group of Western Slovakia (31.95%; n = 120). The range answer of sufficient equipment was most often given by survey group of Eastern Slovakia (60.57%; n = 231). The range answer of not teaching any of sports games was the most frequent answer of male and female teachers of Central Slovakia (11.42%; n = 42). The survey group of Eastern Slovakia achieved the highest percentage answer in range answer of insufficient equipment (only once) in the sports game of floorball (36.65%; n = 140), which was in contrast to range answer of sufficient equipment (4 times; handball, volleyball, basketball, football). When evaluating the absence of teaching sports games, it was only twice (volleyball, basketball). In terms of Central Slovakia, we can state that the range answer of insufficient equipment (32.07%; n = 118) and not teaching the sports game (39.95%; n = 147) was in the sports game of handball, while the range answer of sufficient equipment (52.99%; n = 195) was in the sports game of floorball. Within the Western Slovakia, the survey group most often inscribed the range answer of insufficient equipment in the sports games of volleyball (30.32%; n = 114), basketball (34.04%; n = 128) and football (29.52%; n = 111), while the range answer of sufficient equipment never reached the highest percentage answer of male and female teachers (n = 1 126). Not teaching the sports games appeared as the most common in the sports games of floorball (18.88%; n = 71), basketball (2.39%; n = 9) and football (1.33%; n = 5). Despite of that, the lowest percentage answer of not teaching the sports game (basketball) was recorded among the survey group of Central Slovakia (0.82%; n = 3), while the highest percentage answer of sufficient equipment (basketball) was recorded among the survey group of Eastern Slovakia (76.18%; n = 291).

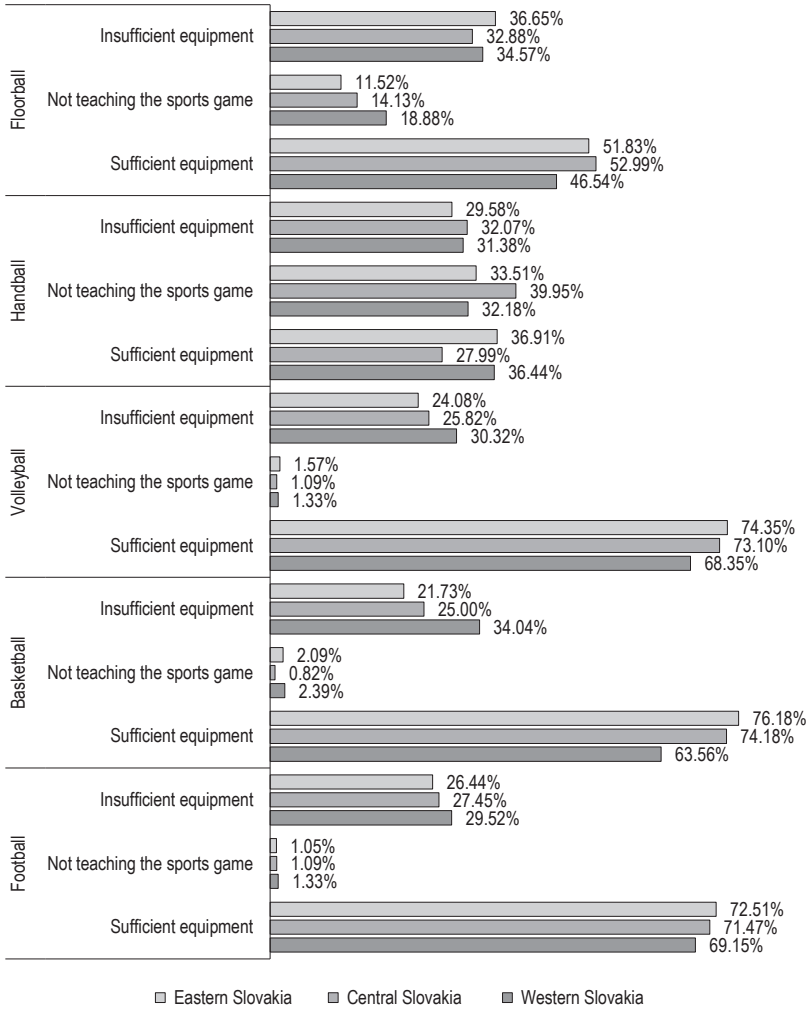

Figure 3. The material and technical support of teaching sports games, within the survey group (n = 1,126)

In terms of statistical evaluation, the difference between the answers of survey group, variable of location and sports game of volleyball was significant at significance level of 0.05 (Eastern and Central Slovakia; p = 0.029; Western and Central Slovakia; p = 0.026). In addition, the statistical difference at significance level of 0.01 and sports game of basketball was recorded between the regions of Western and Central Slovakia (p = 0.003) and Eastern and Western Slovakia (p = 0.0006). The difference between the answers of survey group of Eastern and Western Slovakia was significant at significance level of 0.05, in terms of sports game of floorball (p = 0.017) (Table 4).

Table 4. Survey group's answers about the material and technical support of teaching sports games (n = 1,126)

Selected Regions	Football – Chi-square test (X^2)
Central Slovakia/Eastern Slovakia	0.95042⁻
Central Slovakia/Western Slovakia	0.77334⁻
Eastern Slovakia/Western Slovakia	0.58462⁻
Selected Regions	Basketball – Chi-square test (X^2)
Central Slovakia/Eastern Slovakia	0.21764⁻
Central Slovakia/Western Slovakia	0.00395**
Eastern Slovakia/Western Slovakia	0.00063**
Selected Regions	Volleyball – Chi-square test (X^2)
Central Slovakia/Eastern Slovakia	0.02901*
Central Slovakia/Western Slovakia	0.02659*
Eastern Slovakia/Western Slovakia	0.85423⁻
Selected Regions	Handball – Chi-square test (X^2)
Central Slovakia/Eastern Slovakia	0.74309⁻
Central Slovakia/Western Slovakia	0.36306⁻
Eastern Slovakia/Western Slovakia	0.15407⁻
Selected Regions	Floorball – Chi-square test (X^2)
Central Slovakia/Eastern Slovakia	0.40413⁻
Central Slovakia/Western Slovakia	0.11924⁻
Eastern Slovakia/Western Slovakia	0.01759*

** – Significance level of 0.01; * – Statistical significance of 0.05; ⁻ – Statistical insignificance.

Discussion

Our survey, aimed at teaching physical and sport education at the second elementary education stage in the three regions of Slovakia was focused on analyzing and evaluating the popularity and common issues of teaching sports games in the physical and sport education at elementary schools in Slovakia. In general, we revealed the individual factors, which helped us identify the situation before the Covid-19. Achieved results confirmed the agreement with findings from the research by other authors (Görner, Starší, 2005; Dismore, Bailey, 2011; Izáková, 2013; Nemec, Adamčák, 2013) that, in general, the sports games were the most popular activities, within the physical and sport education (58.02%; n = 653), while the thematic unit of athletics was the second (19.54%; n = 220). Activities realized in the natural environment proved to be the least popular (8.97%; n = 101). One of the reasons for such preference for the indoor activities (sports games) over outdoor activities is the fact that the organization of each activity outside school (in nature) is significantly more challenging for male and female teachers, mainly in terms of safety, weather and transport. In addition, this inclination towards the thematic unit of sports games can also express the effort to realize, within the framework of compulsory school education and the kind of activity that pupils (students) like. According to Adamčák, Novotná (2009) a game is one of basic human activities, in addition to work and learning and brings joy and satisfaction to a participant. The regional difference, despite of two significant relationships at significance level of 0.05 (Eastern and Central Slovakia; p = 0.353; Western and Eastern Slovakia; p = 0.014) did not prove essential and different order of popularity of evaluated activities in teaching of physical and sport education at the second elementary education stage. The ranking did not prove the agreement only in the

activities from the end of popularity ranking, with the low percentage value (gymnastics – $\bar{x}$ 12.14%; n = 136), natural environment – $\bar{x}$ 8.97%; n = 101).

Despite of the highest popularity of teaching sports games, whether in terms of male and female teachers or pupils (students), we were interested in what male and female teachers considered as the most common issue of teaching sports games. In general, the common issue was the following: a) low time allowance of teaching sports games (28.86%; n = 325); b) insufficient spatial conditions (27.08%; n = 305); c) low interest of pupils (students) (25.64%; n = 288). Our chosen research factor – an insufficient equipment (teaching aids) ranked the fourth, in terms of number of survey group's answers (14.58%; n = 164). These findings were consistent with several authors (Slezák, Melicher, 2008; McNeill et al., 2010; Nemec, 2013) who stated that the male and female teachers expressed the dissatisfaction, in particular with the conditions, in which the physical and sport education is realized. If we sum up the spatial and material conditions, they make up more than 41% of survey group's answers. This finding confirmed that even 4 years after the launch of project – *Modernization Debt in the Field of Spatial and Material-Technical Support of Primary and Secondary Schools* (2016), schools and their founders had the issue of weak and average level of material, technical and spatial conditions of the physical and sport education. The innovated International Standard Classification of Education 2 introduced the spatial and material and technical support, which is mandatory for new schools. Other schools were encouraged to meet that standard during the transition period of three to five years, however that issue was the most common in schools from Western Slovakia (47.87%; 180), which were, according to the male and female teachers (n = 1,126) worse than in Central (7.93%; n = 29) and Eastern Slovakia (10.69%; n = 41). The low time allowance of teaching sports games was inscribed by the male and female teachers as the most significant issue (28.86%; n = 325). This issue also appeared in the research of Lehocký (2010) and Šimonek (2011). It was very difficult to evaluate that, as the innovated International Standard Classification of Education 2 allowed the male and female teachers to *"expand"* the sports games for up to almost 50% of total annual range of physical and sport education, which in practice meant more than 30 lessons. We rather considered the overall low time allowance of physical and sport education (2×/week) with such structured content to be the issue. In addition, we confirmed the statistical difference at significance level of 0.05, which was recorded between the regions of Western and Central Slovakia (p = 0.041) and .01 between the regions of Western and Eastern Slovakia (p = 0.0003). As part of our efforts to identify the current issues of teaching physical and sport education at elementary schools, we also acquired the survey answers of how teachers perceived the quality of material and technical support (equipment) of teaching the most popular activities – sports games (floorball, handball, volleyball, basketball, football) and also which of them was the most absent in the process of teaching physical and sport education. The almost identical level of three dominant (traditional) sports games of volleyball (71.93%; n = 810), basketball (71.31%; n = 803) and football (71.04%; n = 800) did not surprise us and confirmed another finding that handball was one of the least taught sports game (39.95%; n = 450). If we look at the research findings of Vilímová, Hurychová (2001), Fahey, Delaney, Gannon, (2005), Dismore, Bailey (2011), Antala et al. (2012) and Nemec Adamčák, Kollár, (2018), we can state their agreement in the fact that the *"traditional"* sports games, in particular football and basketball, and partly volleyball, were leaders in the popularity, whether among the pupils (students) and male and female teachers (n = 1,126). Despite of the ever-increasing popularity, the sports game of floorball is still one of the only gradually established sports games. The reason can also be its more demanding equipment. The highest percentage answer of survey item – insufficient equipment was recorded, within the sport game of floorball (34.70%; n = 390). As in the previous survey question, male and female teachers

of Western Slovakia most often inscribed the range answer of insufficient equipment (31.95%; n = 120). The survey group of Eastern Slovakia expressed the most positive perception about that (60.75%; n = 232). Not teaching the sports game of handball ($\bar{x}$ 35.21%; n = 396) was the longer-term phenomenon at elementary school environments (Antala et al., 2012) and was probably related not only to the traditions and mentality, but also to the considerable aggression (danger) of direct battles between male and female handball players. On the contrary, the number of 1.16% (n = 13) in the range answer about not teaching the sports game of football confirmed that it was one of the absolute phenomenon in Slovakia. The existing significant difference between the evaluated three regions of Slovakia confirmed the dominant positive status of football and negative status of handball.

Conclusion

It is undeniable that the most important aim of teaching sports games is played by the male and female teachers and their approach. Tomajko (1993) stated that only the creative teachers of physical and sport education can lead pupils (students) to independence, creativity and arouse their interest in health and healthy lifestyle. This, of course, requires an effectively functioning regional education system, which in adequate conditions can provide quality education and respond to the current needs of pupils (students).

We consider the most important knowledge arising from the survey the fact that the sports games are the most popular activities in teaching of physical and sport education at the second elementary education stage. Different activities related to staying in nature are, for various reasons the least preferred part of education. Where else can the truly healthy physical activity, if not in nature, be realized in the connection with the current global Covid-19 pandemic.

The findings concerning the common issues with ensuring the sufficient material and technical support of elementary schools for teaching of sports games are mainly in the hands of founders. There are many options (challenges, projects, foundations) that allow elementary schools to improve this situation. It requires not only willingness and time, but also the creativity and commitment.

With regard to the diversity and significance of our findings, in terms of evaluated regions, we would like to mention the following recommendations for practice:

1. To implement the increased interest through the methodological centers and universities of physical education aimed at teaching the sports games presenting the latest knowledge from their teaching and learning, because only in this way it will be possible to maintain the highest professionalism of male and female teachers and last but not least the highest interest of pupils (students) in the thematic unit of sports games.
2. To implement the teaching of sports games not only in the gym, but also in the natural environment (grass fields, school yard, adjacent lawns, parks), especially in elementary schools with limited spaces in the form of gyms.
3. To improve the material and technical support of elementary schools through increased activity of founders, principals and male and female teachers themselves in the form of school involvement in various calls for funding implemented by the Ministry of Education, Science, Research and Sport of the Slovak Republic.
4. In terms of sports games, in which the pupils (students) showed low interest, it is necessary to improve their teaching with the use of playful activities in the form of physical and preparatory games, but also by the diversity of socio-interactional forms (group, individual form) and their modifications.

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1,000-M ROWING ERGOMETER TIME TRIAL PERFORMANCE IN FEMALE AND MALE COLLEGIATE ROWERS

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Abstract **Introduction.** The purpose of this study was to evaluate the time of covering a distance of 1,000 m on a rowing ergometer by competitors of the Academic Sports Association of the Pomeranian Medical University and to relate the achieved results to the best results from the Polish Rowing Ergometer Academic Championships.
Methods. 28 rowers were tested in the 1,000 m "maximum" test (1,000 TM/t)**.** In addition, correlations were sought between the time and power values obtained in the 1000 TM/t with the values of selected anthropometric indices (height and weight, body mass index BMI), hand grip strength, heart rate and body composition components (free fat mass FFM, skeletal muscle mass SMM).
Results. The significant correlation between the time and power output in 1,000 TM/t and values of FFM, SMM, handgrip strength test as well as resting HR have been observed.
Conclusion. The results obtained at 1,000 TM/t can be considered promising for the further training stage due to the fact that the study was conducted on a rowing ergometer under training conditions prior to a special training mesocycle shaping strength and speed, while the athletes competing at the event to which our results were related were in peak competitive performance.

Key words: performance rowing, indoor rowing, ergometer, "1,000 m maximal test"

Introduction

In testing rowers on water, the main limitations are the lack of technical possibilities to perform some physiological measurements, the high costs of portable apparatus and the variability of environmental conditions.

Therefore, conducting diagnostic exercise tests in the laboratory using a rowing ergometer enables standard test conditions to be maintained and sufficiently fulfils the postulate of test specificity. The rowing ergometer is an indispensable training tool in rowing, due to the fact that it most closely reflects the biomechanics of movement in a rowing boat (Sablic, Versic, Uljevic, 2021). The Concept II rowing ergometer was used for this study, allowing a simulation model for starting conditions that reproduces with due accuracy the relationships between the dominant sources of muscle metabolism during the rowing cycle. The use of such an apparatus during periods of preparation on land makes it possible to isolate individual stroke sequences, which allows athletes to better prepare physically and technically for rowing competitions.

Optimal performance on an ergometer involves proper technique and engages all major muscle parts (Secher, 2007; Hennig, 2003). The rowing stroke can be divided into 4 stages: the catch, the drive, the finish and the recovery. The catch is the starting point of the stroke. On a rowing boat this is the moment when the oar feather is immersed in the water. The counterpart to this on an ergometer is the retraction of the chain of the ergometer's acceleration handle. The correct posture during the catch is: arms straight, head in natural position, shoulders lowered, torso leaning forward, knees bent, shins upright. The drive is the force generating part of the pull. The drive can be divided into an early phase and a late phase. In the early phase, the straightened arms and shoulders passively transfer the force generated by the legs, hips and lower back. The force transferred to the ergometer comes first from straightening the legs and then from bending the torso backwards. In the late phase of the ride after the handle pass the knees, there is a pull from the arms. The finish on a rowing boat is the moment when the oar feather is pulled out of the water. On the ergometer this is the final stroke position in which the legs are straightened at the knees, the torso is slightly bent backwards (at an angle of 110 degrees) and the arms are pulled towards the ribcage. The recovery is passive and consists of returning to the starting position and preparation for the next pull. First the arms are straightened, then the torso is returned to 70 degrees, leg flexion begins when the torso is at 90 degrees.

The endurance preparation season during the rower's annual training cycle consists of the athlete performing 3 workouts per week on the ergometer (3 × 20 min continuous pace of 26–28 strokes per minute) for a period of 5 months. The rules of the academic competition differ from other championships in the distance to be covered by the rowers, which is 1,000 m instead of 2,000 m. For this reason, a 1,000 m test on a rowing ergometer is used for ongoing evaluation of the level of training in relation to the times achieved over this distance. Each season's annual preparation of rowing students culminates with the Polish Rowing Academic Championships (AMP in rowing), usually held in May, and the Polish Rowing Ergometer Academic Championships (AMP in rowing ergometer), held earlier, usually in April. The examined rowers competing at the national academic level achieved medal successes in the 2020/2021 season: women a silver medal in the 2021 Polish Rowing Academic Championships, men a bronze medal in the 2021 Polish Rowing Academic Championships.

Due to the lack of opportunity to participate in last year's rowing ergometer competition it seems purposeful to compare actual rowing performance with the rivals from the last year competition. Consequently, the aim of the study was to evaluate the time of covering a distance of 1,000 m on a rowing ergometer by competitors of the Academic Sports Association of the Pomeranian Medical University (KU AZS PUM) and to relate the achieved results to the best results from the Polish Rowing Ergometer Academic Championships.

In addition, correlations were sought between the time and power values obtained in the 1,000 m test with the values of selected anthropometric indices (height and weight, body mass index BMI), hand grip strength and body composition components (free fat mass FFM, skeletal muscle mass SMM).

Material and methods

Test group

A total of 28 rowers (12 women and 16 men) competing on rowing eights (W8+ women's eight M8+ men's eight) training in the college club rowing section of KU AZS PUM took part in the study. In the men's group there were 9 rowers of the first rowing team (technically advanced) and 7 rowers of the reserve rowing team (beginners). In the women's group there were 8 rowers from the first rowing team (technically advanced) and 4 rowers from the reserve rowing team (beginners). The average rowing experience in the male group was 26.25 months (range 12 to 60 months) and in the female group 35.5 months (range 6 to 80 months). None of the study participants, both men and women, except for the participation in regular training sessions and in seasonal competitions of the rowing section of AZS PUM, had previously practised any sport discipline on a competitive basis.

All subjects and the trainer agreed to use the results obtained during the tests, which are part of the routine rowing training unit, for the scientific elaboration.

Maximum speed' exercise test (TM/t)

The study was conducted during a single training unit.

Prior to the speed tests, athletes had their resting heart rate (HR_{rest}) measured by palpation on the radial artery and internal carotid artery and body mass composition was analysed by electrical bioimpedance using a TANITA DC-430 S MA. The global grip strength of the hand (both right and left) handgrip test was also investigated, using a hydraulic handgrip dynamometer (BASELINE). For each upper limb, 3 repetitions of the measurement were made, from which the mean values were calculated for analysis.

Then each competitor was subjected to a speed test: The "maximum" test (TM/t) consisted of an assessment of the athlete's special fitness by simulating a 1,000 m race distance on a Concept II ergometer in as short a time as possible.

The load (drag factor) was set at 120 N s^2/m^2, which best corresponds to the resistance offered by the water when rowing in real conditions. During the test, heart rate was monitored using a Polar H10 heart rate monitor. Data were collected on average heart rate, maximum heart rate and minimum heart rate throughout the test and for each 100 m split. HR_{rest} was used to analyse the determinants of performance (power values [W] and time to complete the distance [s] as well as the calculated average exercise heart rate and maximum heart rate values obtained during the test.

Statistical Analysis

Statistical analyses were performed with the use of STATISTICA 13.3 software (StatSoft. Poland). All variables met normality assumptions using a Shapiro-Wilk test. The data distribution met the conditions of normal distribution, therefore the examined variables were presented in the form of arithmetic means and minimum and maximum values. A comparative analysis of the significance of difference in the temperature values of selected areas between groups was carried out using the Student's t-test. Additionally, the correlations between all of the examined parameters were calculated in studied groups.

Table 1. Anthropometric characteristics of the participants

	Men (n = 16)		Women (n = 12)		Student's t-test *p* t
	mean	min–max	mean	min–max	
Age (years)	22	20–24	22	20–25	NS
Body height (m)	186.19	178–198	172.17	159–183	*p* = 0.0000 t = 5.4
Body weight (kg)	82.66	63.4–98.4	63.98	50.30–86.6	*p* = 0.0003 t = 4.66
BMI (kg/m^2)	23.8	18.9–28.4	21.55	18.60–28.6	*p* = 0.0274 t = 2.18
BF (kg)	9.81	4.8–21.1	15.82	10–30.9	*p* = 0.0114 t = 5.39
PBF (%)	11.49	5.5–23.5	24	16.6–39.2	*p* = 0.0002 t = 2.5
FFM (kg)	72.84	58.3–85.4	48.16	40.3–52.7	*p* = 0.0000 t = 9.43
SMM (kg)	69.43	55.4–81.2	45.72	38.2–50s	*p* = 0.0000 t = 9.66
Rowing training experience (months)	26.25	12–60	35.5	6–84	NS

Legend: BMI – body mass index; BF – body fat; PBF – percent body fat; FFM – free fat mass; SMM – skeletal muscle mass.
Statistically significant difference at *p < 0.05, ** *p* < 0.01, ***p < 0.001.

Table 2. The mean as well as the minimum and maximum values of the results obtained in the cycloergometer speed test (1,000 m TM/t) and the values of heart rate indices (HR)

	Men (n = 16)		Women (n = 12)		Student's t-test *p* t
	mean	min–max	mean	min–max	
1000 m test time (s)	200.58	183.9–243.7	241.58	224.2–264.7	*p* = 0.0001 t = 7.0
1000 m test (W)	3236.3	1832–4072	1810	1356–2231	*p* = 0.0002 t = 5.04
HRrest (BPM)	61	48–75	64	60–72	NS
Avg HR (BPM)	178.13	164–193	177.17	169–199	NS
highest exercise HR (BPM)	186.63	175–199	184	174–202	NS
HGt_{left} left side rowing	51.4 * vs HGt_{right}	33.3–78	26.6 * vs HGt_{right}	21–34.3	*p* = 0.000884 t = 4.29
HGt_{left} right side rowing	51.29 * vs HGt_{right}	36.7–67	30.2 * vs HGt_{right}	27.3–33	*p* = 0.004704 t = 3.62
HGt_{right} left side rowing	52.73	33.7–69.7	28.73	23.7–38.7	*p* = 0.000778 t = 4.36
HGt_{right} right side rowing	53.96	41–65.7	32.4	29.3–36	*p* = 0.000620 t = 4.90

Legend: HR_{rest} – heart rate measured in rest; HGt_{left} – handgrip test left hand; HGt_{right} – handgrip test right hand; Avg HR – average exercise HR; *significance of differences between HGt strength for contralateral upper limbs within competitors from the same rowing side at p < 0.05.

Results

The results of the study are presented in tables and charts. The characteristics of the studied group including body composition indices are presented in Table 1. Due to natural and expected and statistically confirmed inter-gender differences for anthropometric values and body composition, the results were analysed independently for women and men. The mean height and weight values for women were respectively: 172.17 cm and 63.98 kg and for men respectively: 186.19 cm and 82.66 kg. Mean BMI showed significant inter-sex variation, being 21.55 kg/m^2 for females and 23.8 kg/m^2 for males. Similarly, intersex differences were observed for all analysed body composition indices: BF, PBF, FFM and SMM, whose mean values were 15.82 kg, 24%, 48.16, 45.72 for women and 9.81 kg, 11.49%, 72.84 kg, 69.43 kg for men, respectively.

Mean HR_{rest} values measured before the speed test were 64 BPM in women and 61 BPM in men, sequentially calculated from the whole exercise period mean heart rate values were 177 BPM for women and 178 BPM for men.

The mean value of maximum heart rate obtained during exercise was 184 BPM in women and 186 BPM in men. The values for heart rate did not show inter-sex variation.

Table 2 summarises the mean as well as the minimum and maximum values of the results obtained in the cycloergometer speed test (1,000 m TM/t) and the values of heart rate indices. The results of simulation studies (starting conditions) conducted at the end of a mesocycle shaping the general endurance of rowers (Hagerman, Staron, 1983), indicate a significant range of variation in individual power indices obtained in the 1,000 m test. The mean power generated by the subjects was 1,810 W for women (range 1,356–2,231) and 3,236 W for men (range 1,832–4,072). The mean time to cover 1,000 m was 241.58 s for women and 200.58 s for men.

Competitors at the AMP in rowing ergometer compete in one of two weight categories: light weight with a weight limitation in the starting suit for women of up to 61.5 kg and for men of up to 75 kg and open weight with no weight limit for either women or men. In the study group the lightweight criterion was met by 5 men and 5 women the rest were qualified to the open weight category. If we relate the results of times in TM/t test by rowers of KU AZS PUM to the results of individual classification in AMP in the year 2020/21 in lightweight men would take respectively 6th, 28th, 66th, 71st and 95th place out of 98 competitors and in open weight 27th, 33rd, 39th, 45th, 46th, 62nd, 67th, 75th, 76th, 123th and 146th place out of 146 competitors. The women would be ranked 45th, 54th, 59th, 76th and 77th out of 92 athletes in the light weight and respectively 31st, 48th, 50th, 56th, 59th, 61st and 62nd out of 84 athletes in the open weight (Table 3). The results of the best 3 female athletes and the best 6 male athletes of a given university, apart from the individual classification, are also taken into account in the overall team classification for women and men. Considering the obtained results and places, men would take the 6th place out of 28 universities while women would take the 17th place out of 29 universities.

Table 3. Relating the rowers' TM/t results to the results and placed positions in the individual classification from the 2020/2021 AMP in Rowing Ergometer

Category	Number of KU AZS PUM athletes surveyed, whose current results correspond to locations			Number of participants in AMP in Rowing Ergometer 2020/21
	1st–10th	11th–50th	>50th	
Men's lightweight	1	1	3	98
Men's open weight	0	5	6	146
Women's lightweight	0	3	2	92
Women's open weight	0	3	4	84

An additional aim of the study was to search for correlations between anthropometric indices, body composition, handgrip test results, resting and exercise heart rate values and total time in 1,000 m TM/t as well as values of generated power. Statistical analysis did not confirm a statistically significant correlation between Avg HR and highest exercise HR with generated power and test time. Interestingly, the male group showed a statistically significant correlation between the results obtained and values of resting heart rate ($r = –0.506$, $p = 0.0455$). A lower resting heart rate determined higher values of generated power and shorter times. Women showed a similar trend but without statistical significance.

On the other hand, indices characterising the muscular components of body composition and handgrip strength values showed a high correlation with generated power both in women (FFM: $r = 0.7030$, $p = 0.0108$; SMM: $r = 0.7050$, $p = 0.0104$; $HGtright_{left}$ side rowing: $r = –0.0063$, $p = 0.9919$; $HGtleft_{left}$ side rowing: $r = 0.4037$, $p = 0.4273$; $HGtleft_{right}$ side rowing: $r = 0.3300$, $p = 0.5230$; $HGtright_{right}$ side rowing: $r = 0.0311$, $p = 0.9605$) as well as in men (FFM: $r = 0.7713$, $p = 0.0005$; SMM: $r = 0.7414$, $p = 0.0010$; $HGtright_{left}$ side rowing: $r = 0.7053$, $p = 0.0767$; $HGtleft_{left}$ side rowing: $r = 0.6057$, $p = 0.0839$; $HGtleft_{right}$ side rowing: $r = 0.8737$, $p = 0.0021$; $HGtright_{right}$ side rowing: $r = 0.8222$, $p = 0.0232$) and with the results of the times obtained in both women (FFM: $r = –0.7127$, $p = 0.0093$; SMM: $r = –0.7149$, $p = 0.0090$; $HGtright_{left}$ side rowing: $r = –0.0304$, $p = 0.9613$; $HGtleft_{left}$ side rowing: $r = –0.3940$, $p = 0.4396$; $HGtleft_{right}$ side rowing: $r = –0.3549$, $p = 0.4900$; $HGtright_{right}$ side rowing: $r = –0.0748$, $p = 0.9049$) as well as in men (FFM: $r = –0.7201$, $p = 0.0017$; SMM: $r = –0.6898$, $p = 0.0031$; $HGtright_{left}$ side rowing: $r = –0.6859$, $p = 0.0889$; $HGtleft_{left}$ side rowing: $r = –0.6020$, $p = 0.0863$; $HGtleft_{right}$ side rowing: $r = –0.8258$, $p = 0.0061$; $HGtright_{right}$ side rowing: $r = –0.8128$, $p = 0.0263$). The fat components of body composition did not show significant relationships with power and time values in the 1,000 mTM/t test.

Statistically significant correlations by gender are presented in figures from 1 to 6.

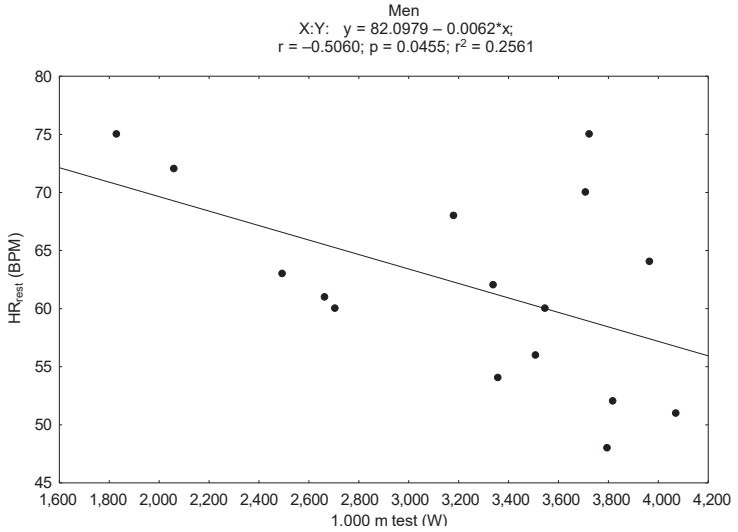

Figure 1. Relationship between rest heart rate and power from 1,000 m test

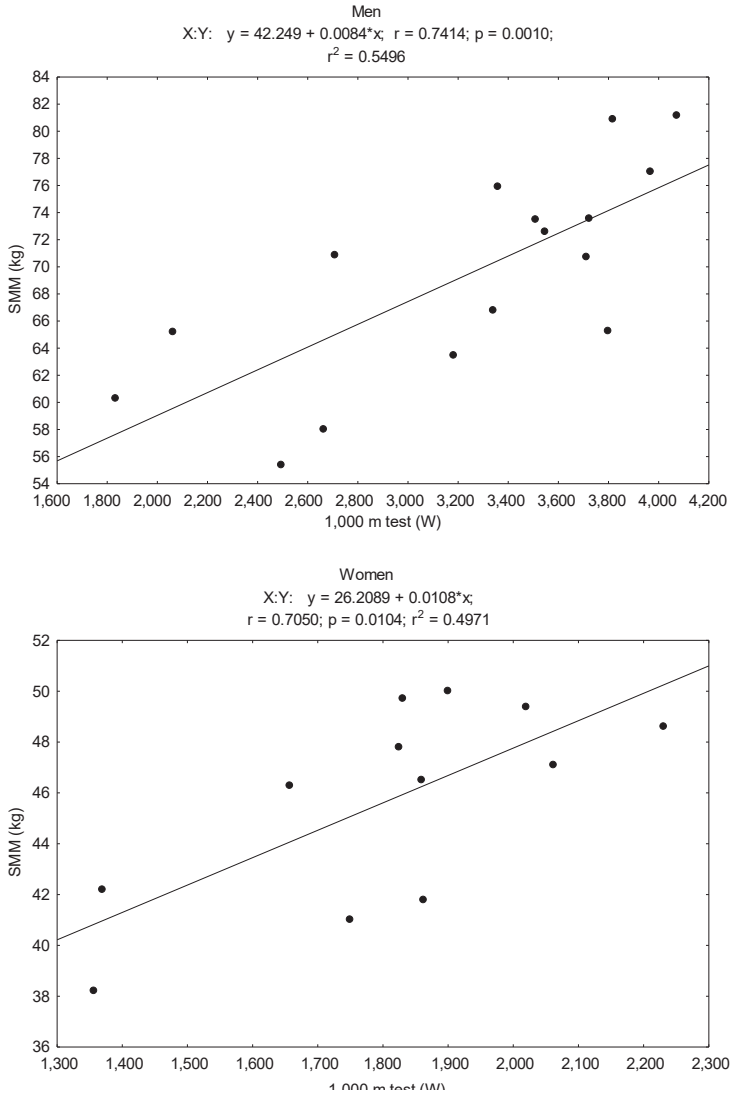

Figure 2. Relationship between skeletal muscle mass and power from 1,000 m test

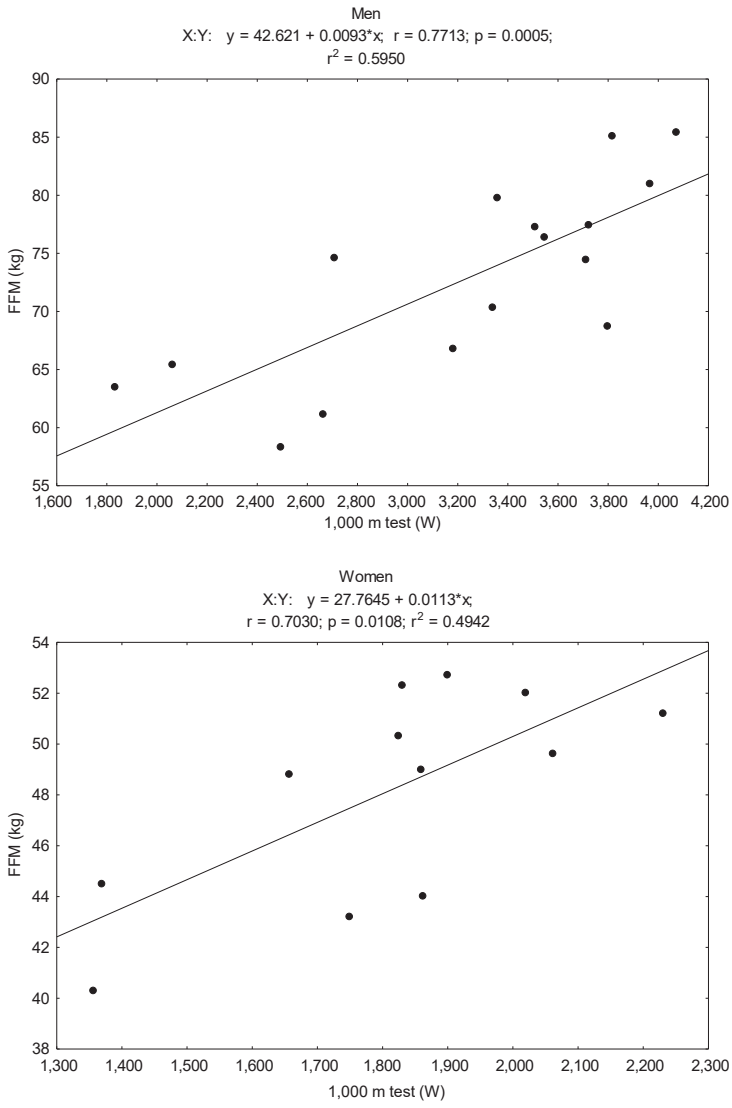

Figure 3. Relationship between free fat mass and power from 1,000 m test

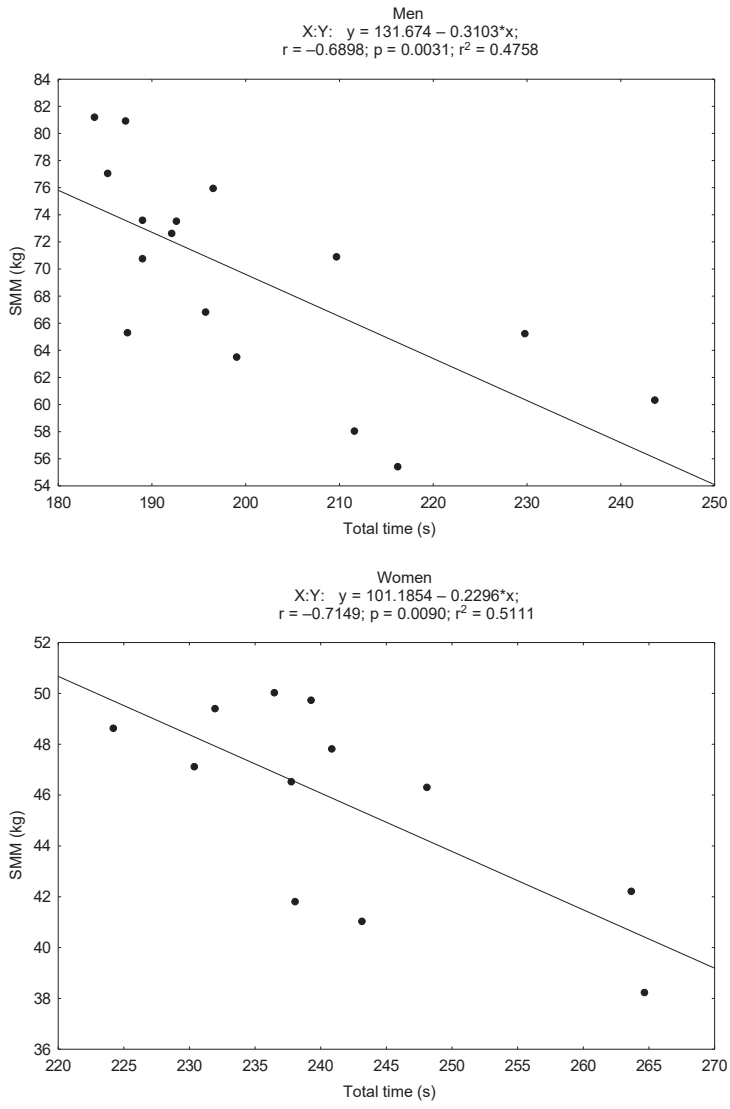

Figure 4. Relationship between skeletal muscle mass and total time from 1,000 m test

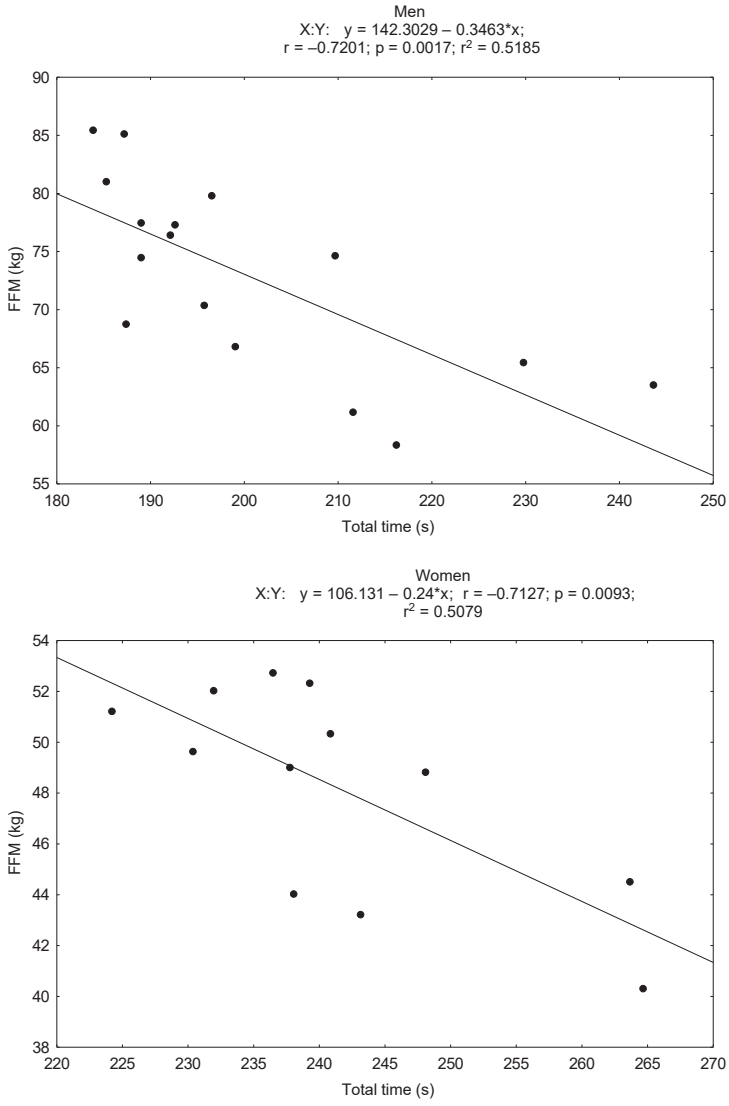

Figure 5. Relationship between free fat mass and total time from 1,000 m test

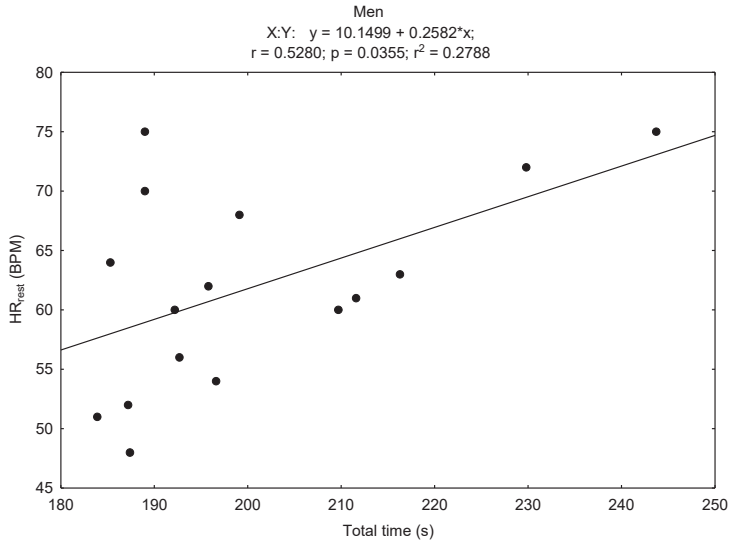

Figure 6. Relationship between rest heart rate and total time from 1,000 m test

Discussion

Rowing is a strength and endurance sport requiring the ability to generate both anaerobic power and aerobic capacity, it involves activation of almost all muscles in the body (Mikulic, Bralic, 2018), in which body size, strength, technique and rowing tactics play an important role in achieving sporting success. It is a cyclic sport containing a repeating sequence of four phases: the catch followed by the drive, the finish and the recovery phases, during which precise technique is required to maximise boat speed. The main objective of the sport is to cover a certain distance of the "run" in the shortest possible time. Assessing an athlete's performance in both amateur and competitive sports is important for monitoring progress and evaluating the effects of training in both practice and research. The Concept II rowing ergometer can reliably physiologically simulate race conditions and is widely used to assess athlete performance outside the water (Soper, Hume, 2004). A recent study by Soper and Hume, comparing the reliability of rowing performance over distances of 500 m and 2,000 m on the Concept II and RowPerfect ergometer, found that the rowers' mean power output was less variable on the Concept II ergometer (500 m = 2.8%, 95% CI 2.3, 3.4; 2000 m = 1.3%, 95% CI 0.8, 2.9) compared to the RowPerfect ergometer, which is not very popular in Poland (500 m = 3.0%, 95% CI 2.5, 3.9; 2,000 m = 3.3%, 95% CI 2.2, 7.0) (Soper, Hume, 2004). Independently, the accuracy of the measurement with the Concept II ergometer was confirmed by Boyas in his work (Boyas, Nordez, Cornu, Guével, 2006). According to his study on a group of rowers, the ergometer software's mathematical algorithms underestimated the power generated by approximately 25 W relative to the actual values assessed using a strain gauge placed near the handle and a position sensor installed on the chain. The Authors concluded that the deletion of the first strokes following changes in power production allows to limit this phenomenon. The high accuracy of the ergometer and the possibility of conducting the test under controlled

conditions make many studies use speed tests at 500 m, 1,000 m and 2,000 m on the ergometer as a criterion for predicting performance. However, it is important to note that the movement on the ergometer does not accurately reflect the hand movements you make on the water (you do not have to lower your arms to pull the oar out of the water) (Hume, 2018).

The main objective of the study was to evaluate the time taken by athletes of KU AZS PUM to complete a distance of 1,000 m on a rowing ergometer and to compare them to academic results from the national competition. On the basis of a comparative analysis of the speed results obtained in our own research in relation to the results from the AMP 2020/2021 in rowing ergometer, the male team consisting of the research participants would take 6th place out of a possible 28 and the female team would take 17th place out of a possible 29. For the team, the best 6 results in men and the best 4 results in women are scored. The high place in the retrospective prediction in the men's overall ranking, despite the lack of athletes fitting in the top ten, is due to the very small intra-group variation in the results of the times achieved. The difference between the best (03:03.9) and worst (03:09.0) times for the 1,000 m in the top 6 men was only 5.1 s. The impact of a small intra-group variation of results can be best explained on the example of the previous results of the competitors of the Gdańsk University of Technology at the AMP 2020/2021. Despite the fact that two leading competitors from Gdańsk took the 1st and the 7th position in the men's light category, the other 4 competitors scored much lower, the difference between the best and the worst result was as much as 23.2 seconds, which placed the Gdańsk University of Technology in the team classification outside the top 10, on the 12th position.

Success in competitive sport is determined by many factors, including psychological conditions, motor skills and body composition. Therefore, an additional aim was to look for those of the modifiable factors that may have the greatest impact on the performance of rowers.

One of the most important is muscle strength, the level of which is often used to identify predispositions in different sports. Of the many muscles of the limbs, the strength of the muscles that generate the global grip is most commonly assessed. The grip strength test is the simplest and least complex of the many instrumental measurements of muscle strength and there is some evidence that grip strength reflects global muscle strength (Bohannon, Magasi, Bubela, 2012) In this study, we divided the study group into the side on which they rowed in a rowing boat. In all subjects, the right upper limb was statistically significantly stronger in the HGt test. Moreover, each time, regardless of the side, the strength in the HGt_{right} test correlated more strongly with the results (generated power and time). Rowing with "one oar", as an asymmetric sport, is characterised by a higher power generated by the outside hand. For those rowing on the right it is the left hand and for those rowing on the left it is the right hand. Among our subjects, only the males showed a statistically significant very strong relationship ($r = 0.81$) between the force value in the HGt_{right} test, generated power and the total time of the test, regardless of the side on which they row. The results for HGt_{left} in men showed no statistically significant correlation. Interestingly, the outside hand correlates more strongly than the closer hand in individuals rowing on opposite sides. Based on this observation, it can be concluded that the grip strength of the left hand is a weak point for right-sided rowers (because this hand is then the outside hand) and they should pay special attention to developing the strength of this hand during training. HGt_{right} and HGt_{left} in women showed a significantly weaker, not statistically significant relationship with rowing performance. This can be explained by the lower upper body strength in women and the compensatory shift of the rowing effort to the lower, stronger body part.

A number of studies have attempted to establish the relationship between selected physiological variables and 500 m 1,000 m or 2,000 m performance, i.e. body mass, V_{O2}max (Secher, 1993); Cosgrove, Wilson, Watt, Grant, 1999; Majumdar, Das, Mandal, 2017; Penichet-Tomas, Pueo, Selles-Perez, Jimenez-Olmedo, 2021; Thiele, Prieske, Gäbler, Granacher, 2021; Purge, 2017). In young rowers a higher aerobic capacity and larger body size are beneficial for performance over 1,000-m rowing ergometer distance (Mikulic, Ruzic, 2008)

In our study, free fat mass and skeletal muscle mass had the greatest influence on 1,000 m TM/t performance in both men and women. Penichet-Tomas in his study (Penichet-Tomas, Pueo, Selles-Perez, Jimenez-Olmedo, 2021) also identified muscle mass in women as the best determinant of outcome. It should be noted that in the case of men, the analysis of the results showed a greater correlation of the values of FFM and SMM indices with the ability to generate power than with the time of the test. In women, on the other hand, these indices correlated more strongly with time than with power values.

This can be explained by the influence of factors other than muscle indices on the total distance covered during ergometer work, such as body height, limb length, rowing pace and technique. As a rule, a higher pace is observed in lightweight athletes (lower height, lower weight, lower muscle mass, lower free fat mass) than in open weight athletes. A higher tempo means more weaker pulls (generating less power) but a better time score. It seems that due to the greater rowing experience of the women's group (on average more than 9 months more than men) they have a better technique in the rowing ergometer test. This allows them to better (without losses) transfer the generated force to the ergometer, which translates into better time conversion rates.

Summary

The results of the research conducted should be interpreted with caution as the main limitation of this study is the size of the group. Therefore, they can be used as a reference but should be interpreted in the context of individual characteristics and needs. The results obtained at 1,000 TM/t can be considered promising for the further training stage due to the fact that the study was conducted on a rowing ergometer under training conditions prior to a special training mesocycle shaping strength and speed, while the athletes competing at the event to which our results were related were in the starting period and therefore by definition in top form. It would be interesting to re-determine the correlation of HGt in rowers rowing on the left and right side of the boat after targeted training on the outside hand.

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