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SELECTED DETERMINANTS OF THE FREQUENCY OF CONSUMING PARTICULAR FOOD PRODUCT GROUPS AMONG REGIONAL-LEVEL FOOTBALL REFEREES

Maria Gacek,[1, A, B, C, D, E] Grażyna Kosiba,[2, A, C, D] Agnieszka Wojtowicz[3, A, C]

[1] University of Physical Education in Kraków, Faculty of Physical Education and Sport
Department of Sports Medicine and Human Nutrition, Poland
[2] University of Physical Education in Kraków, Faculty of Physical Education and Sport
Department of Theory and Methodology of Physical Education, Poland
[3] University of Physical Education in Kraków, Faculty of Physical Education and Sport, Department of Psychology, Poland

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

Address for correspondence:
Maria Gacek
Zakład Medycyny Sportowej i Żywienia Człowieka
Wydział Wychowania Fizycznego i Sportu
Akademia Wychowania Fizycznego
Al. Jana Pawła II 78, 31-571 Kraków, Poland
E-mail: maria.gacek@awf.krakow.pl

Abstract The aim of the study was to assess the frequency of consuming particular food groups among regional-level football referees depending on age, refereeing experience and sense of generalised self-efficacy. The study was conducted among a group of 138 male football referees from the Małopolska and Podkarpacie regions, using the authors' own questionnaire on food consumption frequency and the Generalised Self-Efficacy Scale (GSES). It was shown that along with the age of the referees, the frequency of consuming fruit ($p < 0.001$), milk and dairy products with reduced fat content ($p < 0.001$), poultry and cold-cuts ($p < 0.01$) as well as nuts ($p < 0.001$) increased, while the frequency of consuming white cereal products ($p < 0.001$) and sea fish ($p < 0.05$) decreased. Along with refereeing experience, the frequency of eating fruit ($p < 0.001$), milk and dairy products with reduced fat content ($p < 0.01$), poultry meat and cold-cuts ($p = 0.001$), nuts ($p < 0.001$) and alcoholic beverages ($p < 0.001$) increased, while the frequency of consuming white cereal products ($p < 0.001$), sea fish ($p < 0.05$) and sweet carbonated drinks ($p < 0.01$) decreased. A positive correlation was found between the intensity of generalised self-efficacy and the frequency of consuming milk and dairy products with reduced fat content ($p < 0.01$), fermented dairy products ($p < 0.01$), eggs ($p < 0.001$) and mineral water ($p < 0.001$) as well as dry red wine ($p < 0.05$), and a negative correlation was noted with the frequency of consuming pork ($p < 0.05$), fast food products ($p = 0.001$) and sweetened carbonated beverages ($p < 0.001$). In the examined group of regional-level football referees, there was a tendency towards more rational nutrition choices along with age and refereeing experience as well as a sense of self-efficacy, while the most explicit trends regarded relationships with the sense of self-efficacy.

Key words food consumption frequency, football referees, nutritional determinants, sense of generalised self-efficacy, age, refereeing experience

Introduction

Maintaining and improving health and exercise capacity is facilitated by a varied diet, with a high proportion of products having high nutritional value, such as vegetables and fruits, whole grain products, legume seeds and dairy products with reduced fat content, natural fermented dairy products, fish and nuts, with limited consumption of high energy density products, such as sweets, confectionery and fast food products. Current nutritional models, such as the Swiss nutrition pyramid for individuals undertaking increased physical activity, the Polish Pyramid of Healthy Nutrition and Physical Activity for adults, and recommendations of other scientific centres, emphasize the special importance of water and other unsweetened beverages for hydration and electrolyte management (Burke, 2008; Kreider et al., 2010; Potgieter, 2013; Thomas, Erdmann, Burke, 2016; Kerksick et al., 2017; Oliveira et al., 2017).

A group with increased physical activity and specific nutritional needs are football match referees. They are important for the course of the match at every sports level (Schenck, Bizzini, Gatterer, 2018). During a match, football referees cover a distance of 5–11 km and sometimes even 9–13 km, performing efforts of an intensity similar to those playing the midfield, with high energy expenditure (Bangsbo, Mohr, Krustrup, 2006; Castagna, Abt, D'Ottavio, 2007; Mallo, Navarro, Garcia-Aranda, Gilis, Helsen, 2007; da Silva, Fernandes, Fernandes, 2008; Weston et al., 2012).

Health-related behaviours, including food choices, are determined by a wide spectrum of environmental and personality-related factors (Remick, Polivy, Pliner, 2009; Juczyński, 2012). Among the psychological features important for the development of health culture, personal resources such as self-efficacy occupy an important position. The sense of self-efficacy, derived from Bandura's theory of social learning, is the belief in having the ability to achieve intended goals, such as those related to health, which can be fostered by rational nutritional behaviours (Juczyński, 2012). In existing studies on athletes, it has been shown that eating behaviours can be related to age, professional experience and sport level (Gacek, 2018a, 2019) and the level of generalised self-efficacy (Gacek, 2015, 2019), with an indication of a tendency towards more rational behaviours among athletes with greater experience and representing higher sporting levels (Kopeć, Nowacka, Klaja, Leszczyńska, 2013; Gacek, 2018a, 2019), and those with a higher sense of self-efficacy (Gacek, 2015, 2019).

The literature on the subject contains reports on the diets of athletes training football (Ono, Kennedy, Reeves, Cronin, 2012; Frączek, Brzozowska, Morawska, 2013; Kopeć et al., 2013; García-Rovés, García-Zapico, Patterson, Iglesias Gutiérrez, 2014; Gacek, 2018a), while there are only a few publications on the diet of football referees. Available works concern high-class Portuguese (Teixeira, Gonçalves, Meneses, Moreira, 2014) and French referees (Metz, Deleuze, Pereira, Thivel, 2015), as well as central level Polish (female) referees (Gacek, 2016a). Due to the fact that in earlier studies the relationship has been shown between age, experience, sports level, the sense of generalized self-efficacy and the nutritional behaviours of athletes professionally training team sports (Gacek, Frączek, 2013; Kopeć et al., 2013; Gacek, 2015, 2018a), research was undertaken regarding selected conditions (including psychological) of the food choices of football referees.

The aim of the study was to analyse the frequency of consuming food product groups among a group of regional-level football referees depending on their age, experience and level of generalized sense of self-efficacy, in relation to nutritional recommendations for individuals undertaking increased physical activity.

Material and methods

The study was conducted in 2017–2019 among a group of 138 male regional-level football referees aged 20 to 50 (31.69 ±8.89) years from the Małopolska and Podkarpacie Football Associations. A total of 97 (70.29%) had completed higher education and 41 (29.71%) had only secondary education. The highest percentage of subjects had technical education (47.04%) and those representing the field of physical education equalled 23.56%, while a smaller number included humanistic (17.64%) and economic (11.76%) education. The average refereeing experience was 8.44 ±6.39 years, and the average number of matches refereed was 391.11 ±335.92.

An original questionnaire regarding the frequency of consumption of selected groups of food products was used in the research. The frequency of consuming 20 food products was assessed using a point scale, assigning a specific number to individual frequency categories: daily (6), several times a week (5), once a week (4), once a month (3), rarely (2) and never (1). The applied original nutritional assessment questionnaire was subjected to a validation procedure, which showed high repeatability of results.

To measure the sense of efficacy, the standardised Generalised Self-Efficacy Scale (GSES) by R. Schwarzer, M. Jerusalem and Z. Juczyński (Juczyński, 2012) was used. The GSES scale contains 10 statements constructed in such a way that the higher the test result (within the range of 10–40 points), the higher the sense of generalised self-efficacy. The median raw result on the GSES scale for the examined referees was 30 (M ±SD: 30.94 ±4.96, Min-Max: 22–40).

Statistical analysis of the results was carried out using the PQStat ver. 1.6.6.202 statistical package. The relationship between age, experience and level of generalised efficacy, and the frequency of consuming individual product groups, was analysed by calculating Spearman monotonic correlation coefficients. The test probability of $p < 0.05$ was considered significant, while the level of $p < 0.01$ was considered highly significant.

Results

Based on the median values, it was found that the football referees most often, i.e. daily (Me = 6 ±0.5), included mineral water in their diets. Several times a week (Me = 5) they consumed: vegetables and fruits (5 ±0), light and wholemeal cereal products (5 ±0.5), eggs (5 ±0.5), poultry and pork (5 ±0), and dairy products with a high fat content (5 ±0.5). Once a week (Me = 4) they consumed: oatmeal (4 ±1), fermented dairy products (4 ±0.5), fish (4 ±0), nuts (4 ±0.5), sweets (4 ±1), sweetened carbonated drinks (4 ±0.5) and various alcoholic beverages (4 ±1). At a lower frequency, i.e. once a month (Me =3), they chose: dairy products with reduced fat content (3 ±1.5), fast food products (3 ±0.5) and energy drinks (3 ±1), while dry red wine was included in their diets less often (Me = 2 ±1) (Table 1).

Table 1. Frequency of consuming groups of food products in the group of regional-level football referees (descriptive statistics)

Food products	Arithmetic mean	Median	Quartile deviation	Standard deviation	Minimum	Maximum	Lower quartile	Upper quartile
1	2	3	4	5	6	7	8	9
Vegetables	5.146	5	0	0.476	4	6	5	5
Fruit	5.138	5	0	0.569	4	6	5	5
Wholemeal cereal products	4.696	5	0.5	1.111	1	6	4	5
White cereal products	5.152	5	0.5	1.073	1	6	5	6

1	2	3	4	5	6	7	8	9
Oatmeal cereals	3.283	4	1	1.351	1	6	2	4
Whole-fat milk and dairy products	4.362	5	0.5	1.350	2	6	4	5
Milk and dairy products with reduced fat content	3.297	3	1.5	1.421	1	5	2	5
Natural fermented dairy products	4.217	4	0.5	1.145	1	6	4	5
Eggs	4.449	5	0.5	0.872	2	6	4	5
Fish	3.761	4	0	0.689	2	5	4	4
Pork meat and cold-cuts	4.906	5	0	0.626	4	6	5	5
Poultry meat and cold-cuts	4.797	5	0	0.990	1	6	5	5
Nuts	3.710	4	0.5	1.055	2	6	3	4
Fast food	3.341	3	0.5	0.859	2	5	3	4
Sweets	4.493	4	1	1.291	1	6	4	6
Sweetened carbonated beverages	4.022	4	0.5	1.205	1	6	4	5
Energy drinks	3.022	3	1	1.304	1	5	2	4
Mineral water	5.464	6	0.5	0.983	3	6	5	6
Alcoholic beverages	3.789	4	1	1.298	1	6	3	5
Dry red wine	2.572	2	1	1.039	1	4	2	4

Statistical analysis showed significant correlations between age and frequency of consuming certain groups of food products by the football referees. With age, the incidence of fruit consumption ($p < 0.001$), as well as milk and dairy products with reduced fat content ($p < 0.001$), poultry meat and cold-cuts ($p < 0.01$) and nuts ($p < 0.001$) increased, while the frequency of consuming light cereal products ($p < 0.001$) and fish ($p < 0.05$) decreased (Table 2).

Table 2. Spearman's monotonic relationship between age and frequency of consuming food product groups in the group of regional-level football referees

Food products	R	Error for *r*	–95% CI	+95% CI	*t* statistics for *r*	*p* value
1	2	3	4	5	6	7
Vegetables	0.027	0.086	0.146	0.198	0.315	0.753
Fruit	0.326	0.081	0.163	0.472	4.024	<0.001
Wholemeal cereal products	–0.132	0.085	–0.298	0.040	–1.558	0.121
White cereal products	–0.334	0.081	–0.478	–0.172	–4.130	<0.001
Oatmeal cereals	–0.061	0.086	–0.230	0.112	–0.709	0.479
Whole-fat milk and dairy products	–0.138	0.085	–0.302	0.035	–1.621	0.107
Milk and dairy products with reduced fat content	0.301	0.082	0.136	0.449	3.685	<0.001
Natural fermented dairy products	–0.061	0.086	–0.231	0.112	–0.717	0.475
Eggs	0.068	0.086	–0.105	0.237	0.794	0.428
Fish	–0.179	0.084	–0.340	–0.007	–2.120	0.036
Pork meat and cold-cuts	–0.015	0.086	–0.186	0.158	–0.171	0.865
Poultry meat and cold-cuts	0.235	0.083	0.066	0.391	2.819	0.005
Nuts	0.447	0.077	0.298	0.575	5.826	<0.001
Fast food	0.111	0.085	–0.062	0.278	1.306	0.194
Sweets	0.129	0.085	–0.044	0.294	1.516	0.132
Sweetened carbonated beverages	–0.125	0.085	–0.291	0.048	–1.473	0.143
Energy drinks	–0.065	0.086	–0.235	0.108	–0.765	0.446

1	2	3	4	5	6	7
Mineral water	0.070	0.085	–0.103	0.239	0.821	0.413
Alcoholic beverages	0.160	0.085	–0.011	0.324	1.902	0.059
Dry red wine	–0.097	0.085	–0.265	0.076	–1.139	0.256

There was also significant differentiation regarding the frequency of consuming certain groups of food products depending on the length of the judges' experience. Along with judging experience, there was an increase in the frequency of consuming fruit ($p < 0.001$), milk and dairy products with reduced fat content ($p < 0.01$), poultry meat and cold-cuts ($p = 0.001$), nuts ($p < 0.001$) and alcoholic beverages ($p < 0.001$), while the frequency of consuming light cereal products ($p < 0.001$), fish ($p < 0.05$) and sweetened carbonated beverages ($p < 0.01$) decreased (Table 3).

Table 3. Spearman's monotonic relationship between experience and frequency of consuming food product groups in the group of regional-level football referees

Food products	R	Error for *r*	–95% CI	+95% CI	*t* statistics for *r*	*p* value
Vegetables	0.118	0.085	0.055	0.284	1.383	0.169
Fruit	0.354	0.080	0.194	0.4956	4.413	<0.001
Wholemeal cereal products	–0.165	0.085	–0.328	0.007	–1.956	0.052
White cereal products	–0.469	0.076	–0.593	–0.323	–6.198	<0.001
Oatmeal cereals	0.014	0.086	–0.158	0.185	0.163	0.871
Whole-fat milk and dairy products	–0.094	0.085	–0.262	0.079	–1.101	0.273
Milk and dairy products with reduced fat content	0.263	0.083	0.096	0.417	3.185	0.002
Natural fermented dairy products	0.095	0.085	–0.078	0.263	1.118	0.265
Eggs	–0.032	0.086	–0.203	0.140	–0.377	0.706
Fish	–0.344	0.080	–0.487	–0.183	–4.271	<0.001
Pork meat and cold-cuts	0.002	0.086	–0.169	0.174	0.027	0.978
Poultry meat and cold-cuts	0.269	0.083	0.102	0.421	3.256	0.001
Nuts	0.332	0.081	0.169	0.476	4.098	<0.001
Fast food	–0.047	0.086	–0.217	0.126	–0.549	0.584
Sweets	–0.157	0.085	–0.320	0.015	–1.856	0.066
Sweetened carbonated beverages	–0.266	0.083	–0.419	–0.098	–3.215	0.002
Energy drinks	0.052	0.086	–0.120	0.222	0.613	0.541
Mineral water	–0.044	0.086	–0.214	0.129	–0.515	0.607
Alcoholic beverages	0.285	0.082	0.118	0.435	3.463	<0.001
Dry red wine	0.083	0.085	0.090	0.251	0.972	0.333

There was also a positive correlation between the intensity of the sense of generalised self-efficacy and the frequency of consuming milk and dairy products with reduced fat content ($p < 0.01$), fermented dairy products ($p < 0.01$), eggs ($p < 0.001$), mineral water ($p < 0.001$) and dry red wine ($p < 0.05$), while a negative correlation occurred with the frequency of consuming pork ($p < 0.05$), fast food ($p = 0.001$) and sweetened carbonated beverages ($p < 0.001$) (Table 4).

Table 4. Spearman's monotonic relationship between generalised self-efficacy and frequency of consuming food product groups in the group of regional-level football referees

Food products	R	Error for *r*	–95% CI	+95% CI	statistics for *r*	*p* value
Vegetables	–0.009	0.086	–0.181	0.163	–0.105	0.916
Fruit	0.052	0.086	–0.121	0.222	0.612	0.542
Wholemeal cereal products	–0.034	0.086	–0.205	0.139	–0.395	0.694
White cereal products	–0.081	0.085	–0.249	0.092	–0.945	0.346
Oatmeal cereals	0.134	0.085	–0.038	0.299	1.583	0.116
Whole-fat milk and dairy products	0.131	0.085	–0.042	0.296	1.538	0.126
Milk and dairy products with reduced fat content	0.219	0.084	0.049	0.377	2.617	0.009
Natural fermented dairy products	0.265	0.083	–0.418	–0.098	–3.211	0.002
Eggs	0.349	0.080	0.188	0.491	4.338	<0.001
Fish	0.043	0.086	–0.129	0.214	0.506	0.614
Pork meat and cold-cuts	–0.183	0.084	–0.344	–0.012	–2.174	0.031
Poultry meat and cold-cuts	0.057	0.086	–0.116	0.226	0.663	0.508
Nuts	0.052	0.086	–0.121	0.222	0.606	0.546
Fast food	0.276	0.082	0.109	0.428	3.349	0.001
Sweets	–0.109	0.085	–0.276	0.064	–1.282	0.202
Sweetened carbonated drinks	–0.279	0.082	–0.430	–0.112	–3.387	<0.001
Energy drinks	–0.053	0.086	–0.223	0.119	–0.622	0.535
Mineral water	0.341	0.081	0.179	0.485	4.230	<0.001
Alcoholic beverages	0.060	0.086	0.113	0.229	0.704	0.483
Dry red wine	0.210	0.084	0.039	0.368	2.508	0.013

Discussion

The discussed research showed qualitative nutritional errors and correlations between the frequency of consuming certain food groups with age, experience and sense of generalised self-efficacy among the regional level football referees.

The found erroneous behaviours particularly concerned the low frequency of consuming recommended foods with a high nutritional density, such as vegetables and fruits, whole grain cereals, dairy products with reduced fat content, natural fermented dairy products as well as fish and nuts. A negative tendency should also be pointed out regarding the comparable frequency of consuming contraindicated drinks (alcoholic and sweetened carbonated beverages) with the recommended fermented dairy products. On the other hand, the daily consumption of mineral water can be assessed positively within the context of the increased physical effort performed by the referees and the legitimacy of their using the same hydration strategies as those implemented by athletes (Schenk et al., 2018). The negative effects of alcohol (relatively often considered by football referees) on restoring post-workout homeostasis, such as water-electrolyte balance in physically active people (Vella, Cameron-Smith, 2010), should also be highlighted.

The diagnosed nutritional irregularities, including low consumption of fruit and vegetables and whole grain cereal products, may limit the supply of antioxidant vitamins (C and carotenoids) and polyphenols, group B vitamins, magnesium and potassium and fibre. This is unfavourable within the context of oxidative stress increasing the

demand for antioxidants (Yavari, Javadi, Mirmiran, Bahadoran, 2015), as well as increased demand for vitamins regulating metabolic intensities (group B) and minerals important in muscle contraction processes (Volpe, 2007). Low consumption of dairy products increases the risk of calcium deficiency, which is involved in the regulation of neuromuscular excitability and acid-base balance (Volpe, 2007), while low consumption of fermented dairy products reduces the consumption of probiotics that affect the maintenance of diverse and rich intestinal microflora, with numerous health-promoting properties (Cronin et al., 2017). Low consumption of fish and nuts may reduce the supply of omega-3 polyunsaturated fatty acids (PUFA) optimising blood lipid profile (Gillingham, Harris-Janz, Jones, 2011).

Nutritional errors found in the examined group of regional level football referees correspond to the trends described in other groups of football referees. In research among an elite group of Portuguese referees, irregularities were also demonstrated regarding insufficient consumption of high nutrient density products, affecting the unbalanced supply of some antioxidant vitamins, group B vitamins, dietary fibre, calcium and magnesium (Teixeira et al., 2014). The results of the authors' research, which showed a low consumption of fish and nuts, correspond to the results of research conducted among the Portuguese referees, in whom an insufficient supply of polyunsaturated fatty acids was described (Teixeira et al., 2014). In a different study among 82 female central level Polish football referees, an incomplete implementation of quality nutritional recommendations for physically active people was also shown, especially in the area of consuming vegetables and low-density cereal products and dairy products (Gacek, 2016a). Similar errors related to the inadequate consumption of some groups of high-density food products, including vegetables and fruits, whole-grain cereal products, dairy products and fish, have also been described among Polish athletes training team sports (Frączek et al., 2013; Gacek, Frączek, 2013; Gacek, 2015), and among English and Australian footballers (Ono et al., 2012; Jenner et al., 2018) as well as American football players in NCAA Division III (Abbey, Wright, Kirkpatrick, 2017).

In the discussed studies, relationships were also shown between the age and experience of judges and the frequency of consuming selected product groups, with an indication of the tendency to make more rational choices along with the referees' age and experience (these variables were not significantly correlated, $R = 0.023$, $p = 0.876$). Trends for both variables particularly concerned the more frequent consumption of recommended products, including fruit, milk and dairy products with reduced fat, poultry meat and cold-cuts (as well as nuts in the case of experience), and the less frequent consumption of less recommended light cereal products (and carbonated drinks in the case of experience). At the same time, however, different trends were described regarding the lower incidence of fish consumption (along with age and seniority) and more frequent consumption of alcoholic beverages (along with experience). Therefore, the indicated trends were ambiguous, nonetheless, they may suggest greater nutritional awareness and/or attaching greater attention to food choices with age, in relation to the state of health and an increase in belief in the significant role of diet for exercise capacity, determining the effective performance of refereeing functions. Trends indicating more rational nutritional behaviours along with age (as well as experience and sports level) have also been described among athletes training team sports (Kopeć et al., 2013; Gacek, 2018a) and individual disciplines (Gacek, 2019). Among athletes training individual disciplines, it has been shown that with age, the players significantly more often included poultry and mineral water in their diet, and significantly less often milk with high fat content, pork, sweets and confectionery products (Gacek, 2019). Other research on the conditions dictating the consumption of alcoholic beverages among Polish athletes professionally training team sports showed that with age, the consumption of wine, including dry wine, increased (Gacek, 2016b). Also in another professional

group – men aged 18–65 employed at one of Kraków industrial plants – more rational food choices could be observed with age (Gacek, Chrzanowska, Matusik, 2007).

In the discussed research, a relationship was also shown between the sense of self-efficacy and the frequency of consuming selected product groups, with an indication of a tendency towards making more rational choices as self-efficacy increased. These trends concerned, in particular, the more frequent consumption of recommended products, such as milk and dairy products with reduced fat content, fermented dairy products, eggs and mineral water, as well as dry red wine, and less frequent consumption of pork, fast foods and sweetened carbonated drinks. The demonstrated correlations, indicating the importance of a high level of self-efficacy for the development of more correct nutritional choices among football referees, may find their justification in the characteristics of this personality dimension and relate to the results of other studies. The more rational food choices of referees with a high sense of self-efficacy can be explained by their belief in the possibility of achieving specific goals, including health-related objectives, for which a rational nutrition model plays a significant role. Similar tendencies towards more rational dietary choices among those with higher levels of self-efficacy were obtained in other groups of people representing increased physical activity, including Polish American football players (Gacek, 2015) and those practising individual sports disciplines (Gacek, 2019). For example, Polish American football players with high self-efficacy significantly more often than those with low levels consumed the recommended number of vegetable portions (54% vs. 26%) (Gacek, 2015). In turn, among athletes training individual sports disciplines, a positive correlation was found between the intensification of the generalised sense of self-efficacy and the frequency of consuming high nutritional density products (legumes, semi-skimmed milk, poultry) and isotonic drinks (Gacek, 2019). The diversity of food choices depending on the level of their generalised self-effectiveness (maintaining the indicated trends) has also been described in other groups, such as Polish professional soldiers (Gacek, 2018b) and adults from the Dutch population (Brug, de Vet, de Nooijer, Verplanken, 2006).

The described nutritional errors, which may reduce the nutritional value of the diet among the examined group of regional-level football referees, confirmed the legitimacy of monitoring and rationalising the diet of people semi-professionally (and professionally) associated with sports, for whom diet is one of the factors contributing to professional success. Other authors also point to the need for nutritional education of football referees (Teixera et al., 2014; Schenck et al., 2018). At the same time, they draw attention to the need to develop nutritional recommendations for football referees, because the nutritional needs of this group may differ in certain areas from the nutritional needs of athletes training football (Schenk et al., 2018). Nutritional recommendations for footballers have been the subject of many scientific publications (Bangsbo et al., 2006; Holway, Spriet, 2011; Carling, Le Gall, Dupont, 2012; Heaton et al., 2017; Kerksick et al., 2017).

The significance of the presented work is related to undertaking the subject of unexplored research on the conditions of nutrition choices for football referees, with the results only applicable to the studied group of men. Subsequent studies should include a larger group of referees (also from other regions representing different sports levels) and a larger number of analysed variables.

Conclusions

1. Qualitative nutritional errors related to the low frequency of consuming recommended food products, especially vegetables and fruit, whole grain cereal products, low fat and fermented natural dairy products, fish and nuts, were found in the examined group of regional-level football referees.

2. In the examined group of regional level football referees, the correlation between age, refereeing experience and generalised sense of self-efficacy, as well as the frequency of consuming certain product groups, was demonstrated with a tendency towards more rational choices along with age, experience and sense of self-efficacy, while the most explicit tendencies concerned relationships with their sense of generalized self-efficacy.

3. The results suggest the legitimacy of monitoring and rationalising the diet of people professionally (and semi-professionally) associated with sports, including those representing a lower sport level.

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ANTHROPOMETRIC AND MOTOR PERFORMANCE CHARACTERISTICS OF MALE SOCCER PLAYERS IN PUBLIC UNIVERSITIES

Timothy K. Mensah,[1, A, B, C, D, E, F] Monday O. Moses,[2, A, B, C, D, E, F] Charles Domfeh[1, A, B, C, D, E, F]

[1] University of Cape Coast, College of Education Studies
Faculty of Science and Technology Education, Department of Health
Physical Education and Recreation, Ghana
[2] Kwame Nkrumah University of Science and Technology
College of Health Sciences, Faculty of Allied Health Sciences
Department of Physiotherapy and Sports Science, Ghana

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

Address for correspondence:
Monday Omoniyi Moses
Kwame Nkrumah University of Science and Technology, College of Health Sciences
Faculty of Allied Health Sciences, Department of Physiotherapy and Sports Science
Accra Road, Zip Code: 00000, Private Mail Bag, University Post Office
KNUST-Kumasi, Ghana
E-mail: momoses@knust.edu.gh

Abstract **Background:** Training of athletes for optimal performance would be enhanced in an environment of appropriate data. There is, however, limited data on anthropometric and sport performance characteristics of male soccer players in Ghanaian public universities. This study comparatively presents the distribution of anthropometric and motor performance characteristics of male soccer players among public universities.

Methods: Male soccer players (n = 44, mean age = 22.61 ±1.87 yrs) from four public universities were recruited. Weight, leg length, thigh girth, calf girth, forearm length, upper arm length, upper arm girth, chest girth, and finger span were measured. The participants were also assessed on a 36.58 m (40 yards) dash, vertical jump, agility, flexibility, sit-ups, push-ups, dribbling, shooting accuracy, and kicking distance.

Results: There were significant differences in the forearm length (p = 0.001), leg power (p = 0.040), abdominal strength (p = 0.005), agility (p = 0.001), flexibility (p = 0.009), and upper body strength (p = 0.023) among the male soccer players of the universities. All anthropometric characteristics significantly predicted kicking distance (p = 0.002). Thigh girth (p = 0.014), chest girth (p = 0.010) and finger span (p = 0.012) significantly distinctly served as predictors.

Conclusion: Anthropometric and motor performance characteristics were relatively different among male soccer players in Ghana public universities. University soccer coaches should place major emphasis on individual traits and potentials when developing combined training regimes.

Key words arm length and girth, chest girth, finger span, muscular strength, kicking abilities

Introduction

In Ghana universities, soccer is an integral part of the total educational system and is used as a co-curricular activity. Thus, among the universities in Ghana, soccer is a pervasive tool to develop students for future goals (Acquah, Anti-Partey, 2014). Organized competitive soccer in the tertiary institutions in Ghana, especially in the universities, is played intramurally (inter-hall and inter- faculty games) and extramurally, which include inter-university competitions such as Ghana University Sports Association (GUSA) games. International competitions in which universities in Ghana participate in soccer are the West Africa University Games (WAUG), Federation of Africa University Sports (FASU) games and International University Sports Federation (FISU) games.

Soccer players at the university level, chiefly those who represent their university or the National Federation at national and international levels, are anticipated to possess the physical and physiological qualities, namely physique, stature, speed, agility, muscular and general strength, high skill level, endurance and coordination, that are needed to excel in that sport. Anthropometric and motor performance characteristics contribute chiefly to the supremacy of players and team performances in soccer (Chiwaridzo et al., 2017; Deprez et al., 2015; Loturco et al., 2018) aside from nutrition (Baker, Rollo, Stein, Jeukendrup, 2015) and psyche status (Baker et al., 2015).

These are scientifically proven aspects of modern competitive soccer (Baloncesto, 2019; Chiwaridzo et al., 2017; Saha, Nandy, Bandyopadhyay, 2018). However, these phenomena have not been established currently in competitive soccer in Ghana. As such, there is a dearth of general literature on anthropometric and motor performance characteristics in Ghana sports in general. This situation is no different from what pertains in the public universities in Ghana which are the citadel of knowledge. Therefore, just like any other coach in Ghana, the coaches in these universities use the soccer players as they come into the universities and select them based on the impressions the players make on the field of play, or on the suggestions the players give to the coaches. This is non-scientific as explained earlier, and certainly it hinders the optimal performance and full potential of the players, even though they might have been exerting their maximum efforts. As such, the modern-day competitive soccer coach is expected to have and always update a database of these characteristics of the players to be able to compare them to their opponents for possible tactical play. Also, sport development at the universities would rely largely on appropriate available data. Certainly, because of limited data, particularly in the public universities in Ghana, university coaches go through herculean tasks in pitching quality, fit and healthy players for competitions which always yield minimal results. Thus, the need to assess these characteristics in male soccer players at public universities and compare by institution to discover their major differences and challenges and make recommendations for necessary improvements.

Material and Methods

Research Design

A cross-sectional descriptive research design was employed to measure and describe the anthropometric and motor performance characteristics of the soccer players who participated in the 6th Mini GUSA Games, in line with scholarly standards (Moutinho, Hutcheson, 2011; Spector, 2019).

Participants

The participants consisted of the male soccer players from seven public universities – UG, KNUST, UCC, UEW, UDS, UENR and UPSA, who represented their universities at the 6th mini GUSA games hosted by Kwame Nkrumah University of Science and Technology (KNUST), where institutions were allowed to present up to 20 players each. A total pool of 140 male soccer players were involved in the 6th Mini GUSA competitions.

Four out of the seven public universities in Ghana, namely KNUST, UEW, UG and UCC, who participated in the 6th Mini GUSA games were intentionally sampled for the study as they had been consistently present and had played in the semi-finals of the GUSA games since its inception. The 11 players that made the first teams, which included 1 or 2 striker(s), 4 or 5 midfielders (depending on the strategies of the coaches), 4 defenders (2 laterals and 2 centrals) and 1 goalkeeper, were again intentionally selected from each institution for the study because some of the reserved players did not get the chance to play at all at the games, and therefore the possibility of chancing on those players were eliminated. Consequently, a total of 44 male soccer players were enrolled in the study.

Measurements

To ensure that the participants recorded their best performances at each test, 5-minute intervals were allowed between the tests. All the tests were arranged in such a way that the preceding test could not interfere with the next. The following order of arrangements were followed:

Stage 1: Weight (kg) was measured with a Camry ISO 9001 Model digital portable scale (Japan), height (cm) was measured with a calibrated stadiometer from 5.0 cm to 2.5 cm, leg length (fall), mid-thigh girth (flexed and tensed), calf girth, upper arm length, forearm length, upper arm girth, chest girth, and finger span were measured in accordance to international standards (Bretzin, Mansell, Tierney, McDevitt, 2017).

Stage 2: Speed (36.58 m [40 yard] dash), leg power (vertical jumps), upper body strength (push-ups), and kicking ability (distant kick, dribbling and accuracy) were determined with a Quantum stop watch. Sayers Formula [Peak Anaerobic Power output-PAPw (Watts) = 60.7 × jump height (cm) + 45.3 × body mass (kg) – 2055] was used to estimate peak power output from vertical jumps (Sayers, Harackiewicz, Harman, Frykman, Rosenstein, 1999).

Stage 3: Agility (Illinois run), abdominal strength (sit ups), and flexibility test (sit and reach test).

All the anthropometric measurements, agility test, body strength tests, flexibility and vertical jump, were carried out at the gymnasium and fitness hubs of the various universities, whilst the rest of the physical performance tests, which included throwing, kicking, dribbling and sprint tests, took place on the soccer fields and athletic ovals, respectively. The data collection began at UCC on the 23rd February 2016, followed by UEW on the 24th of February 2016. UG was next on the 25th February, followed by KNUST on the 27th of February 2016.

Kicking Ability: Participants kicked aerial balls in three trials as far as possible from the goal line. The distance to where the ball landed was measured to the nearest 0.1 m with a tape measure. Dribbling was measured with a stop watch in seconds. Procedure: With a whistle and concurrently starting the stop watch, participants started zigzag dribbling with a ball between six cones, then moved forward 3 m, took a right turn, dribbled straight for 5 m through 4 cones and again took another right turn and dribbled the ball 5 m through 5 cones back to the restraining line. The time taken to complete the course to the nearest 0.1 second was recorded and the average of three trails considered as the score (Ghosh, Goon, 2014; Longmuir et al., 2017; Pfeiffer et al., 2020). Shooting for accuracy was measured in points. The goal post was divided into 5 equal parts and labelled with a point system of 5 for the extremes which reduced towards the center to 3 points. The participant kicked the ball from the penalty spot

and scored points according to the target they hit (Ghosh, Goon, 2014). The total points of all the three trials were recorded and the average used as the score

Statistical Analysis

The data collected were analyzed using IBM SPSS Statistics Data Editor. Both descriptive and inferential statistics were employed to analyze the data collected. Descriptive statistics was used to compile the means and standard deviations (SD) of the players for demographic analysis in all the variables. One-way analysis of variance (ANOVA) was employed to compare player characteristics between the four institutions (A–D). Bonferroni post-hoc multiple comparison tests were applied when the ANOVA indicated significant differences, to ascertain the exact differences that existed between the means. Multiple regression analysis was used to analyze the influence of the anthropometric and motor performance variables on the kicking ability. The alpha level was set at 0.05.

Results

The male soccer players of the four Ghana public universities had a mean height of 174.44 ±5.40 cm, weight of 73.39 ±5.60 kg, leg length of 86.51 ±5.55 cm, thigh girth of 58.55 ±3.42 cm, calf girth of 38.76 ±1.75 cm, upper arm length of 38.23 ±2.64 cm, forearm length of 31.71 ±2.69 cm, upper arm girth of 30.48 ±1.46 cm, chest girth of 88.75 ±1.33 cm, and finger span of 58.03 ±4.55 cm. The participants ran 36.58 m (40 yards) in 5.28 ±0.22 sec on average, generated 4407.76 ±7.23 Watts of leg power, performed 26.46 ±2.44 reps/min in abdominal strength, ran the Illinois agility course in 16.32 ±0.63 secs, executed flexibility on average at 25.67 ±3.04 cm and 30.43 ±3.79 reps in upper body movement. On kicking ability, the participants were able to kick the ball a mean distance of 56.94 ±7.44 m, mean mark for dribbling was 14.71 ±1.04 secs and kicking accuracy was 4.09 ±1.29 points (Table 1). A significant regression was found $F(3.40) = 3.623$, $p < 0.05$ with R^2 of 0.523 which translates into 52.3% of anthropometric variance in kicking distance for the soccer players in the GUSA games (Table 2).

Table 1. Differences in anthropometric and motor performance characteristics of male Soccer Players among Institutions

Characteristics	Institutions				ANOVA	
	University A Mean, SD	University B Mean, SD	University C Mean, SD	University D Mean, SD	F	P-value
1	2	3	4	5	6	7
General						
Height (cm)	177.86, 3.82	172.99, 6.32	172.75, 5.83	174.16, 4.33	2.287	0.093
Weight (kg)	75.60, 5.32	72.99, 5.59	72.38, 6.44	72.58, 5.13	0.774	0.516
Anthropometry						
Leg length (cm)	87.72, 2.48	83.34, 9.87	87.22, 2.91	87.78, 2.33	1.707	0.181
Thigh girth (cm)	60.55, 4.08	58.53, 3.38	57.99, 3.11	57.13, 2.40	2.132	0.111
Calf girth (cm)	39.78, 1.26	38.66, 1.92	38.59, 1.68	38.00, 1.79	2.127	0.112
Upper arm length (cm)	39.29, 2.45	38.28, 2.68	37.69, 3.28	37.66, 2.00	0.913	0.443
Forearm length (cm)	34.36, 2.83*	30.40, 2.38*	30.50, 1.93*	31.74, 1.09*	8.032	0.001†
Upper arm girth (cm)	31.00, 1.80	29.85, 1.29	30.49, 1.37	30.57, 1.30	1.183	0.328
Chest girth (cm)	88.66, 1.33	87.44, 3.52	90.53, 3.04	88.39, 2.98	2.279	0.094
Finger span (cm)	57.63, 5.85	58.28, 3.83	57.56, 4.74	58.66, 4.10	0.139	0.936

1	2	3	4	5	6	7
			Motor Performance			
Speed (sec.)	5.14, 0.11	5.30, 0.25	5.33, 0.23	5.37, 0.23	2.601	0.065
Leg power (Watts)	4,224.78, 5.37*	4,693.04, 5.79*	4,438.49, 8.22	4,273.33, 6.80	3.032	0.040†
Abdominal strength (rep./min)	27.64, 1.86*	26.09, 2.12	27.55, 2.77*	24.55, 1.75*	4.994	0.005†
Agility (sec.)	16.59, 0.41*	16.35, 0.32*	15.68, 0.84*	16.65, 0.32*	8.063	0.001†
Flexibility (cm)	28.16, 2.71*	24.13, 2.12*	25.16, 3.25	25.24, 2.74	4.429	0.009†
Upper body strength (rep./min)	30.64, 1.80	29.55, 2.16	33.09, 5.68*	28.46, 2.91*	3.557	0.023†
Distant kick (m)	56.82, 8.91	55.32, 6.42	60.32, 6.36	55.32, 7.66	1.115	0.354
Dribbling (sec.)	14.96, 1.37	14.72, 0.94	14.46, 0.85	14.71, 1.01	0.414	0.744
Kicking accuracy (pt.)	1.37, 0.73	0.94, 1.54	0.85, 1.24	1.01, 1.55	0.490	0.691

† Significance difference in ANOVA at P < 0.05.
* The Bonferroni post hoc test significant at P < 0.05.

Table 2. Multiple regression analysis between Anthropometric Characteristics on Kicking Ability

Characteristics	*B*	β	T-value	P-value
	7.212		–0.820	0.002*
Height (cm)	–0.652	–0.473	–1.385	0.175
Weight (kg)	0.084	0.063	0.268	0.791
Leg length (cm)	0.162	0.121	0.783	0.439
Thigh girth (cm)	1.407	0.647	2.598	0.014*
Calf girth	–0.329	–0.077	–0.346	0.731
Upperarm length (cm)	–1.090	–0.386	–1.518	0.138
Forearm length (cm)	0.649	0.234	1.188	0.243
Upperarm girth (cm)	–0.233	–0.046	–0.264	0.793
Chest girth (cm)	1.231	0.491	2.606	0.010*
Finger span (cm)	0.613	0.375	2.649	0.012*

* Significant at $P < 0.05$, $R = 0.723$, $R^2 = 0.523$, $F = 3.623$.
Significant regression was found $F(3,40) = 3.623$, $p < 0.05$ with R^2 of 0.523 that translates into 52.3% of variance as anthropometric variables model in the kicking for distance of the soccer players in GUSA games.

Discussion

This study comparatively presents the distribution of anthropometric and motor performance characteristics of male soccer players in public universities. Findings generally revealed differences in all the characteristics, while some predicted several motor performance characteristics.

Anthropometric

The mean height of the male soccer players in the GUSA games was not significantly different, although height favored the soccer players from the universities of Ghana comparatively. This indicates that the male soccer players of these public universities had relatively the same height. Holding other parameters constant, the equality in height probably explains why there were very few aerial header goals (less than 5) emanating from the 6th Mini GUSA games. This is in consonance with literature reports that height advantageously enhances excellent performance in sports that require aerial vertical height activities such as handball, rugby and soccer (Bidaurrazaga-Letona,

Zubero, Lekue, Amado, Gil, 2016; Reilly, Williams, Nevill, Franks, 2000). However, the mean height recorded in this study was less than the values reported for collegiate male soccer players (Lockie et al., 2019; Slimani, Nikolaidis, 2019), indicating that the players in this study would be disadvantaged in height at international competition.

According to the findings of this study, there was no significant difference in the weight of the public university male soccer players. Perhaps, this explains why these teams may not have had too much advantage over each other in activities such as charging for the ball. Coaches probably resorted to tactical disciplines to marginally win or draw their matches. This sounds in keeping with earlier viewpoints that larger and heavier athletes typically produce greater absolute strength, power and with similar advantages than smaller athletes (Bale, Colley, Mayhew, Piper, Ware, 1994; Domfeh, 2002). Although, the mean weight in this study was more than the values reported for similar regional population samples (Moses, Duduyemi, 2016; Saha, Kundu, Mondal, 2014) but less than international values of similar studies (Anding, Oliver, 2015; Kilic, Ali, Tosur, 2018). This signifies that the players in this study could have been within limits with weight-related activities but could have been disadvantaged at international competitions.

With regards to the length of the lower extremities (leg length), there was no statistically significant difference in the soccer players in the present study. Similar geographical location and heredity ar e some of the possible interpretations of the non-significant differences observed in this study. The anatomical advantage in favor of long legs creates a better opportunity for competitive soccer performance where vertical height is required (Duarte et al., 2016; Lloy, Oliver, Myer, Croix, Read, 2020). However, this similarity in leg length may be a determinant factor behind the players equally kicking the ball for distance with no undue advantage (Malekar, 2015).

There were also no significant differences in the thigh and calf girths of these soccer players. However, the mean thigh girth (58.55 ±3.42 cm) and calf girth (38.76 ±1.75 cm) compared favorably with the values reported for basketball (595.95 ±39.87/385.90 ±33.44 mm), handball (592.14 ±82.99/390.63 ±27.64 mm), and football (609.64 ±30.48/395.84 ±23.09 mm) players (Baloncesto, 2019), although better than the values for young elite soccer players (Rodríguez-Lorenzo, Olmo, Sánchez-Molina, Martín-Acero, 2018). Large thigh and calf circumferences are often associated with training and muscular strength development, since specific strength training predisposes to hypertrophy of the lower limb muscles (Baloncesto, 2019; Carvalho, Abade, 2014). Calf and thigh girths have correlations with dribbling and kicking distance (Gosh, Goon, 2014; Nuhmani, Akthar, 2014; Wilson et al., 2017; Sylejmani et al., 2019). Thus, the insignificant differences found could also possibly be some of the contributing reasons for the equality in the kicking distance as well as dribbling with no unjustified advantage. The winner of the 6th Mini GUSA games may have resorted to other parameters in their favor to win the contest.

The results of the present study also showed no significant differences in the upper arm length, upper arm girth, chest girth and finger span of soccer players among these public universities, against a significant difference in forearm length. The institution that was favored with forearm length may certainly have had an edge over the rest with throw-ins and their goalkeeper reaching for the ball. In explaining this, studies affirmed that longer arms can help throw a ball faster and further due to the increased centrifugal force they can generate during the throwing motion (Marshall, Hamstra-Wright, Dick, Grove, Agel, 2007; Omar, 2016; Naito, Takagi, Kubota, Maruyama, 2017). This is similar to a ball at the end of a string, the longer the string, the further it can go after release. The findings of our study have a direct comparison with studies where similar characteristics were observed (Hooda, 2015; Saha et al., 2018).

Motor Performance

There was a statistically insignificant difference in the speed performance of soccer players in the public universities. This outcome supports a study that compared vertical jump ability (squat-jump [SJ] and counter movement-jump [CMJ]), mean propulsive power in the jump-squat (MPP-REL JS) relative to body mass, and the 0–5, 5–10, and 10–20 m acceleration and speed among soccer players from the same professional club, divided into age-categories (U15 [n = 20], U17 [n = 53], U20 [n = 22] and senior [n = 25] players) with no significant differences (Loturco et al., 2018). However, the average speed performance in our study where soccer players ran 36.58 m (40 yards) in 5.28 ±.22 sec was comparatively better than earlier finding in a similar population where 30 m was run in 5.99 ±0.15 sec (Coelho et al., 2007). These results probably also explain why there were not many goals scored between these institutions because the attackers' ability to outpace the defenders and vice versa were similar, which underpinned their successful game play (Murphy, Pill, 2011; Little, Williams, 2005; Peñailillo, Espíldora, Jannas-Vela, Mujika, Zbinden-Foncea, 2016; Loturco et al., 2018).

There was a significant difference in leg power between the soccer players in this study. Players from one of the universities were significantly stronger from another university ($p < 0.05$). This outcome supports an earlier report which showed significant differences in explosive leg power growth curves of soccer players across their lifespan (Loturco et al., 2018). This finding suggests variations in leg power of different playing positions and training priority as well as the efficiency of each institution. Dissimilar movement strategies of the limbs and playing in different positions required different skills from players, where "strikers jump higher than midfielders or defenders, and strikers develop greater power in the legs compared to midfielders" (Sportu, Nikolaidis, 2018), could support our results. The study by D.W. Malekar (2015) reported a high correlation between leg power and kicking distance, which was not the case with the players with the highest leg power in this study. This may probably be due to other confounding parameters.

In abdominal strength, players of two universities significantly performed better than the least performance. This indicates that players with the best abdominal strength from the two universities had stronger spine stability and were able to experience better prevention of low back pain compared to the others. A study has shown that the abdominal muscles, hip and back muscles are accountable for enhancing posture, executing movements, regulating muscular activities, ensuring stability and stabilizing strength throughout the body (Aslan, Erkmen, Aktaş, Güven, 2018). A.K. Aslan et al. (2018) further reiterated that core stability permits a concurrent growth of arm and leg strength, with increased movement efficiency and power generation. The team with the strongest abdomen, which also may have accounted for their being very agile (Malekar, 2015), were the eventual winners of the competition.

Although significant differences occurred in the agility performances of the players in this study, players from three universities had relatively similar and/or the same level of performance. This implies that most of the players had relatively equal potential in the ability to exhibit the two components of agility – the ability to change direction as well as perceptual and decision making ability, as presented in the literature (Zouhal et al., 2018). The highest performing team which created a significant difference in this task probably used it to their advantage to outwit their opponents to win the contest.

The results again showed significant differences observed in the flexibility of the lower back and hamstring muscles of the winning team and the rest (28.16 ±2.71 cm and 24.13 ±2.12 cm). Differences in pre-competition stretching and warm-ups may contribute to this result because studies have shown that a pre-exercise period of stretching exercises can acutely increase flexibility (Ide et al., 2017). Non-significant differences obtained from

the players of the remaining universities supports an earlier finding of no significant differences in flexibility of the hip joint between the preferred and non-preferred leg (Rahnama, Lees, Bambaecichi, 2005). A common rationale supporting the increase in range of motion at a joint reported in literature is to prevent injury from overextension of the joint, such as a pulled muscle (Rodriguez, Sanchez, Rodriguez, Villa, 2016; Opplert, Babault, 2018). Indeed, there were a lot of injuries in the team that was least flexible.

Our result on upper body strength showed that players of one university possessed a significantly higher value, and another possessed a significantly lower performance. The effect of years of training may possibly be an explanation for the differences in the upper body strength of soccer players between the two universities (Bilsborough et al., 2015). This is because the university which has most of their soccer players in their final academic year would have relatively more than three training years together compared to those with most players in years one or two. Indeed, the university that won the competition had most of their players in the final year. This also implies that the players of the winning team may have had an advantage of power for the throw-in, run and charge in the games than the rest, as explained by T. Bompa and G.G. Haff (2009) and C. Domfeh (1996).

A notable finding of the present study is the lack of significant differences in kicking distance, dribbling ability and kicking accuracy. We expected diverse performances based on the training principles and ideologies of the coaches. We also envisaged cognitive and biomechanical traits associated with academic training. Students from different academic disciplines should exhibit an appreciable transfer of theoretical knowledge when performing common sport skills. Irrespective of playing position, a desirable kicking distance, dribbling ability and kicking accuracy are inevitable skills of soccer players (Gaspar et al., 2019).

The motor performance characteristics examined in this study were significantly predicted by the anthropometric characteristics, specifically the thigh girth, chest girth and finger span of the soccer players (Table 2). This may be explained in the view of the major influence of training efficiency and heredity, since growth and maturity play effective roles in sport performances (Bilsborough et al., 2015; Gaspar et al., 2019; Guimar et al., 2019).

As stated earlier, the proven scientific ideology behind the placement of players, vis-à-vis their anthropometric and motor performance characteristics, generally did not matter to most coaches during these games (6th Mini GUSA Games), with the exception of one (UCC). We believe the coaches of UCC paid some attention to these technical abilities of their players for each position and the tactics which aided them in winning the entire tournament, as most of the observed significant differences were in their favor. For instance, significant differences that existed in abdominal strength, agility and upper body strength were all in their favor, which must have given them supremacy in moving the ball and charging during attacks and defenses (Bompa, Haff, 2009; Domfeh, 1996).

Conclusions

There were significant differences in the forearm length, leg power, abdominal strength, agility, flexibility and upper body strength between public university male soccer players in Ghana.

Thigh girth, chest girth and finger span significantly influenced the kicking ability (kicking distance and dribbling) of male soccer players in the GUSA games. The forearm length, leg power, abdominal strength, agility, flexibility and upper body strength of the male soccer players were also the basis for differences in performances. The anthropometric characteristics, agility and flexibility of the male soccer players influenced their kicking abilities.

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THE INFLUENCE OF MUSCLE SORENESS ON THE SPEED OF PERFORMING A MOTOR REACTION SPEED TASK IN FOOTBALL GOALKEEPERS DURING A TRAINING CAMP

Jarosław Muracki

University of Szczecin, Faculty of Health and Physical Education, Institute of Physical Culture Sciences

Address for correspondence:
Jarosław Muracki
Al. Piastów 40b, blok 6, 71-065 Szczecin, Poland
E-mail: jaroslaw.muracki@usz.edu.pl

Abstract **Aim:** To investigate the influence of muscle soreness on the speed of performing a motor reaction speed task in football goalkeepers.

Methods: Twenty-four young healthy football goalkeepers, aged 16–18 years old (average 16.7 ±0.67 year), with an average body height of 175.6 ±5.4 cm and body weight of 65 ±5 kg, participated in a study conducted during a 6-day training camp. The first day, referred to as day 0, was intended for initial tests and the following 5 days, referred to as days 1–5, consisted of training. On day 0, before the training period, anthropometric parameters such as weight and height were measured, subjects were questioned to determine the rate of perceived exertion (RPE) and perceived psychophysical readiness (PPR), a speed test with motor reaction choice (ST) was performed using a Smart Speed System and areas with muscle soreness (MS) were recorded by means of a computer tablet with the Navigate Pain application. The goalkeepers participated in two training sessions on each of the following 5 days. Before each training session, the same speed test was performed. Lap times for 5 m and 15 m were recorded. After the second training session each day, the participants drew digital pain maps using a computer tablet, marking separate areas of the body where they felt muscle soreness. These data were consolidated and the total area was analyzed to investigate if, throughout the training, there were any changes to the size of the area that was indicated as having MS. A categorization of body areas was also made to determine areas where muscle soreness was most frequently indicated. Each training session was monitored with heart rate (HR) registration and each goalkeeper determined his fatigue (RPE) and readiness to exercise (PPR) on a 1–10-point scale.

Results: Twenty-three out of twenty-four (98.5%) goalkeepers indicated that they had MS during the study. Day 2 showed the highest incidence rate with 21 participants indicating that they felt MS. The biggest area of MS was also indicated on day 2, yet statistical analysis did not show significant differences in the area of MS between the training days. MS was most often indicated in the upper leg, i.e. the thighs. The average time of the first 5 m was 1.3 [s] (SD = 0.09), ranging from 1.28 [s] to 1.33 [s], while the average time of the following 10 m was 2.07 [s] (SD = 0.18), ranging from 2.04 to 2.1 [s]. The average total speed test time equaled 3.37 [s] (SD = 0.21), ranging from 3.33 to 3.38. Statistical analysis did not show significant differences in any of the results between the training days.

Conclusions: Most of the goalkeepers felt muscle soreness as an effect of specific goalkeeper training, measured by indicating painful zones on digital pain drawings. In this study, where muscle soreness was induced by technical-tactical specific goalkeeper training, no significant changes were noticed in the speed of performing a motor speed test with reaction choice or on the area of muscle soreness indicated on digital pain drawings, although almost every goalkeeper had a large area of muscle soreness.

Discussion: Many studies show that delayed onset muscle soreness (DOMS) causes a decrease in strength, power, range of motion and speed. However, in many cases, these studies are designed to induce high intensity DOMS and then conduct isolated motor skill tests. In this study the objective was not to induce high intensity DOMS but to investigate the effect of muscle pain, which is present naturally during training processes, and then assess its effect on a speed test which reflects real game situations – with a component of reaction choice and change of movement and direction. Approaching the subject from a different viewpoint allows us to see that the reliable assessment of the psychophysical state of players, made by observing their actions on the pitch or even using photocells to measure motion speed, is difficult without an insight into the parameters of soreness that players experience. These can be monitored, for example, through digital pain mapping software.

Key words goalkeeper, DOMS, muscle soreness, pain, speed, reaction

Introduction

The technical report and statistics of the 2014 FIFA World Cup in Brazil_underlined the importance of goalkeepers and coaches' education in the training process in senior and youth football (Sieboth et al., 2014). A goalkeeper's actions during match play include several interventions such as diving, jumping, tackling, 1v1 duels, intercepting crosses, throwing and passing with the feet. Most of the actions are explosive movements; changes of direction, accelerating, decelerating, landing, jumping or sprints which last up to a few seconds. Many authors emphasize the role of speed as crucial for the effectiveness of a goalkeepers' actions (Bergier, 2004; Di Salvo, Benito, Calderón, Di Salvo, Pigozzi, 2008; Knoop, Fernandez-Fernandez, Ferrauti, 2013; Ziv, Lidor, 2011; Deprez et al., 2015; Padulo, Haddad, Ardigò, Chamari, Pizzolato, 2015). Goalkeeper fitness and ability tests often use speed tests (Knoop et al., 2013; Rebelo et al., 2013; Rebelo-Gonçalves, Figueiredo, Coelho-E-Silva, Tessitore, 2016). Goalkeeper technical-tactical training tends to simulate real game situations, but with a higher number of repetitions (Pawłowski, Trzaskoma, 2012; Goliński, Muracki, Wolański, Klich, Murawska-Ciałowicz, 2016). A large number of repetitions aims to improve technique and tactics but may cause overtraining which results in increased soreness, pain, excessive or constant fatigue, loss of optimal physical condition and an increase in the risk of injury (Carfagno, Hendrix, 2014).

Football is a team sport with a high risk of injury (DeHaven, Lintner, 1986; Hootman, Dick, Agel, 2007). K. Kristenson, M. Waldén, J. Ekstrand and M. Hägglund (2013), who recorded 6,140 injuries in 1,401 players from 26 clubs during 797,389 hours of exposure across 9 consecutive seasons, claim that approximately 1 injury occurs for every 130 hours of athletic exposure (0.77 injury incidence per 100 h) (Kristenson et al., 2013). Another cohort study by M. Hägglund, M. Waldén, R. Bahr and J. Ekstrand (2005) demonstrated a 0.78 injury incidence per 100 hours of exposure. Many football injuries involve muscles, depending on the level that is being played at. In professional players, 20–46% of all injuries are muscle injuries (Hägglund, Waldén, Ekstrand, 2003) and in amateurs – 18–23% (Chamari, Haddad, Wong, Dellal, Chaouachi, 2012).

Goalkeepers have a lower injury risk when compared with field players but are more likely to suffer from upper limb injuries (Aoki, O'Hata, Kohno, Morikawa, Seki, 2012; Della Villa, Mandelbaum, Lemak, 2018). A study analyzing elite Norwegian goalkeepers showed injury incidence equal to 27.9 per 1,000 match hours, 23.6 for specific goalkeeper training and 9.1 for other types of training. Injuries of the upper limbs represented 36% of all injuries (Strand, Krosshaug, Andersen, 2011). In a study using questionnaires, over 72% of young male football goalkeepers reported an injury within the last 12 months, over 88% of which occurred during training. The most common were acute injuries (nearly 77%), with fractures/subluxations of fingers, and thigh muscle strains/tears

reported most often. The other 23% were injuries from overuse which most frequently involved the knee and pelvic girdle (Błażkiewicz, Grygorowicz, Białostocki, Czaprowski, 2018).

There are numerous definitions of injury which accent chosen aspects of this phenomenon. The World Health Organization (WHO) developed the International Classification of External Causes of Injury (ICECI) which classifies injuries by: mechanisms, objects/substances which cause injury, a place of occurrence, an activity when injured, and a role of human intent. In sport, an injury is most commonly defined as damage to the body which causes a break in training or in performing an activity (time-loss injury). This definition does not include a situation in which there is damage to the body or pain, but the athlete is not excluded from training or playing. According to this definition, the same pain or damage to the body can be a time-loss injury for one athlete but does not need to be an injury at all for another. In the *Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries'* an injury was described as "any physical complaint sustained by a player that results from a football match or football training, irrespective of the need for medical attention or time loss from football activities". This means that everything a person complains about is classified as injury. The "Consensus" outlined another two types of injuries – a medical attention injury (injuries which need medical attention) and a time-loss injury (injuries which eliminate an athlete from full participation in training or playing) (Fuller et al., 2006). "Physical complaint" injuries result in the highest injury rate, the "Medical attention" definition encompasses a smaller number of injuries, and the "time loss" definition has the lowest. In the "Consensus" statement, a traumatic injury is defined as an injury resulting from a specific, identifiable event, and an overuse injury is caused by repeated micro trauma without a single, identifiable event responsible for the injury (Fuller et al., 2006; Bahr, 2009).

Another aspect is pain and soreness. Soreness and pain are not only connected with acute injuries but also with overuse injuries in which they manifest as: pain in the affected area during an activity (which restricts performance), pain in the affected area during an activity (which does not restrict performance), pain in the affected area after an activity and chronic pain in the affected area, even after resting. R. Bahr (2009) claims that incidence can be very low using the time-loss or medical attention definitions despite the presence of a high prevalence of pain in pain indicating surveys. The DOMS mechanism is induced by muscle work, especially by exercises with an eccentric component such as being highly intensive or using explosive movements (MacIntyre, Reid, McKenzie, 1995; Hughes, Denton, Lloyd, Oliver, De Ste Croix, 2018; Tzatzakis et al., 2019), prolonged isometric work (Nie, Kawczynski, Madeleine, Arendt-Nielsen, 2005) or prolonged exertion (Paquette, Peel, Schilling, Melcher, Bloomer, 2017). A training load including explosive or high intensity movements causes a decrease in strength, speed and jumping performance as well as an increase of DOMS and creatine kinase (Tzatzakis et al., 2019). Prolonged exertion can also cause DOMS which affects the biomechanics of movement (Paquette et al., 2017). As well as this, muscle structure with DOMS can be damaged during goalkeeping in other ways leading to excessive stretching and tears. Prolonged musculoskeletal pain decreases motor activity (Lund, Donga, Widmer, Stohler, 1991) which can lower the effectiveness of the regeneration process.

Popular pain assessment tools include the Sports Inventory for Pain, the Wong-Baker FACES Rating Scale, the 0–10 Numeric Pain Rating Scale, the Visual Analogue Scale and the Verbal Pain Intensity Scale. These tools place little to no emphasis on the location of pain and how it changes. Digital pain drawings are a modern and reliable pain assessment method to record the location, area, intensity of pain and any changes in these parameters (Boudreau, Badsberg, Christensen, Egsgaard, 2016; Egsgaard, Christensen, Petersen, Brønnum, Boudreau, 2016; Muracki et al., 2019; Shaballout, Neubert, Boudreau, Beissner, 2019).

In this study, the author's aim is to investigate whether football goalkeepers suffer pain as a result of training and investigate the impact of muscle soreness on the speed of their actions, characteristic for real game situations and based on goalkeepers' kinematics.

Aim: The aim of the study was to investigate the influence of muscle pain and soreness arising from training, on the speed of football goalkeepers in the specific conditions of their role.

Methods

Participants

Twenty-four young healthy male football goalkeepers aged 16–18 (average 16.7 ±0.67 years) were involved in the study. The average body height was 175.6 ±5.4 cm and the average body mass, 65 ±5 kg. The right upper limb and the right lower limb were indicated as dominant in every case. The participants had been training and playing as football goalkeepers for a minimum of 4 years and at the time of the study, were representing clubs from the highest regional leagues. All of the participants were deemed medically fit to play, had no contraindications to training and playing football and voluntarily agreed to participate in the study.

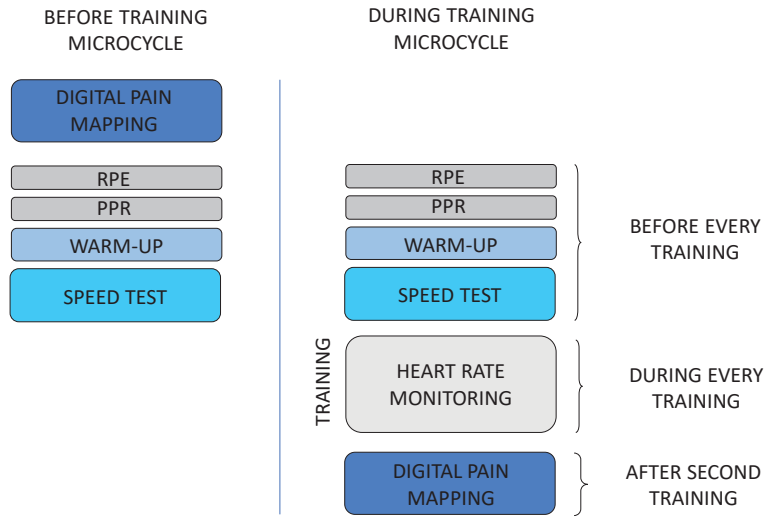
The exclusion criteria were as follows: present illness, present injury, previous severe injuries or symptoms that affect feeling or movement, medical contraindications to playing football, illnesses that require the use of painkillers or any other medication.

Study design

The project was approved by the ethics committee. Subjects participated in the study of their own free will and were informed that they may terminate their participation at any time. In the case of minors, consent for their participation in the research was obtained from their parents or legal guardians. The study was conducted during a 6-day training camp. Before the start of the camp, the participants had from four to seven days of complete rest with no sport or recreational physical activity. Before the training period, on the first day, referred to as day "0", initial tests and checks were conducted. These included measuring anthropometric parameters such as weight and height, performing speed tests with reaction choice using the Smart Speed System and recording painful areas by means of a computer tablet with the Navigate Pain application (Figure 1).

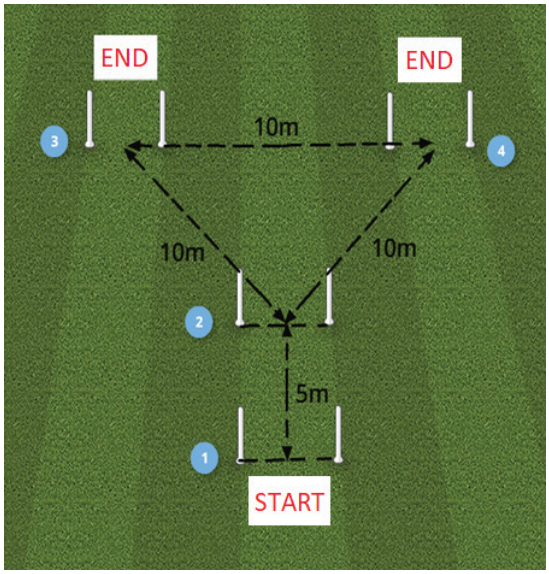
Speed test

The speed test was designed to test starting and running speed combined with reaction and motion direction changes. It used the Smart Speed System consisting of gates with photocells equipped with programmable signal emitting lights. The device can also measure time. Four gates were set up in a Y formation (Figure 2). The first gate started the timer and was 5 m away from the second gate. As the second gate was passed, the timer recorded the time of the lap and randomly selected an end gate where a photocell began blinking. After a voluntary start, the subject would sprint the 5 m from the first to the second gate and then the 10 m to the end gate where the light was blinking. Crossing one of the end gates ended the timer. Every participant completed the speed test 2 times before every training session and both records were included in the data analysis. Lap times were recorded for the first 5 m sprint, reaction time and following 10m run and the total time (15 m).



RPE – Rate of perceived exertion, PPR – Perceived Psychophysical Readiness.

Figure 1. Study design



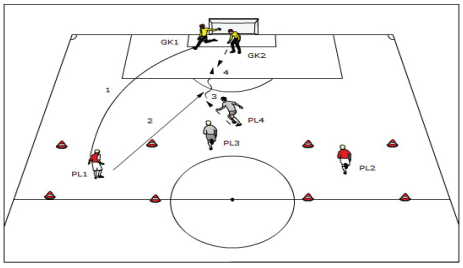
Instructions for the test taker:
1 – Stand in a starting position for running (one leg forward on the marked point) 30 cm in front of the first gate.
2 – Start at any time.
3 – Run as fast as you can to go through the first gate.
4 – One of the two end gates will blink – run as fast as you can to go through the blinking gate.
5 – Try to go as fast as you can, cross the gate and start decelerating a few meters after passing through the gate, do not stop at the gate line.

Figure 2. Speed test design

Goalkeeping exercise

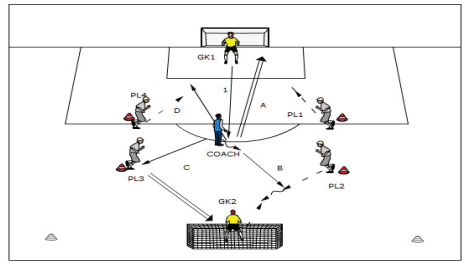
During training days 1–5, there were 2 specialist tactical-technical goalkeeper training sessions each day. The first training session was at 11:00 am, and the second at 5:00 pm, both lasting for 1.5 hours. During the training sessions goalkeepers practiced exercises based on the game situations presented in Figure 3. The exercises involved shot stopping, intercepting crosses, throwing, defending in 1v1 duels and passing. There was no increased physical activity between the sessions and no physiotherapy was used during the camp. Before each training session the same speed test was performed.

Long pass and 1v1 exercise



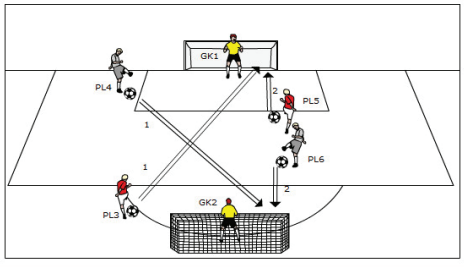
1 Goalkeeper 1 long pass to player 1 or 2
2 Player 1 (or 2) receives the ball and passes at the goal direction.
3 Player 4 (or 3) receives the ball and attacks the goal in 1v1 duel with goalkeeper 2 (or goalkeeper 1).

1v1 and shoot stopping exercise



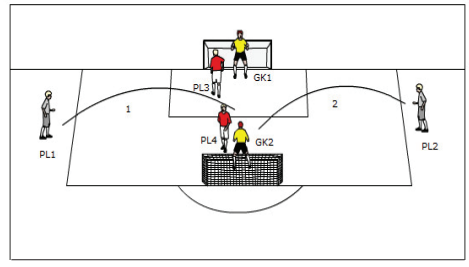
1 Goalkeeper 1 passes the ball to the coach
Coach create one of the following situations:
A – Coach shoots, player runs to shoot the ball if goalkeeper deflects when defending the goal
B – Coach passes the ball to the player and he goes into 1v1 duel with goalkeeper who tries to defend the goal
C – Coach passes the ball to the player and he shoots and goalkeeper defends the goal
D – Coach passes the ball at the goal direction, the goalkeeper and the player compete to get the ball first

Shoot stopping exercise



1 Players 3 and 4 shoot, goalkeepers 1 and 2 defend
2 Players 5 and 6 shoot the deflected ball or the second ball

Crosses interception exercise

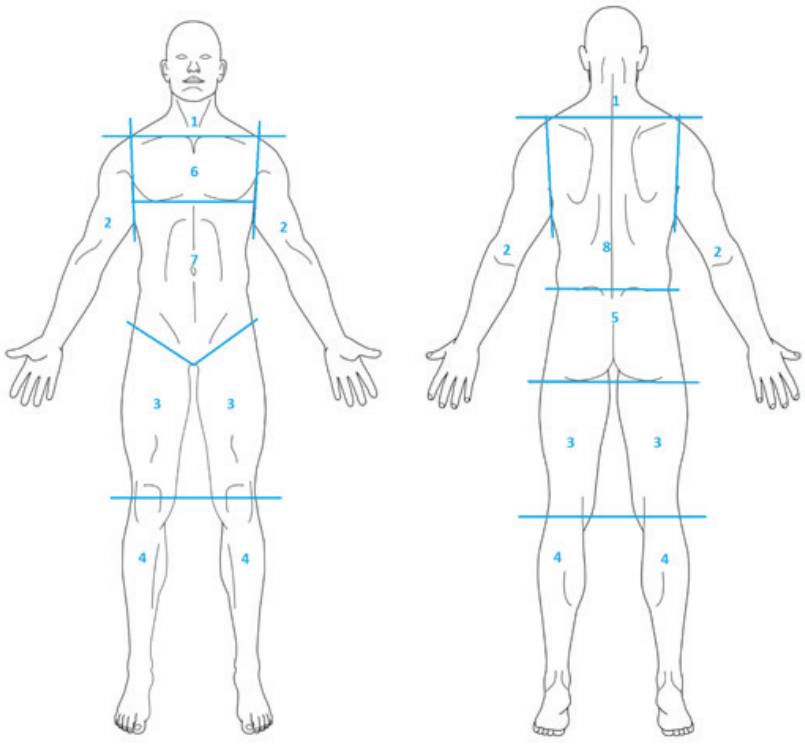


1 Player 1 crosses for goalkeeper 1 or 2
2 If the goalkeeper catches the ball, he throws it to the other side to player 2
Players 3 and 4 try to score or to prevent goalkeepers' intervention

Figure 3. Goalkeeping exercises

Digital pain mapping

Each day after the second training session, the participants drew digital pain maps using a computer tablet (Lenovo Tab 10, TB-X103F). They were marking areas of the body where they felt muscle pain in the Navigate Pain application for Android. The participants were asked to use a finger to draw the area and location of the soreness on a 2D male body outline representing the anterior and posterior parts of the body. This method has a proven reliability and can be comparable with a traditional pen and paper method (Boudreau et al., 2016). The participants were asked to only indicate and draw muscle pain, i.e. pain localized within the muscle structure and not caused by a direct impact. A precise questioning algorithm was used to help the participants fully understand the request (Figure 5). Using the Navigate Pain application, the areas of MS were extracted and expressed as a total number of pixels. Each digital pain drawing was then reviewed in terms of the localization of the MS for further analysis. The posterior and anterior body schemes were divided into areas of large muscle groups according to anatomical and biomechanical factors and was based on our observations from previous studies (Figure 4). These data were then consolidated and analyzed to investigate how the size of the area of muscle soreness changed during the study and where muscle soreness was most frequently indicated.



1 – shoulders and neck, 2 – upper limb, 3 – upper leg, 4 – lower leg, 5 – glutes, 6 – chest, 7 – abdomen, 8 – back.

Figure 4. Body areas

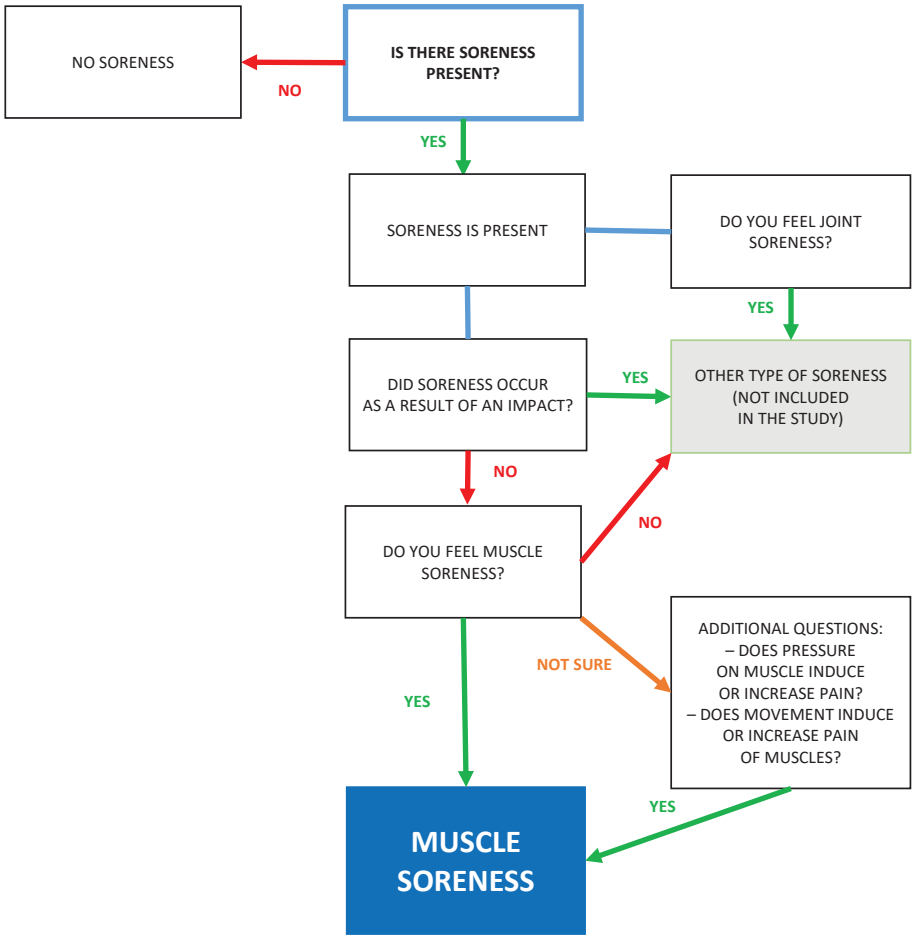


Figure 5. Questioning algorithm – type of soreness

Training load monitoring results

HR and self-reporting scales such as the Rate of Perceived Exertion are considered to be reliable and easy-to-use tools for assessing training load (Coutts, Rampinini, Marcora, Castagna, Impellizzeri, 2009). Each training session was monitored with HR registration (Polar Team System). Before starting training, the goalkeepers indicated their fatigue as a rate of perceived exertion (RPE) on a ten-point scale, where 1 was the lowest fatigue score and 10 was the highest. In a similar way, goalkeepers determined their perceived psychophysical readiness (PPR) to exercise on a ten-point scale, where 10 was the highest readiness to exercise and 1 was the lowest. The aims of monitoring these was to maintain the intensity of the training sessions, to observe the participants, avoid excessive fatigue and to control the goalkeepers' involvement in training.

Statistical analysis

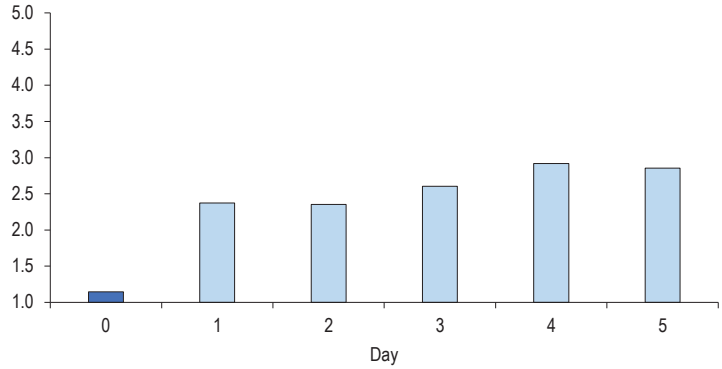
Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS, IBM). To investigate the overall area of soreness reported by the goalkeepers, the total number of pixels for the areas was extracted. The Shapiro-Wilk test for normality was used to test the normality of the residuals. The pixel data of pain extent underwent the Friedman one-way repeated-measures analysis of variance (1-way RM ANOVA) to investigate the differences between the 5 days of training. Furthermore, to explore the change in the total area of muscle soreness from day 1 to 5 of the training camp, pixel data were subjected to the Wilcoxon signed-rank test.

The changes in speed test results were investigated by means of a one-way repeated measure analysis of variance (1-way RM ANOVA). The same test was used to investigate the differences of RPE and PPR between these days. The Bonferroni correction was applied where appropriate. The results are presented as mean ±standard error, unless otherwise stated. Statistical significance for all analyses was accepted at $p < 0.05$.

Training load monitoring results

The goalkeepers trained with maximal intensity for 4% of the total training time, at very high intensity – for 11%, at high intensity – for 28%, at moderate intensity – for 36% and at low intensity for 21% on average. The zones of intensity were calculated individually and were named maximal intensity for 90–100%, very high – 80–89%, high – 70–79%, moderate – 60–69% and low <60% HRmax. The maximal HR reached during the training sessions was 90.4 ±2.75%. The average HR amounted to 66.1 ±2.1%. There were no statistically significant changes between the training days ($p = 0.05$).

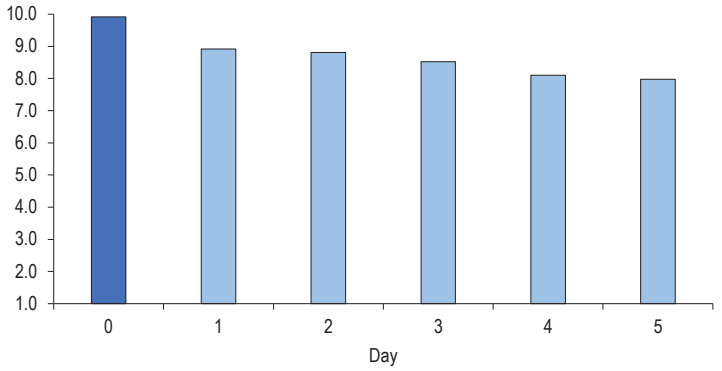
The rate of perceived exertion was 1,1 for day 0, and for the following training days 1–5: 2.4; 2.4; 2.6, 2.9; 2.9 on average, respectively (Figure 6). The average RPE of all participants during training days 1–5 was 2.6 ±0.8. There were no statistically significant changes between results in the training days ($p = 0.05$).



Scale 1–10, where 1 is the lowest perceived exertion and 10 is the highest perceived exertion.

Figure 6. Average score of the Rate of Perceived Exertion across the study

Perceived psychophysical readiness was 9.9 for day "0" and for the following training days 1–5: 8.9; 8.8; 8.5; 8.1; 8.0 on average, respectively (Figure 7). The average PPR of all participants in training days 1–5 was 8.5 ±1.13. There were no statistically significant changes between results during the training days (p = 0.05).



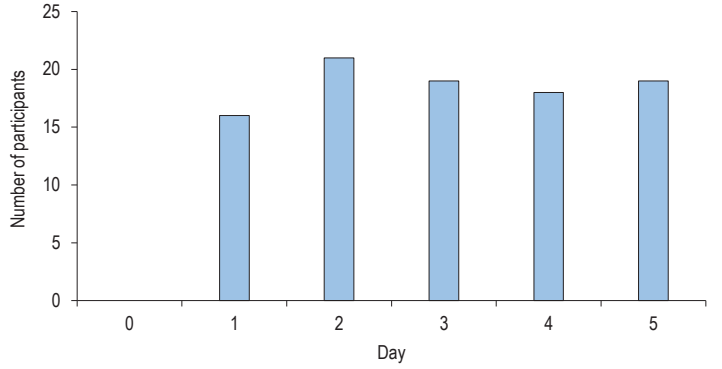
Scale 1–10, where 1 is the lowest perceived psychophysical readiness and 10 is the highest perceived psychophysical readiness.

Figure 7. Average score of Perceived Psychophysical Readiness across days

The analysis of training monitoring data leads to the conclusion that goalkeepers trained at a moderate to high intensity shown through the HR, claimed low RPE, as a measure of exertion, and a high PPR, as a measure of psychophysical readiness to upcoming training.

Results

During training days 1–5, twenty-three of twenty-four (95.8%) goalkeepers indicated muscle soreness on digital pain mapping from the first to the last training day (Figure 8).



The maximal number of subjects indicating muscle soreness was 21 on the second training day.

Figure 8. Number of participants indicating muscle soreness across days

Though the area of muscle soreness was biggest on day 2 (Figure 9), statistical analysis did not show significant differences between the training days (p = 0.05). Similarly, there were no statistically significant differences in size of the area of muscle soreness indicated on the front and back view of the body (p = 0.05).

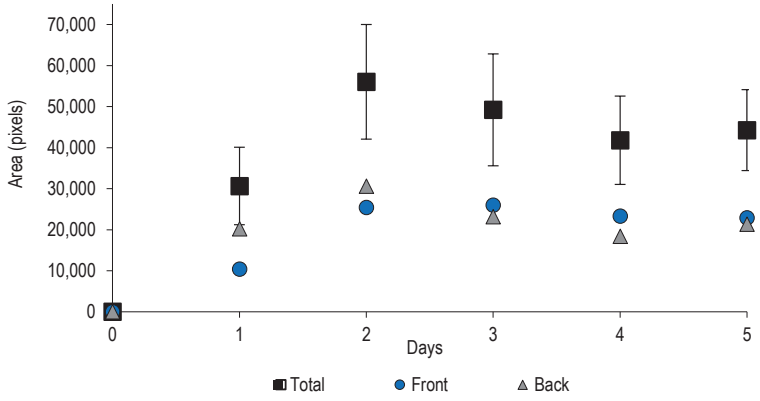
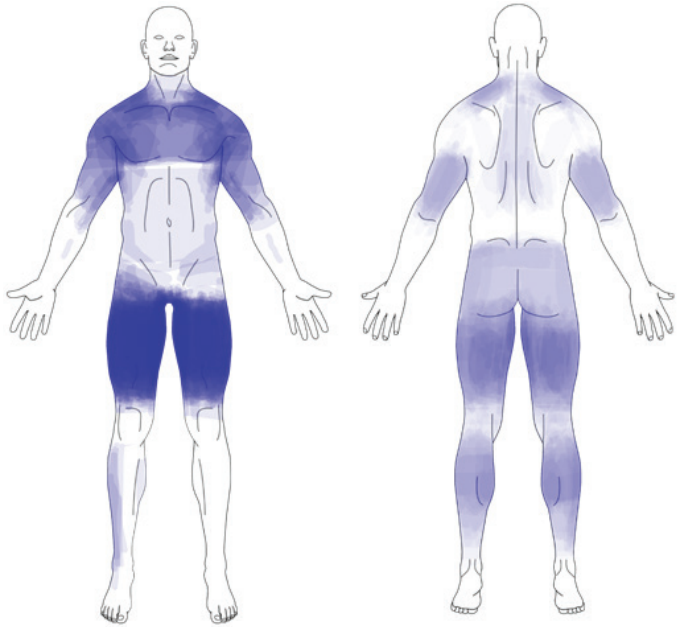


Figure 9. Muscle soreness area across days



Front body area – left, back body area – right.

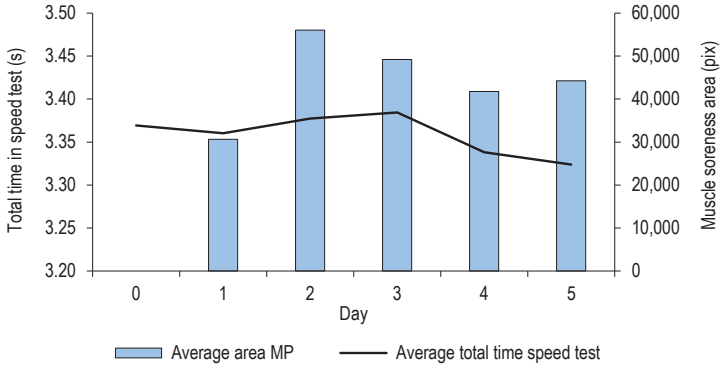
Figure 10. Muscle soreness – graphical representation of all 240 cards superimposed (120 – front view, 120 – back view) from the five training days of all 24 subjects

Muscle soreness was most often localized in the area of the upper leg (Figure 10) – twenty-one out of twenty-four subjects indicated this area (88%). The areas of muscle soreness which were the least frequently reported were the abdomen, back, gluteus muscles and shoulders and neck (Table 1).

Table 1. Localization of muscle soreness

	Shoulders and neck	Upper limb	Upper leg	Lower leg	Gluteus	Chest	Abdomen	Back
Sum out of 24	7	8	21	9	7	8	5	5
Percent of all	29*	33	88*	38	29*	33	21*	21*

* χ^2 (p = 0.005).



On day "zero" none of the subjects indicated muscle soreness and the speed test time was 3.37 (s).

Figure 11. Muscle soreness area and total time in speed test across training days

The results of the speed test in days 0-5 were as follows: 3.37; 3.36; 3.38; 3.38; 3.34; 3.32 (s) (Figure 11). There were no statistically significant changes between the days (p = 0.05). The results of the first 5 m (distance from the first to the second gate) in days 0–5 were as follows: 1.27; 1.33; 1.31; 1.29; 1.31; 1.30 (s). Statistical analysis did not show significant changes (p = 0.05). The results of the last 10 m (decision, change of direction and locomotion speed from the second to the third gate) in days 0–5 were as follows: 2.04; 2.08; 2.07; 2.08; 2.06; 2.09 (s). Again, there were no statistically significant changes between the days (p = 0.05).

Discussion

Many studies show that DOMS causes a decrease in strength, power, range of motion and speed, but in many cases these studies are designed to induce high intensity DOMS and use isolated motor skills tests (Tzatzakis et al., 2019; Nie et al., 2005; Kawczyński, Samani, Fernández-de-Las-Peñas, Chmura, Madeleine, 2012; Kawczyński et al., 2014). Other authors like Hughes emphasize the meaning of assessment the mechanism caused by real game or training situation (Hughes et al., 2018). In this study the objective was not to induce high intensity DOMS or muscle soreness but to investigate the effect of muscle pain which is naturally present during training processes,

and assess its effect on speed tests that reflect real game situations – with a component of reaction choice and change of movement direction. In sport, fatigue monitoring aims to prevent excessive loads including excessive muscle soreness and the DOMS effect. It is already known that straight path running speed, especially for distances over 60 m with a voluntary start, has a poor correlation with the speed needed for acting in football match conditions. Due to these facts and a tendency of team management staff to choose the most effective and reliable goalkeeper for the first squad, author decided to investigate the muscle soreness effect arising in natural training conditions and its influence on the speed in a motor task based on real game situations.

Another approach argues that reliable assessment of the psychophysical state of players, made by observing their actions on the pitch or even using photocells to measure motion speed, is difficult without having an insight into the soreness and pain they feel. This can be monitored by, for example, digital pain mapping. In a long term perspective, at least four dimensions should be considered: training process, training and playing load, injury prevention and rehabilitation and playing performance. Training load is connected with a players' individual and team development. Injury prevention demands an optimization of training load which often leads to a decrease of intensity, training volume or even forces exclusion from training and playing process. Rehabilitation after an injury is nearly always connected with a time-loss period. Injury prevention and rehabilitation are strongly connected with physical preparation, for which training monitoring is crucial. Play performance is the result of many factors, only some of which can be directly influenced by training staff. The most significant besides the personal team squad are training process and injury prevention and rehabilitation. Taking these into consideration makes training monitoring even more important. Training monitoring can increase the quality of training process, injury prevention and rehabilitation. This is the main reason why the author considers monitoring pain as an important and easy way to get an insight into a players' condition as well as to analyze it in a long-term training and playing process.

Conclusions

1. Muscle soreness was indicated by the majority of goalkeepers.
2. The area of muscle soreness did not change significantly across training days.
3. Motor reaction speed test time did not change significantly across training days despite the presence of muscle soreness in many areas of the body.

Practical application

Digital pain monitoring can bring important information for coaches, medical staff and players.

Archiving and longitudinal digital pain monitoring can help in injury prevention and team management.

Analysis of data from digital pain monitoring software can help in recognizing symptoms of overload and to minimize injury risk.

One-aspect (only heart rate, only physiological blood factors, only motor skills, only psychological or perceived factors) monitoring does not ensure a complete insight into a players' psychophysical state. Multi-aspect monitoring is required for reliable findings.

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THE ORIGINS OF THE SPECIAL OLYMPICS MOVEMENT IN POLAND IN THE 20TH CENTURY

Dorota Pilecka,[A, B, D, E] Tomasz Jurek[A, D]

University School of Physical Education in Poznań
Faculty of Physical Culture in Gorzów Wielkopolski

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

Address for correspondence:
Dorota Pilecka
Faculty of Physical Culture
Estkowskiego 13, 66-400 Gorzów Wlkp., Poland
E-mail: d.pilecka@awf-gorzow.home.pl

Abstract Since World War II, sport involving people with disabilities has gradually evolved in Poland, and people with intellectual disabilities had not participated in any sporting events until the end of the 1960s. They were treated as second-class citizens having no rights that they should be entitled to. The reason behind this was the State's policy towards sport, where high-performance sport, especially Olympic sport, played a vital role that was supposed to testify to the high level of civilisation in communist Poland. People with disabilities were regarded as a shameful problem and were practically kept hidden away. They, therefore, did not participate in social life, including athletic activities. The first competition held in Poland under the name of the Special Olympics was not organised until 1969 in Poznań. On May 26, 1973, the first national sporting event for mentally retarded children (as they were referred to at the time) was called Spartakiad and was held in Warsaw. That was around that time that the sports movement in Poland began to draw on American practices, and in the 1980s it adopted the form of the Special Olympics, both in terms of organisation and sporting activities. This period was marked by active cooperation with the USA and other countries, where Polish athletes with intellectual disabilities began to compete in international competitions.

Key words Special Olympics, sport by people with disabilities, Paralympic Games

Introduction

The authors of this paper discuss the origins and evolution of sports involving people with intellectual disabilities in the second half of the 20th century in Poland, as well as outline the process of emancipation of people with disabilities in sport until they could finally join the Special Olympics International competition in the 1980s. The basic research method used in writing this paper was an analysis of historical sources. The methods of induction and deduction have also been applied.

The evolution of sports involving people with intellectual disabilities in Poland has not yet been separately addressed in academic literature, representing a significant gap in the historiography of physical culture. The only

writings that have been published so far are various personal accounts of parents of children with disabilities, and of some activists working for the advancement of physical activity in the community of people with disabilities. Against this backdrop, literature on the Paralympic movement looks much more impressive. Therefore, it is worth presenting the beginnings of this specific area of sporting activity involving people who were initially described as mentally ill or mentally impaired. It is important to note that over the centuries, people with intellectual disabilities have come a long way towards being accepted, to be seen within the bounds of normality and actively involved in sport. They have come a long way, from a long period of physical elimination, exclusion and isolation, through a time of contempt and humiliation, stigmatisation and denigration, indifference, even heartlessness, as they were confined inside the walls of closed institutions. In a number of societies, families did not always create much of a friendly environment for their loved ones affected by this type of disability. It was not until the 20th century that dignity was restored to this group of people and their full rights began to be recognised. People with intellectual disabilities were not able to fully enjoy their fundamental human rights because of the many barriers, restrictions and discriminations they were faced with over the course of history. Many of these rights have been regulated and included in international legal acts, such as; the United Nations Universal Declaration of Human Rights of 10th December 1948; the United Nations Declaration on the Rights of Mentally Retarded Persons adopted by General Assembly resolution 2856 (XXVI) of 20th December 1971; the United Nations Declaration on the Rights of Disabled Persons adopted by the United Nations General Assembly on 9th December 1975 (Resolution 3447); *the Standard Rules for the Equalization of Opportunities of Persons with Disabilities* adopted at the 48th session of the United Nations General Assembly on 20th December 1993; *the European Charter of Sport for All: Disabled Persons*. The Convention on the Rights of Persons with Disabilities was adopted by the United Nations General Assembly in 2006.

The troubled origins of sport involving people with intellectual disabilities in Poland

Since 1945, sports involving people with disabilities have gradually evolved in Poland, however, those with intellectual disabilities did not initially participate in any sporting events. For these people, sport has long been an inaccessible form of activity. One such reason for this was the fact that the authorities considered these people to be an embarrassing problem and not worthy of any priority. As a rule, the parents remained alone at home with their disabled children, deprived of any support, as well as therapy or therapeutic treatment. Moreover, the evolution of the athletic movement was dominated by a high-performance trend, treated as propaganda for the promotion of Poland across the world. What mattered most was Olympic medals, while physical recreation and rehabilitation remained a secondary concern. Nevertheless, the first instances of physical activity involving people with disabilities began to be seen (Tracewski, 2009). Since 1952, the only organisation involved in physical recreation, tourism and high-performance sport for the disabled has been Zrzeszenie Sportowe “Start” [“Start” Sports Association]. Their activities were exclusively aimed at people with disabilities employed by Spółdzielnie Inwalidów [Cooperatives of the Disabled]. It was not until 1961 that the Association of Cooperatives of the Disabled and the “Start” Sports Association of Work Cooperatives initiated a systematic process of development of sport, tourism and recreation by organising sports clubs at every cooperative for the disabled. At that time, the “Start” Sports Association established a system of competitions organised at local, regional and national levels, national championships, tournaments, as well as a national games for the disabled every four years (Jandziś, Migała, 2015). People with intellectual disabilities attended camps and participated in rehabilitation stays or afternoon gymnastics

classes. A huge role in the advancement of sports involving people with disabilities was played by a group of parents of children with disabilities brought together in Towarzystwo Przyjaciół Dzieci [Children's Friends Society]. As part of the activities aimed at supporting their children's development, they explored new forms of activity, such as activities performed in physical education classes. A particularly active involvement in this area could be observed among parents of children with disabilities living in the cities of Warsaw, Poznań and Szczecin (Archive of New Files, 2/1588/0).

Initially, the cities of Poznań and Warsaw were the most prominent centres for the advancement of sport for people with intellectual disabilities, and that was where the idea to organise local competitions and later national tournaments was born. The first competition held in Poland under the name of Special Olympics was organised in 1969 in Poznań. The organisation of the event was initiated by Krystyna Kortus, Wojciech Mazur and Barnard Wieczorek. The national competition was held under the auspices of the "Start" Sports Association and five sports disciplines were represented: track and field, swimming, football, basketball and kayaking. Disabled athletes participating in the event came from all the provinces of Poland. The organisation of the event was modelled on the concept of the Olympic Games for people with disabilities, so there was an Olympic ceremony and a medal table for each province. A genuine competitive spirit could be felt during the event (Kowalik, Miotk-Mrozowska, 2013).

On 26 May 1973, the first national sporting event for mentally retarded children (as they were referred to at the time) was held in Warsaw. The organisation of the event that was called the First Spartakiad of Schools of Life Skills was initiated by Warszawskie Koło Pomocy Dzieciom Specjalnej Troski [Warsaw Aid Group to Support Children with Special Needs], also several schools of life skills from Warsaw, as well as the "Elektra" Cooperative of the Disabled. The event was attended by 211 athletes. The competition was held under the auspices of the School Superintendent's Office for the Capital City of Warsaw, the School Inspectorate for the District of Warszawa-Śródmieście, the Board of Directors of the Children's Friends Society the Committee to Support Children with Special Needs, and the District Association of Cooperatives of the Disabled. The program of the event included an opening ceremony parade of the attendees, athletic competitions, announcement of the scores, a prize-giving ceremony and closing. The event hosted in the Warsaw sports hall "Gwardia" is regarded as the first national sporting event for people with intellectual disabilities in Poland (File Depot of the Special School Complex No. 85 in Warsaw, the 1963/1964 School Yearbook of the Eunice Kennedy Special Primary School No. 243; Damentko, 1988).

In the period 1975 to 1980, a series of events called the Warsaw Special Schools Spartakiad was organised in the region of Warsaw. The venue for the 2nd Warsaw Spartakiad of Schools of Life Skills was held in April 1978 at the Palace of Culture and Science in Warsaw. The 4th Warsaw Spartakiad of Schools of Life Skills was organised in the Capital City Sports Centre in Warsaw. In addition to diplomas awarded to students for their individual performances, depending on the results of the general classification, the schools received financial prizes for the purchase of sports equipment. The 5th Warsaw Spartakiad of Special Schools was held in the "Agrykola" stadium in Warsaw and was attended by the representatives of the Ministry of Schooling and Education, the School Superintendent's Office and the Departments of Schooling and Education. In 1980, over 800 students from 20 special primary schools and 8 special vocational schools were involved in athletic competition. The athletes participated in a lively parade, played a football match, and competed against each other in competitions such as dodgeball, basketball, table tennis and volleyball, football and children's tetrathlon. At the end, the winners were presented with prizes, diplomas and souvenir badges (Czerniecka, 1981).

In 1975, the city of Poznań hosted the First National Sports Games of the Disabled Youth. The event was attended by 114 representatives from such cities as Białystok, Katowice, Lublin, Olsztyn, Opole, Rzeszów, Warsaw, Wrocław and Zielona Góra. The aim of the competition was to review or evaluate the physical condition of people with intellectual disabilities. Other objectives included social integration and assessment of the relevance of holding these types of competitions as well as the selection of competitors. The organisers also wanted to verify the validity of the rules regulating the competition as these rules had been established with no experience to draw on and without any model rules that could serve as an example. The program of the Games included the following sports: swimming: 50 m, 25 m freestyle and 4x25 m relay; track and field events: a 100 m run, long jump, baseball throw, triathlon, women's 4x100 m relay and men's 4x200 m relay; an obstacle course where the athletes had to navigate vertical poles spaced out in a trail, go under hurdles, slip their whole body through a sash or a loop band, do a forward roll on a mat, and go past the finish line running; and a tug of war (rope-pulling) for 5-person teams (Dłużewska, Wieczorek, 1976).

Main hubs of sporting activity involving people with intellectual disabilities in Poland

Apart from the cities of Poznań and Warsaw, favourable conditions for young athletes with intellectual disabilities to compete against each other were also created in the province of Opole. Students and graduates of Zakład Wychowawczy [Educational Institution] and three other special educational centres from this region competed against each other during sporting events called Spartakiads that were organised for several years. The representatives of school sports clubs from all these facilities participated in team competitions playing football, handball and volleyball. Track and field events were in turn for the athletes to compete individually. Each sporting event had an official character. It started with a ceremonial opening and was attended by many invited guests. The winners received cups, diplomas, pennants, as well as individual certificates attesting to their performance (Ciaciura, 1980). Athletic competitions for children with intellectual disabilities were also organised in the province of Konin. In 1977, the 1st Sports Competition of Special Schools was held in Czepów. The competition was organised in May for five years in succession and was attended by representatives of six special schools (with about 130 athletes participating). The event was organised in the park adjoining the school which had been equipped with long jump pits and high jump stands, 60- and 100-meter running tracks, as well as handball and football pitches. The event was supported by the School Superintendent's Office, the Board of Directors of the regional branch of the School Sports Association and the Board of Directors of the regional branch of the Children's Friends Society (Jabłoński, 1982). Sport games were also held in the province of Olsztyn where children and young people with intellectual disabilities were given the opportunity to present their skills, improve their ability to work in a team, and compete in the spirit of sportsmanship (Rawa, 1985).

The idea to organise regional Spartakiads for children with intellectual disabilities was put into practice at a fairly early stage in the province of Szczecin. In 1979, the Spartakiad of schools of life skills was held on the premises of one of the educational institutions located in Policka street in Szczecin. The competition was attended by children from the primary school located in Strzałkowska street and the Special Educational Centres in Tanowo and Chojna. The competition included track and field events (a long jump, a 20 m run, a 100 m run, ball throw) and a deck tennis ring toss. The idea of hosting sporting events using the available facilities required the management and teachers of a number of schools to restore their pitches, gyms, running tracks and other sports amenities to the required condition. Special educational centres were housed in school buildings (the most popular, almost

identical schools which were erected to commemorate the millennium of the Polish state) so there were sports grounds in place but in a very poor state of repair. These actions were backed by school principals who got involved in preparing their students for sports competitions. It was also recognised that physical culture played an important role in the education and rehabilitation of children with intellectual disabilities. Physical activity and regular exercises contributed to stimulating and improving the physical condition of mentally impaired children. In 1982, in cooperation with the parents of intellectually disabled children that had been brought together in the Aid Group to Support Children with Special Needs affiliated with the Children's Friends Society, another Spartakiad was organised in the stadium of the School Sports Association. The event was attended by seven teams, and apart from the students and children from the Aid Group to Support Children with Special Needs, the residents of two care homes joined in. Shortly afterwards, when the idea of the Special Olympics began to gain a foothold in Poland, with students from Szczecin's schools who continued their physical training gradually becoming involved in these activities. The competitions were held on a year-round basis bringing together students from various educational institutions, competing in such sports disciplines as football, table tennis and badminton. These activities were concluded with the Special Olympic games organised in the stadium featuring the typical Olympic symbols and rituals such as lighting the flame, performance of the national anthem and hoisting of the country's flag (Pyszkowski, 2018).

The town of Zakopane has also grown to be an important centre of the movement. The activities of the Aid Group to Support Children with Special Needs were conducted there by Andrzej Sekuradzki and his wife Barbara. Initially, a kindergarten was opened, then a rehabilitation and educational centre, and in the years that followed, an occupational therapy workshop. There were also attempts made at the advancement of physical activity involving people with intellectual disabilities (Abramowska, 2012).

The Special Olympics movement is launched in Poland

In Poland, many initiatives were taken at local and national levels, however, the introduction of unified rules of competition, the organisation of sport competitions, evaluation of results, and awarding athletes with prizes required some outside inspiration and application of external standards or practices. The School of Life Skills in Warsaw at Elektoralna 12/14 was repeatedly visited by guests from the United States who shared their observations and comments. The collaboration with the United States would flourish also thanks to research conducted by Professor Ignacy Wald. Poland was also visited by representatives from France and Austria. The parents of children with intellectual disabilities who were part of the Committee to Support Children with Special Needs worked to establish contacts with organisations from France and Belgium (File Depot of Polskie Stowarzyszenie na rzecz Osób z Niepełnosprawnością Intelektualną [Polish Association for Persons with Intellectual Disability], International materials). Thanks to their active involvement in the international community and the information available to the Polish communities abroad, the news about their sports activities made its way to the Special Olympics Board of Directors in the USA (Tyczyński, 1999).

The first time Poland came into contact with the idea of the Special Olympics was in 1970, when Zenon Jaszczur, who was preparing his doctoral dissertation, contacted Eunice Kennedy-Shriver. He was invited to set up and further develop the Special Olympics movement in Poland. However, he failed to receive any approval from the Polish Ministry of Education (Jaszczur, 2019). In the early 1980s, Leszek Kołakowski maintained contact with Eunice Kennedy-Shriver and Sargent Shriver, but at that time Kołakowski worked and resided in the United Kingdom, and his trips to the United States were mainly to give lectures at the Kennedy Institute of Ethics (National

Library, Manuscript Collection, 1971–1980). Krystyna Mrugalska remarked that her first meeting with Eunice Kennedy-Shriver took place in Warsaw during the latter's visit to Poland's capital city at the turn of 1979 and 1980. It was also then that Frank Hayden visited Warsaw and voiced his encouragement for Poland to join the Special Olympics (Mrugalska, 2018). For the first two years, the matters in question were handled by the Secretary of the Committee to Support Children with Special Needs (KPDST). Since 1979, the KPDST was chaired by Professor Jerzy Doerffer from Gdańsk who could speak English and who had some international experience. However, he had no time to deal directly with the Special Olympics within the Committee to Support Children with Special Needs (Doerffer, 2005; Maszczak, 1994; Krukowska, Maszczak, 1989; Cwojdzińska, 2018).

The founder of the Special Olympics movement, Eunice Kennedy Shriver, sent an invitation to the President of the Children's Friends Society for the Polish delegation to attend the 1983 Baton Rouge World Summer Special Olympics in the United States (Krukowska, Maszczak, 1989). The financial support to buy sportswear for the first athletes was provided by private individuals, e.g. Krystyna Mrugalska bought tracksuits and sports shoes. At that time, there were no systemic solutions or methods to raise funds for the purchase of equipment for the athletes. The costs of air travel and their stay were covered by the Special Olympics International. The Polish team that went to Baton Rouge, Louisiana included four athletes supported by K. Dzikowski as the team's medical doctor and J. Doerffer as the team's coordinator and interpreter. The Polish team and the team from Cuba were the only ones from communist bloc countries. The Polish team's coordinator was invited to the meetings of the Organizing Committee, which took place during the 6th Special Olympics World Summer Games. In October 1983, J. Doerffer accepted the offer to participate in the activities of the International Board of Special Olympics. It was an extraordinary honour for Professor J. Doerffer to join the Board of Special Olympics International. He saw that as an opportunity to gain insight into the ways to introduce and popularise sport among people with intellectual disabilities, as well as to obtain expert support and some funding from the organisation. He received copies of instruction manuals and official competition rules from Washington. At that time, he enlisted the cooperation of Jerzy Tyczyński, who in turn engaged some specialists from the University of Physical Education in Warsaw. The press release that appeared in the Washington Post in 1987 read: "Another board member from a communist country is professor Jerzy Doerffer, a Pole and former president of the Technical University of Gdansk. He has a retarded child and helped bring the Special Olympics into Poland" (McCarthy, 1987).

As the need to explore and further develop new directions of activity had been identified by the Committee to Support Children with Special Needs, in particular the application of ideas and activities promoted by the Special Olympics International in Poland, a split or division emerged within the Committee, followed by the formation of an independent organisation. As a result of the situation at hand, in February 1985 the Polish Committee of Special Olympics was established which was attached to the General Board of the Children's Friends Society. The creator and founder of the committee, as well as the honorary president of the Special Olympics Poland Association, established in the years that followed, was Dr. Jerzy Tyczyński. He himself was a father of a disabled child so his personal commitment certainly played an important role in the process of advancing the idea of Special Olympics in Poland. At the same time, Jerzy Tyczyński was first an active member of the Polish Association for Persons with Intellectual Disability, and in the years 1967 to 1979 he was the Chairman of the Board of the Warsaw branch of the association. He was inspired, among other things, by the swimming skills of Z. Dzierzbicka's daughter that he had the chance to watch during the summer camps, and made efforts to put a programme of swimming classes in place for people with intellectual disabilities living in Warsaw (Dzierzbicka, 2018).

Conclusions

The main objectives of the Special Olympics Committee were to provide those people with intellectual disabilities with access to sporting activities and to organise competitions that were in line with the principles and spirit of the global Special Olympics movement. Other goals were to promote physical culture among people with intellectual disabilities and to advance the global Special Olympics movement (Maszczak, 1994). The members of the Committee were the parents of children with disabilities: Wanda Bargielewicz, Michał Glajzer, Barbara Jaskierska, Andrzej Sekuradzki, Henryk Kudła, social activists from the sports community: Janusz Romanowicz, Jacek Żemantowski, activists working in government departments and agencies that supported children with disabilities: Wiesława Jelska, Daniela Mroczek. From that moment on, sport involving people with intellectual disabilities began to take off in Poland. Official sports rules, instructions, textbooks and training manuals were sent from Washington to be much welcomed in Polish special schools, schools of life skills, educational centres, residential care homes, and regional centres helping people with intellectual disabilities (Tyczyński, 1999). The establishment of a countrywide organisation operating as part of the wider international initiative put an end to the pioneering phase of the development of sport involving people with intellectual disabilities in Poland. As it was aptly summarised: "The Special Olympics movement very quickly earned the support of education and sports authorities and the hearts of influential figures from the world of politics, business and from the artistic circles. As a result, the Special Olympics movement quickly gained a foothold in Poland" (Zuber, Cieszewska, 2003).

It can be stated that the origins of sport involving people with intellectual disabilities in Poland date back to the 1960s. A significant role in the advancement of Special Olympics was initially played by the Children's Friends Society and the "Start" Sports Association. The activities undertaken by groups of parents of disabled children, who initiated and co-organized many sports competitions, proved a vital role in the advancement of disabled sports. In the 1980s, relations were established with the Special Olympics International in the USA, from where organisational and financial support was obtained. As a result, an opportunity emerged to join the international competition as part of the Special Olympics in 1983.

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NUTRITIONAL PROFILE AND OXIDATIVE STRESS IN ADOLESCENT SOCCER PLAYERS

Francine Milani Guissoni,[1, A, B, D] Rafael Deminice,[2, A, D] Paula Payão Ovidio,[1, B, D] Edson Zangiacomi Martinez,[3, C] Mirele S. Mialich,[1, A, B] Alceu Afonso Jordao[1, A, B, D, E]

[1] University of Sao Paulo (USP), Ribeirão Preto Medical School, Department of Health Sciences, Brazil
[2] State University of Londrina, Faculty of Physical Education and Sport, Department of Physical Education, Brazil
[3] University of Sao Paulo (USP), Ribeirão Preto Medical School, Department of Social Medicine, Brazil

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

Address for correspondence:
Alceu Afonso Jordao
University of Sao Paulo (USP), Ribeirão Preto Medical School, Department of Health Sciences
Avenida Bandeirantes 3900, 14049900, Ribeirão Preto/SP, Brazil
E-mail: alceu@fmrp.usp.br

Abstract High-intensity exercise increases reactive oxygen species formation, which in excess may cause oxidative stress. We assessed nutritional status and exercise-induced oxidative stress in 20 adolescent male soccer players (age: 15–17). Participants were divided into two teams for a 60-minute friendly match and evaluated immediately before (Pre-match), 30 minutes after (Post-match I) and 24 hours after (Post-match II) the game. All players recorded a 3-day dietary intake. Biochemical tests were performed for lipid profile, muscle damage (creatinine and creatinine kinase [CK]) and oxidative stress (thiobarbituric acid-reactive substances [TBARS], protein carbonyls [PC], reduced glutathione [GSH], and vitamins E, C, and A). CK and creatinine were significantly elevated at Post-match I ($p < 0.01$), returning to baseline at Post-match II. Vitamins E, C and A were significantly elevated at Post-match I ($p < 0.01$), but only vitamins E and A remained high at Post-match II. TBARS showed no significant changes. GSH showed a significant decrease ($p < 0.01$) and PC showed a slight but significant increase ($p < 0.01$) at Post-match II. The recruitment of non-enzymatic antioxidants prevented lipid peroxidation, but dietary and especially endogenous defence responses were insufficient to prevent protein oxidation. Proper nutrition is essential to improve the activity of the antioxidant defence system, preventing exercise-induced oxidative stress.

Key words adolescent, exercise, nutritional status, oxidative stress, soccer, football

Introduction

In recent years there has been growing interest in evaluating the physical, physiological and psychological characteristics of soccer players in order to contribute to the early identification of talented athletes (Nikolaidis, Vassilios Karydis, 2011; Tahara et al., 2006). There is no doubt that a diet tailored to suit the needs of players has a positive effect on their sports performance (Hernandez, Nahas, 2009; Karakilcik, Halat, Zerin, Celik, Nazligul, 2014; Eskici, 2016).

Overall, the rapid growth and development in adolescence cause an increase in energy and nutrient demand (Boisseau, Vermorel, Rance, Duché, Patureau-Mirand, 2007). As a result, adolescent athletes have special nutritional needs due to the additional demands associated with training and competition (Iglesias-Gutiérrez et al., 2005; Russell, Pennock, 2011; Karakilcik et al., 2014; Eskici, 2016). However, energetic and metabolic demands associated with soccer activities vary according to the level of competition and the individual characteristics of the players (González, Cobos, Molina, 2010; Nikolaidis, Vassilios Karydis, 2011).

The high-intensity training routine associated with non-oriented or bad eating habits may overwhelm the endogenous and exogenous antioxidant systems, causing oxidative stress (Bloomer, Goldfarb, McKenzie, 2006; Nieman, Bishop, 2006; Shing et al., 2007; Powers, Radak, Ji, 2016). Oxidative stress is associated with tissue inflammation, fatigue, muscle injury, impaired recovery after high-intensity exercise, and reduced immune function (Michailidis et al., 2007; Nieman, Bishop, 2006; Shing et al., 2007; Zanella, Souza, Godoy, 2007; Hadžović-Džuvo et al., 2014; Silva et al., 2014), all which may impair athlete performance. Indeed, a monitored and well-balanced diet will provide the antioxidants needed to battle oxidative stress induced by high-intensity training routine in athletes (Karakilcik et al., 2014; Eskici, 2016). It has been hypothesized that oxidative stress is responsible for increased muscle soreness and decreased strength at hours or days after exercise, even in athletes with a well-balanced diet. Despite this, the literature lacks studies that concomitantly evaluate nutritional status and exercise-induced oxidative stress, especially with regard to adolescent soccer players. This study aimed to assess nutritional status and exercise-induced oxidative stress in adolescent soccer players.

Methods

Participants

Twenty adolescent male soccer players aged 15 to 17 years were randomly selected from the under-17 category of a professional soccer club located in the city of Ribeirão Preto, state of São Paulo, south-eastern Brazil. All participants were non-smokers, had no history of alcohol consumption, had been playing soccer for at least 2 years (2.6 ±2.0 years), played in any position but goalkeeper, and were participating in the regular season league competition, with training sessions 5 days a week (mean of 4 hours daily) and at least one official game per week. The use of anti-inflammatory drugs or antioxidant supplements within 3 months prior to the study trial was an exclusion criterion.

The study was approved by the Research Ethics Committee of our institution and was conducted in accordance with the provisions of the Declaration of Helsinki. Written informed consent was obtained from all participants and their parents or legal guardians prior to their inclusion in the study.

Study trial

The players were randomly divided into two teams for a simulated match of 60 minutes in length, with no halftime interval. Two goalkeepers were asked to participate in the match, but they were not included in the study analysis due to the large difference in physical behaviour between goalkeepers and players in all other positions during a soccer match, which could invalidate our results. Participants were asked to refrain from high-intensity physical activities 48 hours prior to the game.

The match started at 3 pm at a temperature of 26°C and relative humidity around 55%. After approximately 30 minutes of playing time we collected 10-µL blood samples by index finger-prick from all players for measurement of blood lactate concentration (Accusport/Accutrend Lactate Analyzer; Boehringer Mannheim, Castle Hill, Australia) in order to determine exercise intensity during the match. Mean blood lactate concentration was 5.1 ±2.0 mmol/L, characterizing a game of moderate to high intensity effort.

In the week before the study trial, all athletes underwent anthropometric measurements and completed a food record at home for dietary assessment. Blood samples for biochemical analysis were collected at three time points: immediately before the start of the game (Pre-match); 30 minutes after the end of the game (Post-match I); and 24 hours after the end of the game (Post-match II).

Anthropometric assessment

Anthropometric measurements were performed using the techniques proposed by D.B. Jelliffe (1966). Percentage body fat (% BF) was estimated using the four skin-fold (triceps, subscapular, suprailiac, abdominal) equation proposed by Faulkner (1968). Body composition was also assessed by tetrapolar bioelectrical impedance analysis (BIA) (Biodynamics®, BIA 310E, Seattle, USA). Height was measured to the nearest 0.1 cm using a calibrated stadiometer (Alturaexata®, TBW, São Paulo, SP, Brazil), and weight was measured with a digital scale (Filizola®, São Paulo, SP, Brazil) to a precision of 50 g. Participants were measured and weighed barefoot and wearing their sporting gear. Body mass index (BMI) was calculated as weight (kg)/height $(m)^2$.

Dietary assessment

Three-day food records were completed by the participants in the week prior to the match on three alternate days (two weekdays and one weekend day) and were used to collect dietary data. The intakes of energy, macronutrients and antioxidant vitamins A, C and E were quantified using the NutWin® software (Universidade Federal de São Paulo/UNIFESP, São Paulo, SP, Brazil) and compared with the Dietary References Intakes (DRIs) and the nutrient intakes recommended by the Brazilian Society for Sports Medicine for healthy adult and adolescent athletes (Hernandez, Nahas, 2009).

Blood biochemistry

A 5 mL blood sample was collected at each time point (Pre-match, Post-match I, and Post-match II) by venipuncture into sterile vacuum tubes containing clot activator. The samples were centrifuged at 3,500 rpm for 10 minutes at room temperature. The supernatant (serum) was separated, transferred to an Eppendorf tube and stored at –30°C, and the pellet was discarded.

For lipid profile analysis, total cholesterol, triglyceride and high-density lipoprotein (HDL-c) concentrations were determined using commercial laboratory kits (Labtest®; Labtest Diagnóstica, Lagoa Santa, MG, Brazil). Low-density lipoprotein (LDL-c) concentration was calculated using the Friedewald equation for triglycerides <400 mg/dL: LDL-c = total cholesterol – HDL-c – triglycerides/5 (Santos et al., 2001).

For the assessment of muscle damage, creatinine and creatinine kinase (CK) levels were measured using commercial laboratory kits (Labtest®).

Several blood components were measured for the assessment of oxidative stress. Serum lipid peroxidation was quantified by TBARS and determined by colorimetric method, according to A.L. Spirlandeli, R. Deminice and

A.A. Jordao (2014). Protein Carbonils were determined according to R.L. Levine, J.A. Williams, E.R. Stadtman and E. Shacter (1994). Reduced glutathione (GSH) was measured using the method described by J. Sedlak and R.H. Lindsay (1968). Ascorbic acid was determined by colorimetric reaction with 2,4-DNPH, as previously described by O.A. Bessey (1960). Vitamin A and E concentrations were determined by high-performance liquid chromatography (Shimadzu Co., Kyoto, Japan) according to J. Arnaud, I. Fortis, S. Blachier, D. Kia and A. Favier (1991).

Statistical analysis

All results were expressed as mean with standard deviation. Because data related to biochemical variables were collected and analyzed at three different time points for each individual, comparisons of means over time were performed using linear regression mixed-effects models. The assumption of normality of residuals was verified graphically using a normal plot. Data showing atypical values were log transformed to achieve normal distribution and expressed as the geometric mean and standard deviation. Data were analysed using the statistical program SAS® version 9.0 (SAS Institute Inc., Cary, NC, USA). The level of significance was set at 5%.

Results

A total of 20 adolescent male soccer players participated in the study, mean age was 16.6 ±0.4 years. The athletes had a mean body weight of 66.7 ±7.4 kg, height of 1.70 ±0.1 m, and BMI of 21.9 ±1.5 kg/m^2, within the normal range for age. Both methods used to estimate % BF yielded similar results, 11.5% by the four-skin-fold predictive equation and 11.4% by BIA.

Dietary intake values of all participants and recommended ranges of calories, macronutrients and antioxidant vitamins are described in Table 1. The athletes had a mean energy intake of 37.6 kcal/kg, which is within the recommended dietary intake range. However, the distribution of macronutrients was unbalanced, showing a high-protein (1.62 g/kg), high-fat (1.12 g/kg), normal to low-carbohydrate (5.28 g/kg) diet. None of the athletes met the recommended daily intake levels for vitamins E and A, but 65% met the recommended dietary vitamin C intake (Table 1).

Table 1. Dietary intake of calories, macronutrients and antioxidant vitamins in adolescent male soccer players (n = 20)

Variables	Mean ±SD	Recommendations	Percent adequate athletes
Total calories (kcal)	2476.6 ±470.1	–	–
Calories/kg body weight	37.6 ±8.5	30–50 kcal/kg BW/day[a]	80
Proteins/BW (g/kg BW)	1.62 ±0.39	1.2–1.6 g/kg BW/day[a]	30
HBV proteins (%)	58.0 ±9.4	Minimum of 65% [b]	20
Carbohydrates/BW (g/kg BW)	5.28 ±1.38	5–8 g/kg BW/day[a]	45
Lipids/BW (g/kg BW)	1.12 ±0.28	1 g/kg BW/day[a]	40
Saturated fatty acid (%)	9.1 ±1.9	10%[a]	40
Monounsaturated fatty acid (%)	8.7 ±1.7	10%[a]	25
Polyunsaturated fatty acid (%)	4.4 ±0.8	10%[a]	0
Vitamin E (mg)	6.19 ±2.45	12 mg/day [c]	0
Vitamin C (mg)	261.08 ±496.06	63 mg/day [c]	65
Vitamin A (ug)	345.13 ±147.77	630 ug/day [d]	0

BW − body weight; HBV − high biological value; SD − standard deviation.

Source: [a] Hernandez, Nahas (2009); [b] Regulamento Técnico... (1998); [c] Estimated Average Requirement (2000); [d] Estimated Average Requirement (2001).

The variables analysed at the three experimental time points (Pre-match, Post-match I, and Post-match II) are compared in Table 2. The lipid profile showed no changes after match-induced physical stress. CK and creatinine levels were significantly elevated at Post-match I (34.4% and 25.4%, respectively) ($p < 0.01$), indicating muscle damage; however, these values returned to baseline at Post-match II. Vitamins A, C and E were also significantly elevated at Post-match I (26.3%, 8.6%, and 14.0%, respectively) ($p < 0.01$), but only vitamin E and A levels remained high at Post-match II. TBARS values showed no significant changes at any time point, which indicates the absence of lipid peroxidation. At Post-match II, while GSH levels showed a significant decrease (38.6%) ($p < 0.01$), PC levels showed a slight but significant increase (10.0%) ($p < 0.01$), indicating protein-induced oxidative stress (Table 2).

Table 2. Comparison of variables analysed in adolescent male soccer players (n = 20) at three different time points – immediately before the start of the game (Pre-match), 30 minutes after the end of the game (Post-match I), and 24 hours after the end of the game (Post-match II)

Variables	Pre-match (mean ±SD)	Post-match I (mean ±SD)	Post-match II (mean ±SD)	*p* (95% CI)
Total cholesterol (mg/dL)	137.85 ±23.59	142.35 ±24.13	139.1 ±23.1	0.08 (−0.5; 9.51)* 0.62 (−3.75; 6.26)† 0.20 (−8.26; 1.75)‡
LDL-c (mg/dL)	71.57 ±25.96	77.28 ±29.19	72.37 ±27.42	0.07 (−0.55; 11.98)* 0.80 (−5.47; 7.07)† 0.12 (−11.18; 1.35)‡
HDL-c (mg/dL)	45.83 ±10.17	47.03 ±13.65	49.05 ±13.82	0.90 (−3.28; 3.70)* 0.21 (−1.26; 5.72)† 0.25 (−1.47; 5.51)‡
Triglycerides (mg/dL)	97.27 ±27.39	90.18 ±28.44	88.41 ±21.26	0.20 (−18.18; 4.01)* 0.11 (−19.95; 2.24)† 0.75 (−12.87; 9.33)‡
CK (U/L)§	317.14 ±2.01	426.27 ±1.88	315.59 ±1.59	<0.01 (55.36; 170.68)* 0.94 (−41.38; 44.03)† <0.01 (−150.50; −65.13)‡
Creatinine (mg/dL)	1.10 ±0.20	1.38 ±0.17	1.08 ±0.15	<0.01 (0.16; 0.38)* 0.71 (−0.12; 0.08)† <0.01 (−0.40; −0.18)‡
GSH (µmol/gProt)	1.84 ±0.24	1.88 ±0.53	1.13 ±0.79	0.83 (−0.30; 0.37)* <0.01 (−1.05; −0.37)† <0.01 (−1.09; 0.41)‡
Vitamin E (µmol/L)	21.91 ±5.86	24.97 ±6.48	25.66 ±5.93	<0.01 (0.99;5.11)* <0.01 (1.68; 5.81)† 0.50 (−1.37; 2.75)‡
Vitamin C (mg/dL)	1.62 ±1.2	1.76 ±1.16	1.68 ±1.16	0.04 (0.005; 0.27)* 0.39 (−0.068; 0.19)† 0.21 (−0.20; 0.05)‡
Vitamin A (µmol/L)	2.66 ±0.48	3.36 ±0.75	3.13 ±0.65	<0.01 (0.45; 0.95)* <0.01 (0.22; 0.71)† 0.06 (−0.47; 0.01)‡
Protein carbonyl (nmol/mg/Prot)	0.10 ±0.02	0.10 ±0.01	0.11 ±0.01	0.76 (−0.008; 0.012)* <0.01 (0.007; 0.028)† <0.01 (0.005; 0.027)‡
TBARS (nmol/mg/Prot)	5.68 ±1.00	5.18 ±0.73	5.23 ±1.04	0.06 (−1.00; 0.01)* 0.08 (−0.96; 0.06)† 0.86 (−0.45; 0.55)‡

95% CI = 95% confidence interval; CK − creatinine kinase; GSH − reduced glutathione; HDL − high-density lipoprotein; LDL − low-density lipoprotein; SD − standard deviation; TBARS − thiobarbituric acid-reactive substances; * Pre × Post I; † Pre × Post II; ‡ Post I × Post II; § Data expressed as geometric mean ±SD.

Discussion

The main findings of the present study were 1) under-17 soccer players have imbalanced macronutrients and antioxidants intake; 2) imbalanced nutrition does not promote impaired circulating blood lipids; 3) however, imbalanced antioxidant intake may exacerbate oxidative stress induced by the training routine.

Although energy intake (37.6 kcal/kg) was within the recommended dietary intake range, there was an imbalanced distribution of macronutrients in the normal diet of players, which is consistent with data from literature reporting a high-protein, high-fat, normal to low carbohydrate diet in soccer players (Iglesias-Gutiérrez et al., 2012; Maughan, Bartagi, Dvorak, Zerguini, 2008; Russell, Pennock, 2011; Galanti et al. 2014). This is a common behaviour among athletes in several sports, including soccer, who attach great importance to proteins and are unaware or disregard the important contribution of carbohydrate intake to sports performance. Conversely, circulating lipids at a normal level were demonstrated in our athletes (Table 2). This seems paradoxical since imbalanced nutrition, especially a high-protein, high-fat diet, may cause elevated circulating triglycerides and cholesterol. Indeed, young athletes have an exercise routine intensity that may control elevated circulating lipids. It may reflect, however, in decreased training performance in the present and future unhealthy perspectives.

None of the players met the recommended daily intake levels for vitamins A and E, but 65% met those for vitamin C. Similar to our study, Y. Noda et al. (2009), analysing nutrient intake in male collegiate soccer players, found that their mean intakes of calcium, magnesium, vitamin A, B1, B2, and C were lower than the recommended dietary allowances. In contrast, M. Russell and A. Pennock (2011), in a study of young professional male soccer players, found an adequate intake of almost all nutrients (including vitamins), except for potassium. Several immune processes require the presence of these micronutrients (Hespel, Maughan, Greenhaff, 2006; Nieman, Bishop, 2006), especially when it comes to adolescent players subjected to physical stress. It is widely known that adolescents consume fewer fruits and vegetables, foods rich in these vitamins. This reinforces the importance of the presence of a nutritionist working together with the coaching staff, especially in youth soccer teams.

Vitamins E and A behaved similarly, increasing at Post-match I and remaining elevated at Post-match II, whereas vitamin C had a slight but significant increase at Post-match I, returning to nearly baseline levels at Post-match II. The behaviour of vitamins indicates an acute recruitment of dietary antioxidants after the game, contributing to prevent lipid peroxidation (Roehrs et al., 2009). M. Roehrs et al. (2009), evaluating the influence of plasma retinol levels on oxidative stress biomarkers in haemodialysis patients, found a positive correlation between retinol and MDA. That is, increased blood retinol was directly associated with lipid peroxidation in their patients, which did not occur in the present study, since TBARS, a biomarker of lipid peroxidation, decreased even in the presence of increased vitamin A after the game. In our study, however, the vitamins failed to prevent protein-induced oxidative stress, since PC levels were elevated 24 hours after the game and GSH levels were consequently reduced at this same time point. H. Andersson, A. Karlsen, R. Blomhoff, T. Raastad, and F. Kadi (2010) and P. Tauler et al. (2008) observed an increase in ascorbic acid after a soccer match, compared to baseline levels. However, C.C. Zoppi et al. (2006), investigating antioxidant supplementation, reported that vitamin C and E supplementation produced no effects on the activity of antioxidant enzymes in adolescent soccer players. Thus, literature remains controversial regarding the behaviour of antioxidant vitamins.

The increase in CK levels immediately after the game, together with elevated protein carbonyls and decreased GSH suggests the occurrence of muscle damage and oxidative stress during the match, which is in agreement with observations already reported (Fatouros et al., 2010; Gravina, Ruiz, Lekue, Irazusta, Gil, 2011; Ascensão et al.,

2008). In the study by I.G. Fatouros et al. (2010), CK levels increased significantly after a soccer game, but unlike our players whose levels returned to baseline after 24 hours, CK remained elevated after 48 hours. These authors also demonstrated elevated oxidative stress markers and reduced GSH 24 hours after a soccer match. Another study also observed a decrease in GSH Levels (Mello et al. 2017).

A. Ascensão et al. (2008) demonstrated a soccer match increases the levels of oxidative stress and muscle damage throughout the 72-h recovery period and concluded that redox alterations induced by a soccer match is associated with muscle dysfunction and performance loss. However, studies analysing the effects of nutritional supplementation in soccer players demonstrated antioxidant vitamins promoted a lower increase in CK levels compared to the control group (no supplementation) without performance enhances (Arent, Pellegrino, Williams, Difabio, Greenwood, 2010; Zoppi et al., 2006). In the present study, none of the athletes was receiving dietary supplementation. Another study with football players demonstrated that antioxidant supplementation with vitamin C and E does not attenuate elevated markers of muscle damage but did reduce oxidative stress (de Oliveira, Rosa, Simões-Ambrósio, Jordao, Deminice, 2019).

Micronutrient supplementation is still controversial, but the consumption of a diverse well-balanced diet is a concept that remains largely valid and fully applicable, which may be sufficient to maintain the micronutrient levels required by physical exercise without the need for supplementation. The playing position of the athlete influenced the length of oxidative stress, inflammation and muscle damage markers after an official soccer game (Souglis, Bogdanis, Chryssanthopoulos, Apostolidis, Geladas, 2018), but as this influence was not measured in the actual study, future studies can consider this information.

Conclusion

The present results indicate that the recruitment of non-enzymatic antioxidants, mainly dietary antioxidant vitamins, prevented the occurrence of lipid peroxidation. However, dietary and especially endogenous defence responses were insufficient to prevent protein oxidation. These findings highlight the importance of proper nutrition in sports in order to improve the activity of the antioxidant defence system and hence the metabolic response, thus preventing exercise-induced oxidative stress. We suggest the implementation of nutrition education programs tailored to adolescent soccer players, including nutritional intervention and follow-up, targeting well-balanced food intake that can help counterbalance excessive damage caused by chronic physical exercise.

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OCCURRENCE AND DEGREE OF ILIOPSOAS MUSCLE CONTRACTURE IN REGULAR MALE SQUASH PLAYERS

Bartosz Trybulec,[1, A, C, D] Grzegorz Liput,[2, A, B] Marta Barłowska-Trybulec[3, D]

[1] Jagiellonian University Medical College, Faculty of Health Sciences, Department of Physiotherapy, Institute of Physiotherapy, Kraków, Poland
[2] Graduate of Physiotherapy, Jagiellonian University Medical College, Faculty of Health Sciences, Kraków, Poland
[3] Jagiellonian University Medical College, Faculty of Health Sciences, Department of Medical Physiology, Institute of Physiotherapy, Kraków, Poland

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

Address for correspondence:
Bartosz Trybulec
Jagiellonian University Medical College, Institute of Physiotherapy
Medyczna 9, 30-688 Kraków, Poland
E-mail: bartosz.trybulec@uj.edu.pl

Abstract **Introduction:** Sprints combined with changes in direction and repeated lunges are the most frequent movements during a squash game. These motions overload the iliopsoas muscle which may cause a lot of microinjuries. Accumulating microinjuries combined with a lack of stretching exercises may lead to iliopsoas contracture.

Aim of the study: Assessment of the frequency and degree of iliopsoas contracture in regular squash players.

Material and methods: The experimental group comprised 25 regular squash players (minimum 2 years of playing at least twice a week) and 21 non-players (control group). A modified Thomas Test was used to assess iliopsoas contracture using goniometric and linear measurements.

Results: Iliopsoas contracture was observed in 96% of the squash players and 66.7% of the non-players ($p = 0.0089$). The degree of muscle contracture in the goniometric measurement was greater in squash players than in the non-players in both the left ($p = 0.0303$) and right ($p = 0.0007$) iliopsoas muscles. There were no statistically significant differences in the linear measurement.

Conclusions: There is a positive relationship between regularly playing squash and the frequency of iliopsoas contracture occurrence being significantly greater in squash players than in non-players.

Key words squash, iliopsoas, contracture, modified Thomas test

Introduction

Squash is a racquet sport played by two players on a court surrounded by walls on four sides, using a hollow rubber ball. The ball is hit by the players alternately using a racquet. The ball can bounce once on the floor and any number of times from the court walls. The main strategy of a squash player is to force the opponent to move around

the entire area to be played. If this strategy is successfully implemented, the opponent travels a greater distance and subjects the body to a greater load (Vuckovic, Dezman, Erculj, Kovacic, Pers, 2011).

According to C. Eubank and N. Messenger (2000), squash players perform an average of 2,866 steps per match (580 steps per set). 74.4% of them contain a flight phase. This indicates that the game is very dynamic. Performing such intensive work can result in increased muscle stiffness and can lead to contracture. However, this is not a physiological adaptation, because adequate flexibility is an innate property of the tissues of the myofascial system, determining the normal range of motion and thus the functioning of the joints and the entire limb (Thacker, Gilchrist, Stroup, Kimsey, 2004).

Commonly performed movements in squash are the lunge and sprint. Repeated executions burden the iliopsoas muscle. Repetitive eccentric work changes the movement pattern and increases muscle stiffness. According to E.P. Roetert, T.S. Ellenbecker and S.W. Brown (2020), these are early adaptations that appear in regular players before the onset of clinical symptoms.

Imbalance between the iliopsoas and glutei muscles can contribute to an increase in the load on the front of the hip. In this way, the anterior glide of the femoral head increases, due to reduced exploitation of the gluteal muscles during hip extension and the iliopsoas muscle during flexion. It is likely that the increase in forces acting on the front of the hip is caused by an increase in the frontal slip. This subtle instability, together with placing the hip in an upright position, can cause serious injuries such as detachment of the labrum. Based on the above information it is assumed that an appropriate distribution of forces on the hip joint can ensure coordination and elasticity of the iliopsoas and gluteus maximus, thanks to which the right strength for the hip movements and the correct position of the joint can be obtained (Lewis, Sahrmann, Moran, 2007; Shindle, Ranawat, Kelly, 2006; Carlos, Guanche, Robby, Sikka, 2005).

A squash player is subjected to a variety loads during a match. Game strategy demands specific body positions to make it easier to cope with this task. The hip, knee and ankle joints during a lunge (fundamental position in squash) are in a flexion position (Gyoung-Mo, Sung-Min, 2015) (Figure 1). The aim of this study was to assess the incidence and degree of iliopsoas muscle contracture in regular squash players.

Figure 1. Lunge – main position for receiving the ball in the squash

Material and methods

The study consisted of 54 men, recruited personally by the authors and through social media, comprising 32 squash players and 22 non-players. At the outset, an original questionnaire was completed by each participant that contained questions about age, weight and height, the frequency of squash trainings, and the possible presence of specific exclusion criteria. The criteria for joining the study group was at least 2 years of practicing squash and a frequency of at least 2 trainings a week. The exclusion criteria were:

1. For the study group:
   - squash playing period <2 years,
   - number of trainings ≤2 per week,
   - iliopsoas muscle/hip region injuries in the past,
   - age <18 or >40 years.
2. For the control group:
   - practicing squash,
   - doing sports requiring intensive usage of the iliopsoas muscle,
   - iliopsoas muscle/hip region injury in the past,
   - age <18 or >40 years old.

Ultimately, the study group consisted of 25 squash players, and 21 non-players in the control group. In the study group the average age was 28.8 years, average body height was 179.8 cm and average body weight was 77.9 kg. In the control group the average age was 25.1 years, average body height was 177.2 cm and average body weight was 76.5 kg (Table 1).

Table 1. Descriptive statistics of somatic parameters in both study groups

Parameter	Squash group (n = 25)				p	Control group (n = 21)			
	mean	SD	Min	Max		mean	SD	Min	Max
Body weight (kg)	77.80	7.56	66	92	0.5723	76.5	9.20	59	100
Body height (cm)	179.80	4.85	168	190	0.0674	177.2	4.48	170	185
Age (yrs)	28.84	6.32	19	40	0.0796	25.1	4.90	20	36

The functional measurement comprised a modified Thomas test (Figures 2 and 3) in a supine position on a table, and in the case of a positive result, a goniometric and linear measurement of the degree of iliopsoas muscle contracture (Wakefield, Halls, Difilippo, Cottrell, 2015; Whiting, Zernicke, 2008). The test consisted of lifting the knee to the chest until the lumbar lordosis was compensated. The test result was considered positive when the thigh of resting leg was lifted above the table surface. In this case, the angular measurement between the thigh axis and the table plane was taken assuming the greater trochanter as the axis of the rotation (Figure 2) and the measurement of the distance between the thigh and the table plane at the level of the lateral epicondyle of the femur (Figure 3).

Figure 2. Modified Thomas test: goniometric measurement

Figure 3. Modified Thomas test: tape measurement

Statistical data analysis of the obtained results was carried out using STATISTICA v.12.0 software (StatSoft Inc.). Compatibility of variable distribution with a normal distribution was tested using the Shapiro-Wilk test. To compare the means of the independent variables, Student's t-test and Mann-Whitney U tests were used, and to assess differences in the occurrence of contracture in both study groups a Chi Square test was used. The results were considered significant at $p < 0.05$.

Results

In the study group, iliopsoas muscle contracture was observed in 24 of the 25 squash players (in 20 of them bilaterally). In the control group contracture was noticed in 14 of the 21 men (bilaterally in 10 of them). After analysis using the Chi Square test, a statistically significant relationship was stated between playing squash and the occurrence of iliopsoas muscle contracture ($p = 0.0089$) (Table 2).

Table 2. Distribution of the frequency of contracture in the study and control groups

Groups	Contracture	N	Percent
Study group	no	1	4.0
	yes	24	96.0
Control group	no	7	33.3
	yes	14	66.7
Chi Square test = 6.84; p = 0.0089			

Table 3 presents a comparison of the degrees of iliopsoas muscle contracture in both groups. Analysis by Student's t-test (Left [deg] and Right [cm] measurement) and Mann-Whitney U test (Right [deg] and Left [cm] measurement) showed a statistical significance for differences between angular measurements (p = 0.0303 for the left lower limb, 0.0007 for the right lower limb).

Table 3. Comparison of the degree of iliopsoas muscle contracture for lower limbs in both study groups in the goniometric (deg) and linear (cm) tests

Limb	Study group (n = 24)				p	Control group (n = 14)			
	$\bar{x}$	SD	Me	Max		$\bar{x}$	SD	Me	Max
Left (deg)	11.45	6.21	13.00	20	**0.0303** (t)	7.07	4.94	7.50	15
Left (cm)	3.52	2.98	4.50	9	0.9881 (U)	3.68	3.47	3.25	12
Right (deg)	11.08	5.61	10.00	20	**0.0007** (U)	5.29	3.87	5.50	14
Right (cm)	4.18	3.25	4.75	12	0.1933 (t)	2.86	2.44	2.50	7

$\bar{x}$ – mean, SD – standard deviation, Me – median, t – t-Student test, U – Mann-Whitney test, p – level of significance.

Discussion

This research is pioneering as no publication available to date have addressed the topic of iliopsoas muscle contracture in squash players. While publications related to other racquet sports exist, such as in tennis and badminton, they can be considered an important element of this discussion due to the lack of published research on squash (Young et al., 2014; Kovacs, 2006; Girard et al., 2007; Ellenbecker et al., 2007).

The incidence of iliopsoas muscle contracture was investigated in both study groups and a statistically significant (p = 0.0089) difference found between the 96.3% of the squash players and 66.7% of the non-players with this condition. These results differed from those obtained by S.W. Young et al. (2014) who examined 125 professional tennis players using the Thomas test and found contracture of the iliopsoas muscle in 51% of the players. In addition, the positive result of the hip flexor test was significantly correlated with abdominal muscle overload in female players (Young et al., 2014). Results of the study conducted by W.B. Kibler and T.J. Chandler (2003) showed that the myofascial system in women is more flexible than in men. Thus, iliopsoas muscle contracture may be more common in male squash players than in tennis players. The techniques of squash require the lunge, while in tennis this is almost absent. The eccentric work generated during the lunge is a significant burden on the lower limb, especially for the iliopsoas muscle. Thus, contracture may occur more often in squash players. Another difference between these sports is the different dynamics of the game of squash (Kovacs, 2006; Girard et al., 2007).

The occurrence of iliopsoas muscle contracture in squash players as well as in other sports (tennis, handball, volleyball, golf, swimming, gymnastics, dancing, judo, weightlifting, and even motocross) may be related to the theory of microtrauma summation. This mechanism may lead to the appearance of musculoskeletal disorders: trauma from overload (e.g. fatigue fracture) or chronic soft tissue rheumatism (e.g. tennis elbow, iliac-lumbar muscle tendonitis). Micro-injuries arising in muscles as a result of repetitive eccentric work can lead to muscle contracture and consequently, to an increase in the incidence of serious injuries (Roetert et al., 2020; Ho, Lee, Chang, Chen, Huang, 2020; Kajetanek et al., 2016; Russel, Wiese-Bjornstal, 2015; Doyscher, Kraus, Finke, Scheibel, 2014; Váczi, Rácz, Hortobágyi, Tihanyi, 2013).

On the basis of the results of this study, a significant reduction in iliopsoas muscle function was observed in the form of contracture occurring in regular squash players. It can therefore be assumed that functional changes should also be observed at the structural level. This conclusion is not confirmed by the results obtained by G. Nketiah et al. (2015) who assessed the condition of the iliopsoas muscle in squash players using magnetic resonance imaging. The results showed that there are no significant structural differences between squash players and the control group. This is probably due to the lack of exact criteria for inclusion in the study group (e.g. a minimum of 2 years of squash, at least 2 times a week) or the small sample of 10 patients. Confirmation of the presence of structural changes requires further research.

In this study, goniometric and linear measurements were used to assess the degree of iliopsoas muscle contracture in both sides. This course of research was intended to check for possible convergence of these types of measurements. Statistical analysis showed a significant difference between the degree of contracture in the goniometric measurement in both the left ($p = 0.0303$) and right lower limbs between the test group and the control group ($p = 0.0007$). In turn, statistical analysis of linear measurements did not show significant differences in contracture between the groups. This discrepancy in the results may be caused by the methodology of the goniometric and linear measurements. The goniometer has a larger span scale, so the relative approximation error during measurement may be smaller with a higher measurement compliance factor. Another factor that can affect the measurement results is how the test was designed. Goniometric measurement was performed first. It is therefore possible that the iliopsoas muscle during the goniometric measurement was stretched, which could increase the range of hip joint motion affecting the result of the linear measurement (Young et al., 2014).

Our study has certain limitations that may significantly affect the results. The modified Thomas test has many variables that can distort the result or completely prevent a performance, such as: motion of the lumbar spine, forward or backward tilt of the pelvis, the ability to bend the hip and knee joint, waist circumference, thigh circumference. The factor that most often disturbs the test result is the mobility of the lumbar-pelvic complex. Pelvic inclination can make up for the lack of hip extension and thus compensate for flexion contracture. Thus, the modified Thomas test (MTT) used to investigate iliopsoas muscle contracture may not give reliable results (Vigotsky et al., 2016). Despite the fact that MTT is widely used in orthopedic and physiotherapeutic practice, it shows little credibility if the movement of the lumbar-pelvic complex is not controlled. Proper pelvic stabilization is therefore a key factor for MTT reliability, and this largely depends on the experience of the examiner. The universality of using MTT in clinical practice has been justified in previous studies showing a high consistency between the researchers, between 95% and 97.6%. The above information allows us to assume that a correctly performed MTT is a reliable for assessing iliopsoas muscle contracture (Ferber, Kendall, McElroy, 2010).

Another limitation is the relatively small size of both study groups. For a larger number of subjects, it would be possible to use more accurate parametric tests in place of the non-parametric Mann-Whitney U test. There is also the chance that a larger number of groups would result in a greater similarity and thus a greater reliability in the results (Jones, Carley, Harrison, 2003).

The study showed a significantly higher incidence and degree of iliopsoas muscle contracture in squash players compared to the non-players. Therefore, it is worth paying attention to the prevention of this unfavorable compensation in the context of reducing the risk of sport injuries (Jones, Carley, Harrison, 2003). Creating appropriate prevention programs may contribute to minimizing this risk and protect squash players from injuries (Ellenbecker et al., 2007).

Conclusions

1. Contraction of the iliopsoas muscle occurs significantly more frequently in men regularly practicing squash than in non-players.
2. The degree of iliopsoas muscle contracture in men regularly practicing squash is significantly higher than in the non-players, indicating a lack of targeted stretching exercises to alleviate this condition.
3. Further research is needed on the specific impact of squash on the musculoskeletal system, taking into account more factors and using specialized measuring equipment.

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ONLINE COACH DEVELOPMENT AND CERTIFICATION PROGRAMS IN SPORTS: ARE THEY POSSIBLE?

Konstantinos G. Papageorgiou

Department of Informatics, Ionian University, Corfu, Greece

Address for correspondence:
Konstantinos G. Papageorgiou
Department of Informatics, Ionian University, Corfu, Greece
7 Tsirigoni Square Corfu, 49100
E-mail: cconstantinoss@gmail.com

Abstract Anticipating the inevitable shift of coach education and Coach Certification Programs (CCP) to distance-learning platforms in the imminent future, I have attempted to identify obstacles that we are likely to face. After explaining the rationale and the potential benefits of such courses, I have identified technique as the most difficult component to both teach and evaluate. A specific viewpoint regarding technique is briefly discussed and several related guidelines are provided to assist in both teaching (coach education) and evaluating technique (CCP) within the context of distance education.

Key words online learning, distance education, tennis, distal method, technique

Introduction

The current coronavirus (COVID-19) pandemic has hit hard and it is expected that there will be a post-COVID-19 era. The quarantine-measures, lockdowns, and "social distancing" in many countries will have a lasting effect on our psychology. The impact on the economy, public health, and education will be no less significant; global economic recession seems inevitable; stress, reduced physical activity and lockdowns make up an explosive cocktail contributing to domestic violence and even murders, suicides, increased mortality rates from cardiovascular diseases. In light of these changes, online learning has become the new normal, and will be our focus here.

As online learning is definitely on the rise (Zheng, Lin, Kwon, 2020), we must ask: can we provide online certification programs to coaches? The author is currently working towards that goal; a goal that seems unavoidable, "because it crossed our minds". Let me explain myself: in Dürrenmatt's "Die Physiker", at some point, the "crazy scientist" of the play, Fräulein Doktor Mathilde von Zahnd, expresses a big truth about whatever is thinkable "weil es Denktbar ist".[1] Because something is thinkable, we have a moral responsibility towards its potential to become

[1] "Er versuchte zu verschweigen, was nicht verschwiegen werden konnte. Denn was ihm offenbart worden war, ist kein Geheimnis. *Weil es denkbar ist*", meaning: "He tried to conceal what could not be kept concealed. Because what was revealed to him

a reality. If something is thinkable, Fräulein Doktor Mathilde von Zahnd argues, it is the same as if it were already real. In light of that, it seems unavoidable that online certification programs for sports will become a reality in an era that "the impossible becomes a reality". The COVID-19 pandemic seems to have simply accelerated the inevitable (in my opinion there will be a demand for such programs) and so in this article I will examine how such a thing might be possible, despite the obvious restrictions.

Firstly, I will examine the differences between certification programs and coach development. The Coaching Association of Canada (CAC) distinguishes three levels on their webpage (Lifelong Learning Definitions, 10.04.2020):

- in training: a coach has completed some of the required training for a context,
- trained: a coach has completed all required training for a context,
- certified: a coach has completed all evaluation requirements for a context.

Being trained or "developed" is to be educated, while being certified means that one has been evaluated based on a *curriculum* and therefore able to demonstrate mastery in areas such as "program design, practice planning, performance analysis, program management, ethical coaching, support to participants during training, and support to participants in competition" (McQuade, 2020, p. 200). CCP are not there to develop coaches but to verify the success of a coaching development program – hence education and certification organizations are different entities. So, while coach development provides coaching skills, coach certification provides social credibility. In practice, "coach development" and "CCP" are almost interchangeable.

Certification standards and requirements

The many problems of coach certification date back to the 50's and are relevant even now (Schweitzer, 1989). Related issues are:

1. The supply-demand conflict.
2. Difference in requirements.
3. Bridging the gap between theory and practice.
4. Expertise models.
5. Social stereotypes.

The ebb and flow of certification requirements are driven by this supply and demand conflict. A lack of available trainers loosens even State standards; for example, Greek sports federations may provide fast-paced development-certification programs in specific sports – usually when there is a lack of trainers. In the year 2000, when the standard for a state license was a BA (Hons) in sports science, the federation was keen to establish seminars that provided a state license in two weeks and again in 2018, where the duration was a month. However, this is neither a Greek phenomenon nor a new one (Sabock, 1981).

This problem is further magnified by differing requirements, not only among distant parts of the world, but also adjacent states and even within states over short periods of time. An official certification from the same organization one year later may become unofficial (as is the case with the special-needs education seminars in Greece). Certification business around the globe are not always consistent – at least in tennis.

Do universities contribute to the structure of such programs? As was already identified by C. Schweitzer (1989), scholarly knowledge must be reflected in the certification program structure. However, an additional obstacle

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is no secret. Because it is *conceivable*". Dürrenmatt, 1961.

is the gap between educators and "scientists" (Cain, 2015; McIntyre, 2005) – it is not just about knowledge, but also about what is considered "relevant" to the coaches and their every-day practice sessions. That issue is also due to the social pressure driven by stereotypes: a successful athlete **must be** a successful coach. Especially in tennis, where the playing skills of the coach are considered essential, and expertise in receiving and providing training are considered one and the same. Elsewhere, I support that this is also due to the wrong type of expertise that coaches have (there is not just one type of expertise!). There is the classic dichotomy between the contributory and the interactional expert (Collins, Evans, 2007). A good athlete (a contributory motor expert) is just an interactional expert in sports science. This is a distinction we must not forget when choosing or educating any kind of expert. Besides that, I have introduced a new demarcation criterion, that of the methodological scope of expertise. This leads to contributory expert generalists in sports (the Secondary Synthetic Coach Model) that have a broad understanding (**surveillance** is the technical term) of the entire evolution of athletes (Papageorgiou, 2020a). Certifications should be developed in such a way that this kind of difference is taken into account and adequately tested (cf. the Turing test-like procedures in H.M. Collins, Evans, 2002).

Online courses & Coaching Certification Programs (CCP's)

CCP's offer a variety of benefits to coaches:

- improved game strategy and technical efficacy of certified coaches (Kai-Sim Lee, Malete, Feltz, 2002),
- increased confidence level of CCP participants (Campbell, Sullivan, 2005),
- effective theoretical and practical knowledge acquisition (Haslam, 1990),
- improved performance of athletes when trained by certified coaches (Misener, Danylchuk, 2009).

For coaches these four characteristics are the most valuable: (a) the structure of the program must have a logical, sequential and comfortable format; (b) pedagogical knowledge should be taught to the participants and modeled by the program facilitators; (c) knowledgeable program facilitators providing relevant content knowledge are essential; and (d) an introduction to, and integration of, pertinent research in sport pedagogy and subject matter content must be apparent (Mccullick, Belcher, Schempp, 2005).

All in all, a CCP should be:

- **empowering** for its participants,
- **effective** via the tools it provides,
- **holistic** by addressing all the developmental parameters (physical, mental),
- **balanced** as far as theory and practice are concerned,
- **enriched** providing many approaches to address each issue.

Note: it is evident that CCP and coach development programs are not really separated in both literature and practice. Usually, an online course also offers quizzes, assignments, or some form of additional final examination leading to certification. This implicit convention is also used here (while trying to also refer to their differences).

In principle, the aforementioned characteristics are achievable through an online course. There is a great scarcity of online coach development programs and only a few references, e.g. the use of videos for coaching-skills development of university students (Born, Nguyen, Grambow, Meffert, Vogt, 2018). Other fields have greatly benefited from such online courses. Health sciences offer a good reference point for sports since they too combine theory and practice. Nurses and other health professionals may improve their clinical practice using such online courses (Brooks et al., 2020; Ortega-Morán et al., 2020). Platforms, such as Edx, are full of certification courses

for both students and the general public. While certification courses for sports are not yet widespread, courses for biomechanics, sports statistical analysis, anatomy, physiology and the like already exist on numerous platforms.

Potential benefits of the era of online CCP include:

– better access to knowledge in distant parts of the world,
– better communication among coaches located in distant parts of the world,
– reduced cost of acquiring knowledge and skills,
– development of higher coaching standards, provided quality prevails over quantity,
– increased physical literacy.

Whether a platform offers just coach development, coach certification, or both, the central question remains: What cannot these online platforms provide? Playing skills seem to be the one thing online courses may have a difficulty in providing to coaches – or, worse still, to evaluate and certify.

Developing and evaluating sports skills

Recently I have launched an online coach development program for tennis called the Distal Method Coach Development (DMCD – Papageorgiou, 2020a). While much of its *curriculum* can be conveyed online, what happens with the biomechanical model, i.e. its presentation and the evaluation of the coaches' understanding of it? Not their theoretical understanding, but their ability to **perform** and **teach** the skills.

For years people have been learning motor skills by watching videotapes (for example, N. Bollettieri's "[tennis] Stroke Instruction Series" from the '90s or the even older videotapes of M. Saito's instructional Aikido videotapes). More recently, YouTube videos with technical explanations and learning tips have also become popular. Slow motion videos of professional players, views from different angles, diagrams, players' comparisons etc. all are being utilized to "teach" skills and technique visually. No formal evaluation of these methods has taken place, even though the literature regarding various forms of feedback and video-feedback is huge (however, video-feedback is used on-site, not as a means of distance learning).

To approach the problem of conveying and evaluating skills in distance learning, I will break the question into three components.

How do we learn a technique?

Everything starts at the neurophysiological level of our monkey neurons (Rizzolatti, Fadiga, Gallese, Fogassi, 1996; Terrace, 2001). Humans have an amazing inherent ability to copy what we see. This is why I advise former players who are poor coaches to stop giving directions to children and instead **show** them the moves. Typically, what they do is different from what they say, usually because they simply do not really know what it is that they themselves do (and usually what they do is less ugly than what they say). At the level of instruction, one may use **reference points** or "snapshots" of static positions that are simple and universal. For example, the "readiness position", where the arm is fully extended backwards, the elbow is fully supinated and the wrist fully extended. Such reference points can be checked by the player either through vision, proprioception (internal bodily feeling) or both.

For our next step we must differentiate between **sensation**, **feeling**, technical model (*technique*), technical **form** – our goal for coach online development – and technical **style** – the athlete's long-term goal (see also Papageorgiou, 2020b). A quintuple distinction **not** made in the relevant literature:

– sensation: the universal haptic feedback,

– feeling: the personal psychosomatic imprint of a specific set of body sensations,
– technique: the universal abstract technical model,
– form: the adaptation of the technique to human bodies,
– style: the long-term unique, personal, and effortless adaptation of form to the specifics of our own bodies.

Note: it is also valid for our model to include **emotions** as the next step after feelings. However, emotions need extended practice (at another level also), whereas feeling is quicker and can lead us directly to the form.

The form is preceded by the **feeling** and feelings are preceded by **sensation**. The external study of form as kinesiology does not concern the players themselves. For the players what matters is what they sense, what they feel and what they feel about it. Every form has a different sensation on our body and also feels different – many martial artists use the word "taste" to describe this – i.e. every form has a different **taste**. This is another reason why we should consciously practice our skill to observe our body. In any case, the coach tries to teach the athlete, to train them (to addict them in a sense) to a certain body sensation which, of course, for the literature translates into a biomechanical model. The body, however, is not programmable with biomechanical data: it needs kinesthetic integration, a process that creates specific feelings. Feelings themselves, either separately or in combination with each other, also produce, or bring to the surface, **emotions**. For this reason, the element of aesthetic experience, **art**, is inherent in motor skills-training. This is the reason why e.g. theatrical pedagogy is so important in the development of the athletes.

Now, if we include tactics, a certain **learning hierarchy** emerges: feeling is first, followed by form (second), followed by tactics (third). The reverse hierarchy applies to competition: there, tactics dictate the technique to be used which we express as a certain form by consciously accessing the respecting feeling through a connection we have been building for years during practice sessions. In competition, if form becomes a priority over tactics – due for example to injury or lack of skill – then we necessarily have a limitation of our possible tactical choices.

How do we convey the procedural knowledge of a skill in distance learning?

We should understand firstly what we want to do. Our target group is coaches, not players. Therefore, we do not want to develop contributory motor experts (competitive players) but interactional motor experts (coaches capable of demonstrating proper form); we do not want to develop interactional expert coaches (ex-players who know a thing or two about training), but contributory expert coaches (specialists or generalists). Our target group should not expect to learn how to win tournaments, but how to acquire the basic technical form and demonstrate it to learners in non-competitive conditions. We want to develop minimally competent tennis coaches in the DMCD technical model, which means that they are already at least minimally competent as players.

In order to effectively convey the procedural part of the form we should:

1. Use videos where the form is demonstrated from various angles.
2. Always refer to the sense of the form.
3. Provide reference points.

Taken together, these three points should solve the issue of communicating procedural knowledge in distance learning. Another parameter that is important for the success of both online teaching techniques and the other parts of the course is the existence of a community. Online learning built around an active and engaged community is more likely to achieve its goals (Jia et al., 2019).

How do we evaluate the procedural knowledge of coaches in CCP?

There are many instances where athletes (motor experts) are formally evaluated at a distance. Martial artists performing a Kata, dancers, pilots. Obviously, informal evaluations are everywhere in sports: TV and radio commentators discuss technique and tactics, YouTube channels analyze and evaluate strokes, websites host numerous presentations of athletes' technique etc.

To automate such a procedure, one might look to Artificial Intelligence programs (expert systems) detecting movement in real-time. Technically this is possible but the cost, for the time being, is too high. For now, the simplest way to do such an evaluation is through a webinar or video-call – where not only can technique be evaluated, but micro-corrections can be fed back, too.

It seems that certifying coaches should include at least one such session. Mobile phones have made it possible to live-stream directly from a tennis court and I suggest online CCP should include at least one webinar session. I am against fully automated certification procedures.

If the aforementioned guidelines are followed, both online coach development and online CCP may be successfully implemented.

Conclusions

The inevitable shift to online training and certification in the next few years should find us open and ready to embrace its many potential benefits. The potential obstacle identified was the communication and the evaluation of the technical part through an online course. The solutions identified were:

1. Use of videos.
2. Sense-anchors.
3. Reference points.
4. Live webinars (evaluation).

Limitations: we have not touched the issue of the structure of courses or the structure of the platform that best serves such an online learning program. We have not referred to the need for periodic re-evaluations.

Future directions: what about the future? As far as the courses are concerned, we should expect to eventually see augmented reality training systems integrating expert systems. Technical and tactical learning and evaluation will become automated. So, what about the broader picture? Unfortunately, this may not be the last lockdown we experience. Experts in infectious disease have long warned that we might face such a pandemic and warn that we might face one again. For us, the best practice is to **be prepared**.

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TOKYO 2020. OLYMPIC AND PARALYMPIC QUALIFICATIONS OF STUDENTS, GRADUATES AND EMPLOYEES OF THE UNIVERSITY OF SZCZECIN

Jerzy Eider

University of Szczecin, Faculty of Health and Physical Education, Institute of Physical Culture Sciences, Poland

Address for correspondence:
Jerzy Eider
University of Szczecin, Faculty of Health and Physical Education, Institute of Physical Culture Sciences
Al. Piastów 40B, blok 6, 71-065 Szczecin, Poland
E-mail: jerzy.eider@usz.edu.pl

Abstract The aim of this article is to present an analysis of the current qualifying standards for the 32nd Summer Olympics and the 16th Paralympics, Tokyo 2020 (2021). The article takes account of athletes who are students and graduates of the University of Szczecin in their respective sports disciplines, as well as sports restrictions related to the COVID-19 pandemic. Moreover, the article presents trainers, physiotherapists, employees and graduates of the University of Szczecin who are working with athletes who meet the qualifying standards or plan to compete in sports events to meet the standards, for the Tokyo 2020 Olympic Games. If their athletes qualify for the Games, they will become members of, or potential candidates for, the coaching and medical staff of the Polish Olympic and Paralympic team participating in Tokyo 2020 (2021).

This article serves as a continuation of research and analyses on the participation of student athletes, coaches and physiotherapists who are graduates of the Higher School of Pedagogy in Szczecin (later: University of Szczecin), in the Summer Olympics and Paralympics. For the first time in the history of the modern Olympic Games, the event has been postponed: Tokyo 2020, although retaining its name, will take place the following year. This decision is a result of the global COVID-19 pandemic.

The research material consisted of 14 individuals: eight athletes, five trainers, and one physiotherapist. Out of the eight analysed athletes, four of them – Patryk Dobek, Michał Gadowski, Piotr Lisek and Marcin Lewandowski – have already achieved qualifying standards which enables them to participate in the Olympic Games. The Paralympic qualifications in rowing, won by Michał Gadowski, have guaranteed coach Tomasz Kaźmierczak and physiotherapist Beata Buryta's participation in the 16th Paralympics Tokyo 2020 (2021).

Key words athletes, qualifications, students, graduates, employees, Olympians, Paralympians, coaches, physiotherapists

Introduction

For many countries and athletes, the last few months of the year before the Olympics and Paralympics take place are the final chance to compete in high ranking sporting events to achieve qualifying standards (individual, personal and national). The indicators and qualification standards for Olympic and Paralympic disciplines are established by the International Sports Federations of a given sport and approved (or even increased) by Polish sports associations (e.g. www.pzla.pl). In January, February and March 2020, many athletes trained intensively and

prepared for the qualifying rounds of Tokyo 2020. The Olympic Games were to be held from July 24th to August 9th; and the Paralympic Games, August 25th to September 6th. Unfortunately, on March 24th, 2020, the Prime Minister of Japan spoke to the President of the International Olympic Committee (IOC) to propose a postponement of the 2020 Tokyo Games, due to the global COVID-19 pandemic. In its decision, the International Olympic Committee also took into account the demands of national committees, including the Polish Olympic Committee, and changed the date of the 32nd Summer Olympic Games to July 23rd to August 8th, 2021 (Urbaś, 2020), although it would still be officially referred to as Tokyo 2020. The International Paralympic Committee (IPC) complied with the decision of the IOC and moved the date of the 16th Summer Paralympic Games to August 24th to September 5th, 2021. All athletes who, prior to the announcement of the postponement, achieved qualifying standards in their disciplines are guaranteed to participate in the largest global sports event in 2021 in the capital of Japan (www.olimpijski.pl). Other athletes who did not qualify (including national teams, relay teams, and rowing teams) will still have a chance to achieve qualifying standards for Tokyo in the final months of 2020 up until June 2021. It should be noted that athletes who achieve qualifying standards in some sports disciplines (e.g. in canoeing or rowing) are not guaranteed to participate in the Olympics/Paralympics. The obtained qualifications are attributed to the country represented by the athlete and so, for example, the authorities of the Polish sports association of a given discipline (e.g. the Polish Canoe Association) decide which individual athletes will represent the sport at the Games.

The purpose of this article is to:

1. Perform an up-to-date analysis of the qualifying standards for the 32nd Summer Olympic Games and 16th Paralympic Games Tokyo 2020 (2021) of athletes who are students and graduates of the University of Szczecin in various sports disciplines, taking into account the restrictions related to the COVID-19 pandemic.
2. Present trainers, physiotherapists, employees and graduates of the University of Szczecin working with athletes who achieved qualifying standards, or plan to compete in sports events to meet the standards, for the Tokyo Games. With their athletes qualifying for the Games, they will become members of (or potential candidates for) the coaching and medical staff of the Polish Olympic and Paralympic team participating in Tokyo 2020 (2021).
3. Continue the research and analyses on the participation of student athletes, coaches and physiotherapists who are graduates of the Higher School of Pedagogy in Szczecin (later: University of Szczecin), in the Summer Olympics and Paralympics.

Materials and methods

The research material included 14 individuals: eight athletes, five trainers, and one physiotherapist, who were or had been cooperating with the University of Szczecin: Institute of Physical Culture (IKF), Institute of Physical Culture of the Faculty of Natural Sciences (IKF WNP), Department of Physical Culture and Health Promotion (WKFiPZ) and Department of Health and Physical Culture (WKFiZ). Among the group of athletes currently studying in the 2019/2020 academic year at the Department of Health and Physical Culture are: Patryk Dobek, Michał Gadowski and Katarzyna Mądrowska (Table 1). The following athletes: Piotr Lisek, Marcin Lewandowski (student of a second major: Public Health), Paulina Woźniak, and Krystian Zalewski – quit studying at their own behest (for personal, sports-related, and other reasons). In the analysis of the research results, other than Marcin Lewandowski, they

were included in the group of former students of WKFiPZ US, WKFiZ US. The group of athletes who graduated from the University of Szczecin includes Masters in physical education – Anna Harkowska and Marcin Lewandowski.

The analysed research material also included five trainers: Tomasz Kaźmierczak, Jacek Kostrzeba, Tomasz Lewandowski (Marcin Lewandowski's brother), Grzegorz Musztafaga, and Miłosz Stępiński (Table 2). They are all graduates of the University of Szczecin (Eider, 2019a). Miłosz Stępiński, PhD and professor at the University of Szczecin, is a lecturer at the Institute of Physical Culture Sciences of WKFiZ US, and the coach of the Poland women's national football team. The remaining coaches are mainly trainers of single sports disciplines. In their professional work, they have achieved significant successes and performed coaching duties at the Olympic and Paralympic Games (Eider, 2019a). The research material also included Beata Buryta, MSc, a lecturer at the Institute of Physical Culture Sciences at WKFiZ US. As a physiotherapist, she has been working with disabled rowers for many years, e.g. as a participant of the Polish Medical Mission at the 15th Paralympic Games in Rio de Janeiro 2016 (Eider, Eider, 2017).

Table 1. Research material – athletes

First name and surname*	Sports discipline		Student status		
	Olympic	Paralympic	Current student	Former student	Graduate
Patryk Dobek	Athletics – 400 m hurdles	–	WKFiZ US	–	WKFiPZ US**
Michał Gadowski	–	Rowing	WKFiZ US	–	–
Anna Harkowska	–	Cycling	–	–	IKFWNP US***
Marcin Lewandowski	Athletics – 800 m 1500 m	–	–	WKFiZ US**	WKFiPZ US***
Piotr Lisek	Athletics – pole vault	–	–	WKFiZ US	–
Katarzyna Mądrowska	Wrestling – 62 kg	–	WKFiZ US	–	WKFiPZ US*
Paulina Woźniak	–	Swimming	–	WKFiZ US	–
Krystian Zalewski	Athletics – 3,000 m steeplechase	–	–	WKFiZ US	–

Legend:
WKFiPZ US – Faculty of Physical Culture and Health Promotion US.
WKFiZ US – Faculty of Health and Physical Culture US.
IKFWNP US – Institute of Physical Culture, Department of Natural Sciences US.

* Alphabetically ordered.
** Completed Bachelor's studies.
*** Completed Master's studies.

Source: Archival documentation… (2020); Eider (2019b); www.wikipedia.pl.

Table 2. Research material – trainers, physiotherapist

First name and surname*	Sports discipline	Current trainer of		University status	
		Olympic	Paralympic	Current employee	Graduate
Tomasz Kaźmierczak	Rowing	–	Rowing	–	IKF WNP US
Jacek Kostrzeba	Athletics	Athletics	–	–	IKF US
Tomasz Lewandowski	Athletics	Athletics	–	–	IKF WNP US
Grzegorz Musztafaga	Swimming	–	Swimming	–	IKF WNP US
Miłosz Stępiński	Football	Football	–	INoKF WKFiZ US	IKF WNP US
Beata Buryta	–	–	Physiotherapist of disabled rowers	–	IKF WNP US

* Alphabetically ordered.

Source: Buryta (2020); Archival documentation… (2020); Eider (2019a).

The research also used archival documentation of WKFiZ US, oral accounts of athletes, coaches, physiotherapists, other studies by the author of this study, as well as websites, social media profiles, databases and other digital collections of information about players and coaches[1].

Results

Table 3 indicates which athletes have already achieved qualifying standards (as of March 24th, 2020) for the 32nd Summer Olympics or the 16th Paralympics – Tokyo 2020 (2021). The group of students (as of August 31st, 2020) from the Faculty of Physical Culture and Health includes Patryk Dobek, Michał Gadowski, and Katarzyna Mądrowska (Table 3).

Table 3. Qualifications gained for the 32nd Olympic Games, 16th Paralympic Games Tokyo 2020 by the analysed athletes – students and graduates of the University of Szczecin, as of August 31, 2020

The analysed group of athletes	First and last name*	Qualifications obtained in their disciplines					
		Olympic	Yes	No	Paralympic	Yes	No
Current students	Patryk Dobek	Athletics | 400 metres hurdles	Yes	–	–	–	–
	Michał Gadowski	–	–	–	Rowing	Yes	–
	Katarzyna Mądrowska	Wrestling 62 kg	Yes	–	–	–	–
Former students	Piotr Lisek	Athletics | Pole vault	Yes	–	–	–	–
	Paulina Woźniak	–	–	–	Swimming	–	No
	Krystian Zalewski	Athletics | 3,000 metres steeplechase | marathon	–	No	–	–	–
University of Szczecin graduates	Anna Harkowska	–	–	–	Cycling	–	No
	Marcin Lewandowski	Athletics | 800 metres | 1,500 metres	Yes	Yes	–	–	–

* Alphabetically ordered.

Source: Dobek (2020); Kaźmierczak (2020); Krupecki (2020); Mądrowska (2020); Terczyński (2020); Zalewski (2020); www.olimpijski.pl; www.paralympic.pl; www.pzla.pl.

Patryk Dobek is a member of the Municipal Athletics Club (MKL) in Szczecin, and his club coach is Valentyn Bondarenko. He has already participated in the 400 m hurdles in the Rio de Janeiro 2016 Olympic Games (Eider, 2019b). At the 8th European Team Athletics Championships held in Bydgoszcz (August 9th–11th, 2019), Patryk Dobek won his qualifying race on the first day of the championships in the 400 m hurdles with a very good time – 48.80 s (the Polish Athletics Association established the qualifying standard at 48.90 s). Thanks to this result, he secured a personal qualification for the Tokyo 2020 Olympic Games. It should be noted that on the second day of the championship – on August 10th – he won the final race with a time of 48.87 s (Dobek, 2020), which was a still a better result than the required minimum for the Olympic Games.

The second athlete – a current student of WKFiZ US – is Michał Gadowski, a member of the Disabled Sports Club (KSI) "Start" in Szczecin; he is a two-time Paralympic rowing participant (London 2012, Rio de Janeiro 2016). His national team and club trainer is Tomasz Kaźmierczak: a graduate of IKF WNP US (Kaźmierczak, 2020), a disabled rowing trainer at the Paralympics in Beijing 2008, London 2012, Rio de Janeiro 2016, and the president

[1] The information contained in this article is current as of August 31, 2020.

of KSI 'Start' Szczecin. At the Para-Rowing World Championship held in Linz (Austria) on August 25th–September 1st, 2019, the Polish mixed double PR2 Mix2x Michał Gadowski and Jolanta Majka Pawlak landed third place in the semi-final, and then took 4th place in the A–final (Krupecki, 2020). Thanks to these results, they secured their participation at the Paralympic Games in Tokyo by placing in the top 8 (Kaźmierczak, 2020). Their trainer, Tomasz Kaźmierczak, will also be called to serve as a coach during the 16th Paralympic Games Tokyo 2020.

The third athlete is the WKFiZ US student, wrestler Katarzyna Mądrowska, a member of the People's Sports Club (LKS) Feniks Pesta Stargard. Mariusz Kucharczyk is her club coach, while Piotr Krajewski is her national team coach. In the year before the Olympics, she competed in the World Championship in Nur-Sultan in Kazakhstan (September 14th – September 22nd, 2020), during which she did not achieve the qualifying standard of a place in the top 6 in her weight category below 62 kg. Katarzyna Mądrowska will also participate in two wrestling tournaments – the European Wrestling Championships (March 2021) and the global (April/May 2021). In both tournaments, the two best participants in each weight category will qualify (Mądrowska, 2020).

The group of former students of WKFiPZ US, WKFiZ US includes Piotr Lisek, Paulina Woźniak, and Krystian Zalewski. Piotr Lisek is a member of the Pole Training Centre (OSOT) in Szczecin (Iwińska, 2019); his club and national team trainer is Marcin Szczepański. In 2019, in his discipline of the pole vault, Piotr obtained results that exceeded the qualifying standards set by PZLA (5.80 m) (www.pzla.pl) numerous times. On June 13th, 2019, at the Diamond League Competition in Oslo, he achieved a result of 5.81 m, while on July 12th, 2019, during the Diamond League in Monaco, he won first place with a perfect result of 6.02 m, thus improving on the Polish record he had set on July 5th, 2019 in Lausanne (6.01 m). At the World Championships held in Doha (Qatar), on October 1st, 2019, he won a bronze medal with a score of 5.87 m. This pole vaulter is part of a group of Polish athletes who have already achieved personal qualifications for Tokyo 2020 (2021), and have a great chance of winning an Olympic medal. Piotr Lisek has already participated in the Olympic Games in Rio de Janeiro 2016, where he won fourth place, with a result of 5.75 m (Eider, 2019b).

Paulina Woźniak is a disabled swimmer and a member of KSI "Start" Szczecin. For many years, Grzegorz Musztafaga has been her club coach, while Wojciech Sajdel is her national team coach (Grzegorz Musztafaga cooperates with the national team as well). A year ago, Paulina and her parents left for Germany (near Hamburg), where she continues to train according to coach recommendations (Kaźmierczak, 2020). Her sports achievements already include two Paralympic medals in the 100 m classic style competition; a silver medal (Beijing 2008) and a bronze medal (London 2012) (Eider, Eider, 2012). In the spring of 2021, she plans to take part in swimming competitions and gain a personal Paralympic qualification, or to gain a high enough place in the world rankings to be awarded a place in the Polish national swimming team, by the International Paralympic Committee (IPC) thus guaranteeing her participation in the 16th Paralympic Games Tokyo 2020 (Eider, 2019b). One of the former students of WKFIPZ US and WKFiZ US is also Krystian Zalewski, who mainly specializes in the 3,000 m steeplechase and is a member of the Student Sports Club (UKS) Barnim Goleniów. His club and national team coach is Jacek Kostrzeba from Goleniów (an IKF US graduate). Krystian Zalewski competed in the 3,000 m steeplechase at the 31st Olympic Games in Rio de Janeiro (2016). At the time that the postponement of the games was announced, he did not obtain the qualifying standard (PZLA requirement: 8:22.00). After the 2019 season, he and his coach decided that they would prepare for the marathon in Tokyo (running distance 42.195 km, PZLA requirement: 2:11.30 hours). He plans to participate in the athletics competition in Valencia on December 6th, 2020, fight for the Olympic qualification and

obtain a result within the top 80 (Zalewski, 2020). If Krystian Zalewski does not qualify, his trainer Jacek Kostrzewa will go to Tokyo anyway, as he also trains other runners.

The analysed group of University of Szczecin graduates includes two accomplished athletes: Anna Harkowska and Marcin Lewandowski. Anna Harkowska is a member of the Olsztyn Sports Club (OKS) "Warmia i Mazury". Marian Kowalski is her club and national team coach. She is preparing for the Tokyo Paralympics cycling competition and has great medal chances. At the London Paralympic Games 2012, she won three silver medals (mass start race, individual time trial, 3,000 m) and two at the Paralympic Games in Rio de Janeiro 2016 (mass start race and individual time trial) (Eider, 2019a; Szaj, 2016). At the time of announcing the postponement, she did not obtain the personal Paralympic qualification in her cycling discipline.

It should be noted that in June 2021, the number of places allocated to Poland for individual disciplines will be known. This will be based on world rankings in certain competitions and the limits, as well as any wild cards that will be awarded to our cycling team by the International Paralympic Committee (Eider, 2019b; www.paraolympic.org).

Marcin Lewandowski also graduated from the University of Szczecin, having received a Master's degree in Physical Education (Eider, 2015; www.wikipedia.pl). He is a member of the Athletics Section of the Military Sports Club (SL WKS) "Zawisza Bydgoszcz", and his long-standing club and national team coach is Tomasz Lewandowski (Iwińska, 2019). Since March 2nd, 2020, he has been training under the supervision of Piotr Rostwoski (Terczyński, 2020). He is an accomplished and experienced athlete in the 800 m race (Beijing 2008, London 2012, Rio de Janeiro 2016) and the 1,500 m race. He won 6th place in the finals of the 800 m in Rio de Janeiro, his highest ranking so far. He is preparing to compete in the 32nd Olympic Games in the 1,500 m race (Lewandowski, 2019). In 2019, Marcin Lewandowski won a personal qualification at several sports competitions, including, on August 24th, 2019, during the Diamond League in Paris where he set a Polish record in the 1,500 m race with a time of 3:31.95 min (PZLA requirement: 3:35.00). At the World Championships in Doha (Qatar), he won a bronze medal in his discipline, the 1,500 m race (October 6, 2019), setting a new Polish record (3:31.46 min). It should be noted that he also achieved the qualifying standard in the 800m race but is not planning on participating in the competition in Tokyo. His long-time coach and brother – Tomasz Lewandowski – a graduate of IKF WNP US, is no longer a member of the PZLA coaching staff as he now works with other runners in Norway. For this reason, Tomasz's participation in Tokyo 2020 as the coach of his brother Marcin or other Polish runners, is no longer valid.

Discussion

2019 was a pre-Olympic year for many athletes; they prepared for the next season and planned to participate in the 32nd Olympic Games or the 15th Paralympic Games. They took part in selected sports competitions, where they obtained Olympic and Paralympic qualifications (individual, national, relay, tournament, ranking etc.) or failed to meet the qualifying standards. Many athletes planned to participate in subsequent sports events in 2020 to achieve the qualifying standards in their respective disciplines. Unfortunately, in March 2020, due to the global COVID-19 pandemic, the International Olympic Committee made a historic decision to reschedule the 32nd Olympic Games from 2020 to 2021. All sports events, league competitions, club training sessions, training camps, sports and recreational activities in fitness clubs, physical education classes at school, etc. were suspended, while sports and recreation facilities were closed. As well as this, the celebrations of the 56th Central Olympian Days Ceremonies, which were to be held in Wałcz on April 16th–18th, 2020, were moved to the later date of October 15th–17th, 2020 (Eider, Wańkiewicz, Skalski, 2020). For the first time in the history of the modern Olympic Games, the world's

biggest sporting event has been postponed to the year after – although it has kept its name of Tokyo 2020. It should be noted that the Japanese capital had already hosted the 18th Olympic Games in 1964.

Moreover, the 16th Summer Paralympics Games have also been re-scheduled to 2021, which means that the athletes who have not yet achieved qualification standards will still have a chance to do so during competitions postponed to other dates in 2020 and the first half of 2021. These athletes include Katarzyna Mądrowska (wrestling), Paulina Woźniak (disabled swimming), Krystian Zalewski (athletics, marathon), Anna Harkowska (disabled cycling). Of the coaches who are graduates of the University of Szczecin, Tomasz Kaźmierczak (disabled rowing) and Beata Buryta (physiotherapist, in the Paralympic discipline) can be certain of their participation in the Tokyo Olympics. Jacek Kostrzeba (athletics) and Grzegorz Musztafaga (disabled swimming) have a chance to go to Tokyo, provided that their trainees qualify for the competition.

Miłosz Stępiński (trainer-analyst in Czesław Michniewicz's coaching staff) will not perform his role at the Olympic men's football tournament in Tokyo. The Polish representation for the U21 at the 2019 European Championships in June 2019, held in Italy and San Marino, did not secure a place among the four best teams which was the requirement to compete (Stępiński, 2019).

Conclusions

1. For the first time in the history of the modern Olympic Games, the event has been postponed to the following year – Tokyo 2020 (2021).

2. The main cause of re-scheduling the largest sports event of the four-year period was the global COVID-19 pandemic.

3. Out of the analysed eight athletes, four of them – Patryk Dobek, Michał Gadowski, Piotr Lisek and Marcin Lewandowski – have already achieved qualifying standards which enables them to participate in the Olympic Games, Tokyo 2020.

4. The Paralympic qualification won by Michał Gadowski in rowing, guaranteed coach Tomasz Kaźmierczak and physiotherapist Beata Buryta's participation in the 16th Paralympics Tokyo 2020 (2021).

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SUPPORTIVENESS OF UNIVERSITY PHYSICAL ENVIRONMENT ON UNDERGRADUATE STUDENTS PARTICIPATION IN LEISURE-TIME PHYSICAL ACTIVITY IN SOUTH WEST NIGERIA

Michael Alayode Ajibua,[1, A, B, C, D] Omotayo Adebayo Onanuga[2, A, B, C, D]

[1] Federal University of Technology, Sports Centre, Akure, Ondo State, Nigeria
[2] Federal University of Technology, Department of Architecture, School of Environmental Technology, Akure, Ondo State, Nigeria
[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation

Address for correspondence:
Michael Alayode Ajibua
Sports Centre, Federal University of Technology, P.M.B.704, Akure
Ondo State, Nigeria
E-mail: alayodeajibua@gmail.com

Abstract Participation in Leisure-Time Physical Activity (LTPA) has declined among university undergraduate students in Nigeria. Studies have identified the physical environment of universities as a potential cause of the decline; however, this claim has not been verified. Therefore, this study evaluates the role of the physical environment in universities in inducing student participation in LTPA. This study is necessary, as previous research has shown the involvement in LTPA helps in developing the physical, physiological, social, emotional and mental capacities of students. It is also a factor in the relief of daily stress from the heavy academic workloads of the university students. A quantitative research methodology was adopted for this study. A total sample of 2,867 students was selected from 14 public universities in South West Nigeria using a multi-stage sampling technique. It was deduced from the study that the physical environment was a determining factor for LTPA participation among university undergraduate students in South West Nigeria. In addition, it was found that the availability of facility infrastructure that encourages students roaming and safety pre-cautions on campus would enhance participation in LTPA among the university students.

Key words built environment, occupational activity, commuting activity, weather conditions, seasonal variations, meteorology

Introduction

Physical activity broadly describes all forms of large muscle movements, such as sport, dance, games, work, lifestyle activities, walking, cycling or exercise, to improve fitness (Cutts, Welk, Curbin, Welk, 2004). It describes any form of activity that involves movements that people take part in for fun or satisfaction out of playfulness. Physical activity is undertaken in various contexts, and can be categorized into Leisure-Time Physical Activity (LTPA), commuting activity and occupational activity (Jarvie, 2006; Morgan, 2016).

Leisure-Time Physical Activity (LTPA), the focus of this study, is defined as sporting activities, exercises, chores or any other recreational activities that people engage in during their discretionary or free time. LTPA generates long-lasting energy which helps to improve quality of life (Oyeyemi, Sallis, Deforche, Oyeyemi, Dyck, 2013; Harrison, Corder, Ekelund, van Shiys, Jone, 2014). The emphasis of LTPA is on all free-time activities that require physical exertion (or coordination), such as gardening, tramping, walking, fishing, hunting, etc. For university students, LTPA activities are engaged in during their free time, possibly before or after daily academic activities.

The university environment in Nigeria is a stressful environment for students while they adapt to new educational and social-environmental loads (Burbridge, 2008; Aderonmu, 2016). Studies have shown that accumulating these stressors depletes their physical and psychological resources, and raises the probability of physical illness and psychological distress (Orodele, 2008; AgriLife Extension, 2008). One of the benefits of participation in LTPA is that it eases the daily stress caused by the demands of the academic workload (Newton, Guo, Yang, Malkin, 2012). Thus, LTPA has grown to become strategically important for securing and sustaining a good quality of life in the academic environment. Furthermore, LTPA has a potent capacity to reduce the symptoms of anxiety and depression and improve self-esteem and self-concept in the students (Chan, Ryan, 2009; Aderonmu, 2016).

The level of participation in LTPA is modulated by biological, social and environmental factors (Ewing, 2005; Hagaard, 2009). Apart from biological incapacitation, factors such as community design, facility proximity and accessibility, safety, security, weather conditions and their seasonal variations (key elements of the physical environment that can dissuade interest in leisure programs), have little scholarly attention. Previous related studies have focused on the participation of university students in organised sporting activities as a way of expending energy or gaining favourable health outcomes. There are varieties of ways university students can achieve this outside participation in organised sports. And an area that has been largely neglected in previous investigations is the context (physical environment) within which the physical activities take place. Consequently, this study has evaluated how the physical environment of the universities has affected student engagement in LTPA, with the anticipation of improving the wellness of the students. This was achieved through a study of the physical environmental (built environment, weather conditions and seasonal variations) factors that influences participation in LTPA among undergraduate students in South West Nigeria.

Literature

Traditionally, Nigerians are inherently active people, especially during social events such as cultural and religious festivals, weddings, naming and coronation ceremonies. They also engage in intense physical activities such as local boxing, acrobatic dances, tree and hill-climbing, hunting and fishing, as well as mental activities such as hide and seek, craft and sculpture works, and social activities (Polinkas, 2001; Lahti, 2011; Audu, 2013). These activities are done mostly after daily works as leisure and have been valued as a unifying force among the people. Consequently, participation in a leisure activity is part of the culture and tradition of Nigerians. Similarly, studies have shown that a lifestyle that involves leisure activities is encouraged by the Nigerian government through the integration of Physical and Health Education (PHE) as part of the educational curriculum from primary school to university level (Merril, Shields, White, Druce, 2008, Bakare, 2015).

Although the levels and modes of participation in LTPA depend solely on the individual, motivating factors such as environmental cues for LTPA participation are very important. Most human behaviours, LTPA inclusive, are environment-related. Environmental variables may serve as facilitators or inhibitors to LTPA. For instance,

extreme changes in the physical environment have an extreme impact on the human body, indicating that the status of human beings can be altered by the physical environment to dissuade them from participating in LTPA. The survival of the species would at least partly dependent upon adaptation and the suitability of their environment (Karbir, Sulaiman, 2011).

LTPA among university students can be categorized into organised and unorganised physical activity. Organised activity is supported by environmental design and the availability of sporting infrastructure, while unorganised activity can derive from lifestyle activities such as household chores, stair climbing, walking from a hostel to classes, or from hobbies such as dancing, skating and cycling. A recent study has shown that both organised and unorganised forms of LTPA are on the decline in Nigerian universities (Asagba, Ibraheem, 2006) due to changes in university orientation and programmes that now focused more on rigorous academic pursuits, neglecting the place of leisure (Polinkas, 2001). The emphasis of University management is more on the lecture halls, theatres, hostels and libraries, with little interest in environmental designs that motivate sporting or recreation activities. Likewise, other factors such as environmental challenges, poor weather, over-engagement in academic workload, and a lack of consideration for sporting elements have led to a decline in LTPA among university students. People can face a variety of threats while engaging in LTPA in their environment, such as crime, street barbarism and terrorism (Owolabi, Adebayo, 2013). A lack of serenity, a perception of a lack of security, and fear of victimization are threats to the use of public spaces.

Previous studies have shown that the perception of environmental challenges such as safety and security in the physical environment are an important predictor of participation in physical activities (Gebel, King, Bauman, Vital, Gill, Rigby, Capon, 2005; Corbin, Welk, Corbin, Welk, 2009). It has been argued that the behaviour of physical activity would be more influenced by how individuals perceive their environment safety than by the absolute safety measure. People are more reluctant to walk, bicycle, jog or play in environments that are considered unsafe, which in turn leads to less physical activity.

The issue of communal relationship between students and the physical environment of the university is of particular importance today. Students require space and facilities better suited to their needs. The space designed for leisure activities in universities in Nigeria is not commensurate with the populations of the students (Shuval, Wiessblueeth, Brezis, Dipiero, 2009; Sallis et al., 2015). Again, facilities available for sport and leisure such as parks, playgrounds, sporting grounds and gymnasiums in the universities today remain mostly inaccessible and grossly inadequate. Accessibility includes the availability of opportunities to engage in LTPA and the proximity to facilities that may encourage the activity (Committee on Physical Activity, 2005; Canpplat, Yildiz, Dorak, 2016).

With the aforementioned views, this study investigated the challenges of the physical environment of universities in South West Nigeria. The study evaluates the physical environment of the university as a determining factor for LTPA participation among the students.

Methods

The study examined the supportiveness of the physical environment toward undergraduate student participation in LTPA in South West Nigeria. The study sample (n = 219,964) was taken from all public-owned universities in South West Nigeria. Selection of the studied sample size involved four (4) stages, from general to specific and from wide to small and representatively constituent, using multi-stage sampling techniques. Seven public universities (4 State and 3 Federal Universities) out of 14 public-owned universities in South West Nigeria

were selected at stage one, and 50% of that population was selected from the faculties and departments in stages two and three respectively. Then, 10% of the stage three sample population, comprising students from the penultimate and final classes, were selected for the fourth stage, with a final study sample size of n = 2,867. The two most senior level classes were chosen from the perception of knowledge of the customs and practices of students in the various universities under study. A self-constructed instrument, "Leisure Activity Questionnaire (LAQ)", was created for the study. The subjects responded to various questions that captured physical environmental variables established in the literature, such as security and safety of university environment, the availability and accessibility of LTPA facilities, weather conditions and seasonal variations. The questionnaire was based on 4-point Likert scale of "Strongly Agree" (SA), "Agree" (A), "Disagree" (D) and "Strongly Disagree" (SD). The content validity of the instrument was established by five experts in the Human Kinetics and Test and Measurement departments from the University of Ilorin, Kwara State and Obafemi Awolowo University, Ile-Ife, Osun State, in Nigeria. The instrument for the study was subjected to a pilot test, during which it was administered twice within two weeks interval using a "test re-test" method at Joseph Ayo Bablola University, Ikeji, Arakeji, Osun State, which was not one of the universities in the study. A reliability test was carried out using Cronbach's Alpha statistics, which helps to measure the reliability and consistency of the instrument. The result showed a Cronbach's Alpha of 0.87, which is reliable for the study. The data collected were analyzed using descriptive statistics of frequency counts, percentages for the demographic data, while the inferential statistics of Chi-square was used to analyze the hypothesis formulated for the study. The model used LTPA as the dependent variable and other risk factors such as demographics, built environment and meteorological factors, as independent variables. The demographic factors used were gender, age, field of specialization, religion and disability.

Results

The demographic data shown in Table 1 reveal that 47.3% of the respondents were male and 52.7% were female. Table 1 shows that the youngest age bracket was 16–18 years (16.5%) and 41.7% of the respondents were 19–21 years old. This age category is not unexpected as the majority of the respondents were in their semi or final classes.

Table 1. Demographic distribution of the respondents

Variable	Measure	Frequency	Percentage
Gender	Male	1,290	47.3
	Female	1,440	52.7
Age	16–18 yrs	451	16.5
	19–21 yrs	1,139	41.7
	22–24 yrs	504	18.5
	25 yrs and above	636	23.3
Field of specialization	Science	1,031	37.8
	Art	1,699	62.2
Religion	Christianity	1,871	68.5
	Muslim	859	31.5
Disability	Yes	359	13.2
	No	2,371	86.8

The majority of respondents specialized in Art subjects (62.2%), while the religion distribution showed 68.5% Christian and 31.5% Muslim faiths. The majority of respondents had no physical challenge, with just 13% indicating a disability.

The study further tested whether the physical environment (built environment, weather conditions and seasonal variations) was a significant determinant of LTPA among undergraduate students in Universities in South West Nigeria. In order to test this hypothesis, the sets of data required were subjected to Chi-square analysis through the use of SPSS 16.0 at an $\alpha = 0.05$. The Chi-square results in Table 2 showed that $p = 0.000$, which is less than 0.05, therefore the hypothesis was accepted. This suggests that the physical environmental factors such as the built environment, weather conditions and seasonal variations, were the determinants of LTPA among university undergraduate students in South West Nigeria.

Table 2 shows that respondents (66.9%) feel secure in their university environment to participate in LTPA. The students (68.2%) concurred that the safety of their environment affects their involvement in LTPA. The respondents were requested to identify the characteristics of the physical environment that made them feel safer to participate in LTPA. In response, they agreed that the availability of streetlight (57.3%), more public open place for sports and recreation (65.1%), slower speed limit of cars and motorcycles (65.2%), better sidewalks (59.5%), street connectivity (57.1%) and favourable weather conditions (59.6%) would make them feel safer to participate in LTPA in their universities. The findings indicated that respondents (71%) would participate in LTPA if their environment were safer.

Table 2. Frequency distribution and Chi-Square Analysis Showing the relationship between Physical Environment and LTPA among University Students in South West Nigeria

Items	SD	D	A	SA	Cal	df	ASYMP .SIG.
1. You feel secure in your university physical environment to participate in LTPA	285 (10. 4%)	620 (22.7%)	1,168 (42.7%)	657 (24.0%)			
2. The safety of your university physical environment affects your participation in LTPA	152 (5.6%)	717 (26.2%)	977 (35.8%)	884 (32.4%)			
3. The following will make you feel safer to participate in LTPA in your university physical environment							
i. More street lights	237 (8.7%)	926 (33.9%)	1,047 (38.3%)	520 (19.0%)			
ii. More public open spaces for sports	326 (11.9%)	626 (22.9%)	729 (26.7%)	1,049 (38.4%)			
iii. Slower speed limit of cars and motorcycles	193 (7.1%)	757 (27.7%)	660 (24.2%)	1,120 (41.0%)			
iv. Better sidewalks	214 (7.8%)	891 (32.6%)	1,130 (41.4%)	495 (18.1%)			
v. Street connectivity	342 (12.5%)	827 (30.2%)	1,153 (42.2%)	408 (14.9%)	2017.568	54	000*
vi. Favourable weather	308 (11.2%)	772 (28.3%)	875 (32.0%)	775 (27.6%)			
4. You will participate in LTPA if your university physical environment is safer	137 (6%)	544 (19.9%)	1,112 (40.7%)	937 (34.3%)			
5. You will participate more in LTPA if there is easy access to safe sport and recreation facilities in your university	208 (7.6%)	974 (35.7%)	1,080 (39.5%)	468 (17.8%)			
6. There are attractive sport/recreation facilities in your university	298 (10.9%)	736 (27%)	1,186 (43.4%)	510 (18.7%)			
7. You have the following exercise equipment in your hostel/school e.g. treadmill, bicycle ergometer, elliptical machine, rowing machine, stepper, free weight etc.	357 (13.1%)	736 (26.9%)	1,020 (37.3%)	617 (22.6%)			

* Significant.

The results also showed that respondents (57.3%) would participate in LTPA more if they have easy access to safe sports and recreation facilities. Respondents (59.9%) revealed that they have exercise equipment such as treadmill, bicycle ergometer, elliptical machine, rowing machine, stepper free weight of different sizes, etc., in their hostels and schools. Also, respondents indicated that they participated in LTPA both in dry (58.4%) and wet season (60.8%).

Table 3. Physical Environment as Determinant Cont'd

Items	SD	D	A	SA	Cal	Df	ASYMP.SIG
1. In which of these seasons do you like participating in LTPA?							
i. Wet (raining) season	288 (10.5%)	779 (28.5%)	950 (34.7%)	713 (26.1%)			
ii. Dry season	325 (11.9%)	810 (29.6%)	686 (25.1%)	909 (33.3%)			
2. Which of the weather parameters mostly affects your participation in LTPA in your university?							
i. Rainfall/precipitation	156 (5.7%)	693 (25.4%)	905 (33.1%)	976 (35.7%)			
ii. Temperature	191 (7%)	694 (25.4%)	935 (34.2%)	910 (33.3%)			
iii. Wind velocity/wind direction	255 (9.3%)	954 (34.9%)	988 (36.2%)	533 (19.5%)			
iv. Relative humidity	331 (12.1%)	767 (28.1%)	879 (32.2%)	753 (27.6%)			
3. Which of the under-listed do the weather affect most when on campus?							
i. Your state of mind	181 (6.6%)	879 (32.2%)	914 (33.5%)	756 (27.7%)			
ii. Equipment and facility surfaces	209 (7.7%)	690 (25.3%)	1,233 (45.1%)	598 (21.9%)			
iii. Types of apparel/clothing	186 (6.8%)	903 (33.0%)	957 (35.0%)	684 (25.0%)			

If $p < 0.05$, there is a significant difference.

In response to the question of "which of the weather parameters mostly influence you to participate in LTPA?" the respondents claimed that rainfall/precipitation (68.8%) was the weather parameter that mostly affected their participation in LTPA. After rainfall, temperature (67.5%) determines participation in LTPA. According to the respondents, wind velocity and direction (55.7%) and relative humidity (59.8%) affected their participation in LTPA. The respondents indicated that weather parameter affects their state of minds (61.2%), equipment and facility surfaces (67%), and apparel/clothing (60%).

Discussion

When the hypothesis was tested, it revealed that the physical environment (built environment, weather conditions and seasonal variations) was a significant determinant of LTPA among university undergraduate students in South West Nigeria. It thus means that the characteristics of the built environment and meteorological parameters are determinants of LTPA engagement. This is in accord with the study which hypothesized that environmental variables were associated with participation in LTPA (Cutts, Dirby, Boone, Brewis, 2009). The physical environment characteristics were as significant as the personal characteristics (age, gender, socioeconomic status, positive outcome expectancy, self-perception, intention, attitude, self-efficacy, motive and household demography) in determining the likelihood of participation in LTPA (Doyle, Kelly-Schwartz, Schlossberg, Stockard, 2006). The physical environment variables that are believed to be associated with LTPA are safety, traffic level, street connectivity, accessibility to open leisure infrastructure, public transportation and weather conditions (Cutts, Dirby,

Boone, Brewis, 2009; Sallis, Floyd, Rodriquez, Saelens, 2012). Therefore, it can be said that those who live in activity-friendly environments are likely to be more physically active during their leisure time.

The study revealed that the respondents had a keen interest in participating in LTPA in an environment that satisfied some conditions of their needs. The study showed that the physical environment must be perceived as safe and secure if participation in LTPA is to be encouraged. Safety in the university environment is a prominent worry that could impede participation in LTPA. A study in Nigeria has found that the perception of safety without crime within an environment was positively associated with both objectively moderate-to-vigorous physical activity and self-reported activity (Spasova, 2011). Individuals living in an unsafe environment participated less in LTPA than those living in a well-secured environment (Evenson, Mota, 2011). The immediate surroundings of leisure facilities are very critical in determining the attendance, density and frequency of LTPA. People may have the necessary knowledge, skills, attitudes and motivation to be physically active, but if the activity environment is insecure, they may be constrained from participating in it. Thus, creating a sense of security and safety is an essential pre-requisite for successful LTPA engagement.

Furthermore, one study has discovered that the availability of open spaces is a factor determining participation in LTPA (Shuval, Weissblueth, Brezis, Dipiero, 2009). The results of this study also showed that students would participate in LTPA if there were more open spaces for recreation and sport activities in their university. The previous study found that participants who had access to open spaces were 2.6 times more likely to be physically active than participants without access to open spaces (Shuval et al., 2009). Consequently, students are motivated to participate in LTPA when open spaces and parks are available, attractive, near to their dwellings, accessible and are perceived safe to use. The sports facilities in public universities today in Nigeria were actually meant to serve 450,000 students at a time of 1,252,913 enrolled students: 85% undergraduates, 5% sub-degrees, 3% postgraduate Diplomas, 5% Masters and 2% PhD (Okebukola, 2014). This also supports the view that hypothesised that the availability of public open spaces and parks was associated with recreational and possibly transport activities (Kabir, Sulaiman, 2011). With this background, it is clear that the facilities and open spaces in Southwest Nigerian universities have exceeded their carrying capacity and therefore cannot encourage LTPA.

The results corroborated an earlier study (Ladani, 1999) which claimed that the availability and attractiveness of LTPA sites were directly associated to the level of LTPA. Access to leisure facilities plays a critical role in LTPA engagement which is a direct result of the built environment or the layout of the community (Canolat et al., 2016). Research has indicated that the number of people who would show interest in LTPA would be determined by the nature and accessibility of leisure facilities. It thus means that achieving a greater LTPA depends largely on an environmental stimulus such as open space. It must be noted that if facilities are poorly located within a community, it matters little how well that facility is designed, as it is unlikely to be well-patronised. Furthermore, positive venue atmosphere (aesthetics), which is a product of facility design, has been discovered to be a key factor in encouraging people to participate in LTPA (Mulin, Hardy, Sutton, 2007). Therefore, the likelihood of achieving a greater LTPA depends on the physical environmental stimuli.

Access to equipment is a motivating factor for habitual participation in LTPA. The results of this study indicated that university undergraduate students in South West Nigeria would engage more in LTPA if they had access to training equipment in their schools/hostels. Stressing the correlations between the availability of exercise equipment and exercise engagement (Trost, Owen, Bauman, Sallis, Brown, 2002), propounded that access to exercise equipment supported exercise engagement and adherence. The results of this study also agreed with

(Spasova, 2011) in their study on physical activity determinants in obese and non-obese children which showed that irrespective of the weight status of the child, access to exercise equipment such as treadmills, bicycle ergometer, elliptical machine, rowing machine, stepper, free weight, etc., in schools/hostels were positively associated with an active lifestyle.

This study further demonstrated that students would be encouraged to be active in their neighbourhoods if the streets were well connected. This view corroborated (Mehta, 2006; Kamruzzaman et al., 2014; Sallis et al., 2015) who maintained that walking for transportation would be encouraged when the street network was more connected. They argued that the street pattern or connectivity affected the directness of travel and proximity of the destination and made travel more efficient, and that people who lived in well-connected streets tended to drive less than those who lived in car-dependent and not well-connected communities (Hansen et al., 2012). In examining existing literature concerning street connectivity, it was discovered that grid street designs create connectivity between the streets and more direct route choices for pedestrians, while curvilinear street designs (cul-de-sac) decrease community connectivity and discourage pedestrian activities in favour of automobiles.

The availability of street lighting was another attribute of a good environment that encouraged student exploration of their environment. The findings of this study indicate that students would engage more in LTPA in their neighbourhood if there were more streetlights. Street lighting is an attribute that is needed for nighttime activities (Sallis, Floyd, Rodriquez, Saelens, 2012; Kamruzzaman et al., 2014; Williams, 2015), increasing the feeling of security among LTPA participants (Nabofa, 2010). The lack of street lighting may hinder individual students from participating in LTPA in the evenings, during which they have more time to engage in LTPA as academic activities take a substantial part of the day.

The results of the study further indicate that meteorological factors were determinants of LTPA among university undergraduate students in South West Nigeria. The findings demonstrated that students would engage in LTPA if the weather conditions were favourable. This supports the findings (Ojeme, 2014) which explained that when there was congruence between individual and weather conditions, they would be happier, better adjusted and more likely to achieve personal goals such as active involvement in LTPA. Weather conditions can strongly promote LTPA (Turker, Gulliland, 2007). The attributes such as the amount of daylight, temperature, wind direction and velocity can hinder or promote participation in LTPA. The data in Table 2 show that rainfall/precipitation affected LTPA most, followed by temperature, relative humidity and wind velocity/direction, in that order. This agreed with (Junior, Reis, Hallal, 2014; Adesoye, Ajibua, 2017) which had earlier asserted that rainfall was negatively associated with physical activity. Studies showed that rainfall decreased the pleasure derived from outdoor activity (Coghill, 2012). Moreover, during rain or wet conditions, visibility reduces the satisfaction of physical activity programmes.

However, the data in Table 2 shows that university students participated in LTPA both in wet and dry seasons. One striking finding is that respondents engaged more in LTPA in the wet season than in the dry season. This is contrary to (Naser, Evans-Cowley, 2007) which posited that physical activity in the wet season was less than that of warmer seasons as it was inconvenient and inaccessible compared to warmer seasons. Likewise, A. Tuker and J. Gulliland (2007) remarked that physical activity among the general population increases from cold weather to warm weather. It should be noted that studies which examined the effects of weather and seasonality on LTPA were undertaken in Europe and America. These results should not be the same as those in Nigeria because of differences in weather conditions and seasonality. The reason that could be advanced for the results of the

present study is that there are no extreme weather conditions in South West Nigeria. In addition, South West Nigeria is located on the coast of Atlantic Ocean, which makes dwellers more water/cold weather friendly.

Again, this study revealed that weather parameters influenced the students' state of the mind. This corroborated research which compared cold temperatures with mental processes where low temperatures influenced the concentration of attention, memory and general cognitive practices (Staiano, Broyles, Kartzmaryk, 2015). From another research standpoint, it was discovered that extreme temperature might lead to mood disturbances such as nervousness, irritability, aggressiveness and reduced concentration of attention (Merril, Shields, White, Bruce, 2008). In the same vein, a study postulated that human physical vigour was influenced by temperature, humidity and wind. Consequently, high temperature and humidity tend to decrease physical and mental vigour and could adversely affect attitudes towards LTPA (Silva, Lott, Mota, Welk, 2013).

It was stressed that weather conditions influenced environmental resources, as indicated in this present study (Turker, Gulliland, 2007). Weather has great effects on physical activities (sports) such as football, baseball, golf, tennis, etc. Any game that involves objects flying through the air is affected by wind. In football, players must determine which way the wind is blowing (head or tail) to achieve accuracy and precision. In hot and humid weather, an object like a baseball travels further. The surface of leisure facilities is affected by venue atmospherics and are very crucial in people's interest in physical activity (Adesoye, Ajibua, 2017). Rainfall can also make the surfaces of sports facilities become inconvenient and impede the free flow of games.

The results of the present study affirmed that weather conditions affected the type of clothing participants use during physical activity. Research agrees that not only does the human body absorb heat from the environment, but it also creates heat (AgriLife Extension, 2008). In order to protect against overheating, it is important that people outdoors wear light-coloured and loose clothing during warmer periods for physical training. In the same vein, (American College of Medicine, 2006) was of the view that physical activity caused people to produce heat, so it recommended light-coloured cotton or cotton blended clothing to reflected sunlight in warmer seasons, and dark layered clothes in the wet season (American College of Medicine, 2006). This was based on similar results from the American College of Sport (Amuchie, 2002) suggesting that proper clothing was a very essential preventive strategy against health hazards when engaging in LTPA during extreme weather conditions.

Conclusion

This study found that the physical environment (built environment and weather condition) was a determining factor for participation in LTPA among university undergraduate students in South West Nigeria. In addition, the good location of facilities and the perception of safety were other factors that must be given serious consideration during the design of the environment. The present study suggested the need for more open spaces, strategic installation of street lights, better sidewalks, and better connections between areas of interest through intentional pedestrian-oriented development. Furthermore, there is a need for policymakers to put in place measures for vehicular speed control to promote the perception of safety in the built environment. The weather should be considered to ensure that outdoor and indoor facilities are put in locations that ensure students can be active in all the seasons of the year. The results of this study will help Sport Managers, Coaches and Fitness Trainers understand the need to suggest an activity-friendly environment during university infrastructural development programmes. It will also encourage an activity-friendly design of the university environment.

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THE HANDBALL GOALKEEPER – CHARACTERISTICS OF THE POSITION, PLAY, TECHNIQUES, TRAINING

Adrian Struzik

University of Szczecin, Faculty of Health and Physical Education, Poland

Address for correspondence:
Adrian Struzik
University of Szczecin, Faculty of Health and Physical Education
Al. Piastów 40B, 71-065 Szczecin, Poland
Email: adrian.struzik@usz.edu.pl

Abstract Changes in a goalkeeper's technique, his physical and mental preparation are ongoing, forced by the increasing power of the throw, speed of the game, improved players' throwing capability; throws with rotation and other technical innovations involved in this element.
The goalkeeper's tasks are not only limited to defending the goal. He participates in launching a quick attack or quickly resuming play after conceding a goal.
Goalkeeper training should be varied in order to mobilize the body's full energy potential and shape the elements of the technique. The goalkeeper should be intelligent, courageous, endowed with the excellent physical condition and above all physically fit.

Key words goalkeeper, handball, characteristics of the position, play, techniques, training

Training

Classification of physical exercise

Training involves the nervous system and affects its performance. Because of the training stimulus, conduction is much faster, since it activates motor units.

Movements (technique) become automated, acquired and therefore precise. Training – not only of a goalkeeper – should take into account the influence on all human senses in order to be able to take full advantage of the capabilities and abilities of a player.

Physical exercise induces a series of immediate functional changes in the body which accumulate over time to result in specific adaptation to physical exercise, which in sports terminology is referred to as physical capacity (physical capacity is the potential capability of intensive and long-term exercise with minor fatigue-related changes and fast effective rest) (Suchanowski, 1997).

Physical exercise can be divided into two basic categories:

1. Aerobic exercise, characterized by long-term physical effort lasting from 2–3 minutes to several hours, where the body functions in a steady-state to maintain a certain intensity.
2. Anaerobic exercise, characterized by short intensive physical effort using limited intramuscular energy resources. The high pace of changes makes it impossible to replenish this potential either by oxidation or by circulating blood, which results in oxygen debt, repaid during the rest.

Each of the exercise types mentioned above is characterized by a different type of strain, depending on its length, intensity and method of renewal (phosphocreatine, glucose, glycogen, fat and protein). Bearing this in mind when developing motor skills (strength, speed, endurance), other factors which will allow to develop a given ability should also be taken into consideration each time, such as the intervals between individual stimuli. Fatigue is inextricably intertwined with the training process.

Sources of exercise-induced fatigue can be divided into four groups of strains, depending on the characteristic mechanisms of fatigue:

a) the first group is maximum anaerobic strain (10–20 seconds in duration), fatigue is associated first and foremost with processes in the central nervous system and expending of phosphocreatine resources;
b) the second group includes close to maximum and maximum anaerobic strain (20–90 seconds in duration) connected to the production of lactic acid, where fatigue is caused by the accumulation of lactates, which negatively affect the function of the central nervous system (lactic acid hinders the conduction of nerve impulses);
c) the third group is associated with strain of maximum (5–10 minutes) and submaximal (30–80 minutes) aerobic capacity, leading to greater involvement of the oxygen transport system and using glycogen and glucose from the blood.

Fatigue

In this context, fatigue has a vegetative character and is due mainly to depletion of glycogen in the liver and muscles, and reduced capability of the cardiac muscle. The fourth group are strains of small and medium aerobic capacity, i.e. over 80–90 minutes, where the mechanism of fatigue is similar to the previous group, but in this case, fatigue can also be affected by incorrect thermoregulation and the effects of anoxaemia of products of breakdown of fats.

The main cause, often resulting in interruption of the exercise due to fatigue, are defensive reflexes in the central and peripheral nervous system. This leads to a dominance of inhibition over stimulation and disruption of the flow of impulses transmitted along nerve-nerve synapses (general fatigue – central) and nerve-muscle synapses (local fatigue – peripheral). It is a cause of disturbance in the technique of movement, incorrectness of movement, impairment of reaction, the wrong choice of the type of movement (Malarecki, 1981).

Rest

Another important issue related to training is rest. Recovery processes depend on the type, duration and intensity of the effort, and with reference to the various types of exercise it can be concluded that:

a) after anaerobic exercise lasting up to 30 seconds at an intensity of approx. 90%, recovery occurs within 90 to 120 seconds;
b) in the case of anaerobic exercise involving the accumulation of lactic acid, certain vegetative (e.g. respiratory) indicators go back to normal after approx. 60–90 seconds, and recovery of others may take 3–4 minutes or more, depending on the intensity and duration of the effort causing the accumulation of lactic acid; sometimes the metabolism of lactic acid can take 1–1.5 hours;
c) after maximum aerobic effort with an average pH value of 6.9, normalization of indicators happens at a variable rate and the recovery time for pH of arterial blood – 1 hour, for blood glucose – 3 hours, for glycogen in the muscles – 3 days;
d) for aerobic continuous load, the renewal of glycogen in muscles is usually carried out in two stages, and after 1 hour – 67%, and after 24 hours – return to the baseline.

In addition, it should be added that the intensity of the recovery processes varies over time, and the greatest intensity is usually seen immediately after the cessation of effort. After intense effort, e.g. strength exercises, the intensity of recovery decreases significantly after just 10–15 minutes after exercise. It is characteristic that the recovery is usually carried out in three stages, as follows:

– in the first stage of rest, 60% of recovery takes place,
– in the second stage of rest, a further 30% takes place,
– in the third stage of rest, the remaining 10% of recovery takes place.

Knowledge related to this issue is certainly important and should be used in the organization of the training.

Let us consider how all this information relates to the specificity of the goalkeeper's functions in handball, since it creates the basis for specifying the nature of the goalkeeper's efforts in the context of overall conditions related to the development of the relevant functional characteristics. This is necessary to accurately define the scope, direction and nature of measures implemented in the training process. From that standpoint it can be concluded that the goalkeeper's functions are characterized by short high-intensity actions which require intense concentration and precision of movement, resulting in both physical and mental stress. Referring to the previously discussed sources of energy, it can be stated that the goalkeeper's efforts can be defined as non-lactate anaerobic exercise, further characterized by a large involvement of the psychological sphere (Norkowski, 2002; Malarecki, 1981).

The nature of sports competition

The area of the handball goalkeeper's activity is around the goal area (ca. 80 m^2), wherein he operates mainly in the close vicinity of the goal, i.e. in about 1/3 of the area, and his range of movement usually does not exceed 10–15 metres. Consequently, the space and range of activities are relatively small. Analysis of his actions in the gameplay leads to the conclusion that three basic groups of activities can be identified, namely:

– moving in order to take a position in relation to the current position of the ball, or in connection with taking over the ball in order to resume play,

– interventions, i.e. appropriate use of the torso and limbs when the ball is thrown,
– manoeuvring the ball in order to take control of it after intervention, or resuming the game after a missed shot or a shot deflected by the goalkeeper or the goal.

The goalkeeper intervenes between 40 and 50 times. The rhythm of his actions depends on the rhythm of the opponents' offensive actions, and barring breaks in the game, a goalkeeper acts according to the following scheme: focusing for 30–50 seconds, responding to the ball movement, resuming play with a throw, and distractions while co-players are in possession of the ball. The whole cycle starts again from the moment an opponent is in possession of the ball. The extent and nature of the goalkeeper's activity lie within short duration maximum efforts, interspersed with periods of rest, the length of which allows regaining a physiological balance. The nature of the activity indicates that the sources of energy here should be non-lactic anaerobic processes (the main source of the resynthesis of ATP is phosphocreatine), since the goalkeeper's actions or interventions, even if it requires running to the ball after a missed shot, last between a few to several seconds. Determination of the intensity of the goalkeeper's activity based solely on the measurement of the heart rate can be misleading, due to the small range of movement and short duration of effort where the pulse does not adequately reflect the level of the body's response to the exercise. The scale of the load depends largely on psychological tension and emotional states related thereto, since the goalkeeper performs under increased psychological pressure, which in difficult situations (ineffective intervention, critical evaluation) can reach a level of stress. Great strain on a goalkeeper's psyche can be put down to the need to repeatedly re-focus and can also be the result of a sense of responsibility for the result of his actions.

The goalkeeper's effort is cyclical, his behaviour repeatable, its rhythm is determined to the same degree by the pace and nature of the actions of the defensive co-players and the offensive opponents.

Despite such difficult operating conditions, the goalkeeper's efficiency is on average approximately 40–43%, and depending on the degree of difficulty of each situation, connected to the place and methods of the throws, may vary between 25–65%.

Characteristics of the position

The number of goalkeeper's effective interventions in a handball match largely determines its outcome. A good goalkeeper, who defends 40–50% of throws, contributes significantly to increasing the value of the team and improving the game's outcome. The goalkeeper's performance requires great and specific physical effort, excellent skill and courage. The small distance from the throwing player and the constantly increasing force of the throw require not only quick reflexes but also predicting the trajectory of the ball, as well as good cooperation with defenders.

The number of goalkeeper interventions in one match amounts on average to 50 throws. Each of his mistakes is easily visible, and at the same time almost beyond repair.

But the most important factor in the goalkeeper's play is the analysis of the situation on the court, position of the throwing player's hand, frequency of throws into the specific area of the goal, place of the throwing player's jump.

Being tall is now a requirement for a goalkeeper at the highest level. The required speed and agility require that the goalkeeper's weight must be proportional to his height (athletic body type). The most characteristic types of goalkeepers are:

1. **Stationary goalkeeper – height over 190 cm, defends mostly using good positioning and range.** The goalkeeper plays in front of the goal, always trying to cover the area of the goal as much as possible using his position, which is made possible by the size of his body. He occasionally loses contact with the ground or balance (jump or defence combined with a roll).
2. **Dynamic goalkeeper – 184–190 cm tall, his advantage is speed and dynamic performance.** He is always moving in the goal (advance, shift). Very good overall fitness and technical training allow the goalkeeper to undertake a variety of measures.
3. **Speedy goalkeeper – height around 180 cm, the need to make up for physical shortcomings (range) forces him to display very quick reactions**. Intervention mostly takes place in so-called first tempo, that is, without anticipation. He often defends in the air (jumping), or with a "flying save". His strong suit is anticipation. Currently rarely seen in handball at a high level (Nowiński, 2002; Czerwiński, 1990).

Goalkeeper's body position

The goalkeeper's position is the orientation of his body in relation to the ground, goal and offensive throwing player, and is conditioned by the necessity of fast and free responses. All the movements in the goal should be performed according to the principle of a "screen" covering the face of the goal (arms, torso, legs). A ball deflected by the goalkeeper's hands should be retained, not bounced forward in a "boxing-tennis-like" movement.

Elbows should always be bent, forearms and hands diagonally forward. In order to feel at ease, the goalkeeper should minimize unnecessary muscle tension, as below:

a) feet slightly apart at hip width; body weight should rest on the midfoot, with heels slightly raised. Feet should be parallel, with fingers pointing in the direction of the ball flight;
b) position of knees and hips – looking at a correctly positioned goalkeeper from the side, his whole silhouette should be leaning a bit forward, legs slightly bent at the knee and hip;
c) position of arms – shoulders and torso should form a kind of wide W letter, hands should be at shoulder height (goalkeepers approx. 190 cm tall and taller). Shorter goalkeepers should keep their hands at eye level; the arrangement of the arms in this manner is dictated by the fact that the distance between the arms and high and low balls in this position is the same and thus the probability of deflecting the ball is higher. Looking from the top, the goalkeeper's arms should form an arc, and the palms with their biggest surface should be facing the direction of the trajectory of the ball; the arms should be held forward in a way to allow the goalkeeper to see both hands while looking ahead (Nowiński, 2002; Norkowski, 2002).

Playing technique

Within the technique, three groups of issues corresponding thematically to three aspects of goalkeeper's play can be distinguished, namely:

– issues related to the methods of carrying out locomotor tasks, e.g. everything that has to do with goalkeeper's techniques of moving outside and inside goal area,
– issues involving handling equipment, e.g. techniques of catching, blocking, passing and throwing the ball,
– issues concerning reacting to throws toward the goal, e.g. techniques of the goalkeeper's intervention.

Examining the kinds of goalkeeper's movement, show the difference between the technique of moving within the playing area, where he must submit to playing regulations, and the technique of moving in the goal area, where he is not constricted by rules regulating his movement. The specific nature of the goalkeeper's play makes him operate mainly within the goal area, which should also be of main interest.

Techniques of moving include elements such as various forms of running, walking (variants of side shuffle), jumping, one-legged and two-legged jumps, various rolls, and any other forms of locomotion-related movements.

Generally, there are two ways of moving within the goal perimeter depending on the players' height (Figures 1, 2).

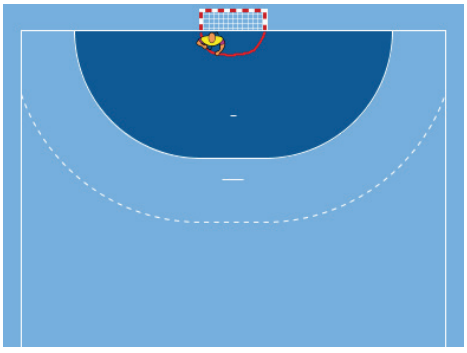

Figure 1. Tall goalkeepers move in an arc in the front of the goal, while simultaneously circulating the ball

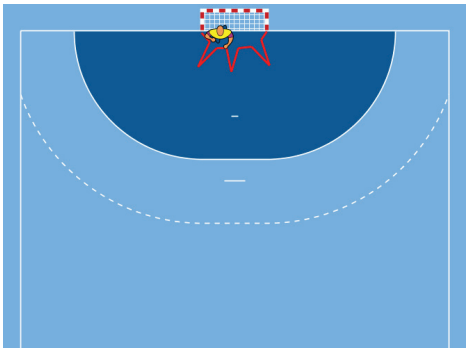

Figure 2. Shorter dynamic goalkeepers at every attempt on throw make a short leap forward and return to their line

Other ways to move in the goal include:

1. Moving forward – reducing the angle of the shot.
2. To the side – after the ball, prolonging the moment of taking a correct position.

Another very important issue is to teach young goalkeeping trainees to save high shots through jumping with the leg opposite the direction of intervention. Especially in case of throws out of the goalkeeper's reach.

Operating the equipment refers to the technique of the goalkeeper's contact with the ball in the goal area, which includes items such as catching, passing and dribbling the ball, bouncing or blocking the ball with the limbs and torso, and throwing the ball different distances.

The goalkeeper's reactions also depend on the ball's speed and trajectory.

While analysing defence techniques, the kills of a goalkeeper should be developed and varied, which is perfectly illustrated by Figure 4. It also confirms the necessity, complexity and comprehensiveness of the specialized training. Mastering all defence techniques and methods of moving in the goal takes time, careful planning and consistency in coaching.

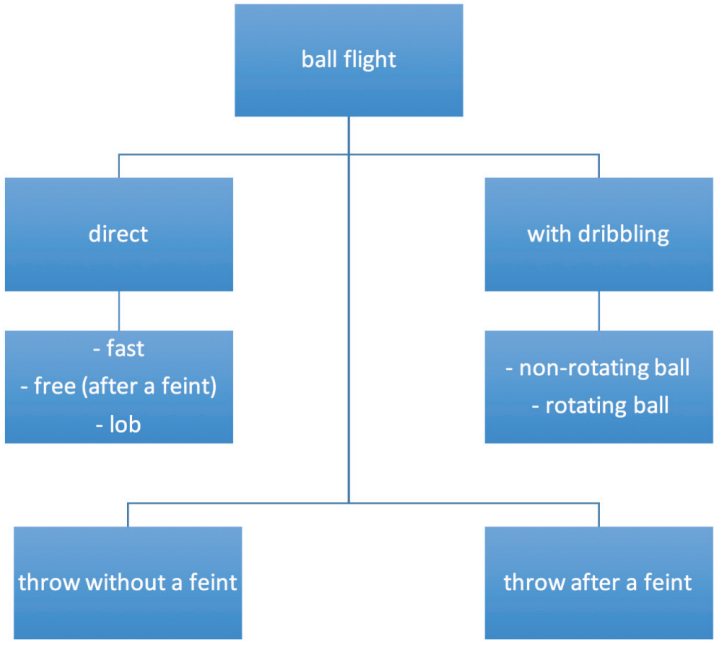

Figure 3. Circumstances of a handball goalkeeper's intervention

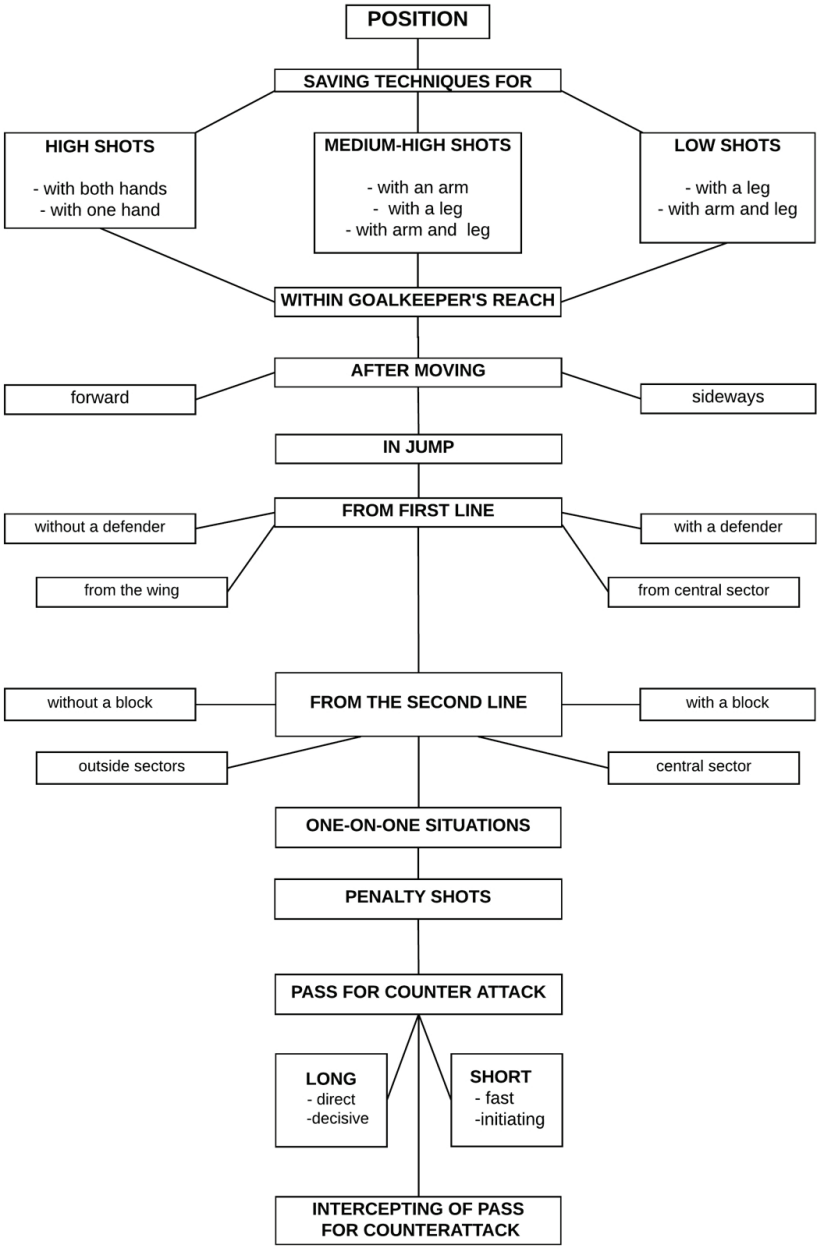

Figure 4. Individual skills of a handball goalkeeper

Cooperation between goalkeeper and defence

Regardless of his abilities, the goalkeeper tries to somehow predict into which part of the goal a shot is going to be directed. The choice depends on the situation on the court. Today we can say without a doubt that the best goalkeepers in the world are players over 30 years old. The ability to observe and analyse in an instant is the main asset of their experience. Every throw brings additional information. The trajectory of the thrown ball usually depends on the direction of the throwing player's movement, position of the hand with the ball and the presence or absence of a defender.

This latter information determines the block in the central sector in case of throws from the second line or in a presence of a defender, and the choice of intervention in the case of throws by a wingman allows the goalkeeper (even forces him) to choose the correct action. Defenders try to facilitate the intervention of the goalkeeper, through individual and team actions.

External defenders:

a) pushing (in accordance with the regulations) the wingman to the outside and limiting his choice of shots;
b) in the case of long shifts an attempt to return immediately and limit the wingman's "area of deflection" with simultaneous use of the hands (raising up) or falling under the feet, i.e. sliding tackle, which makes it difficult for an attacker to easily perform a high shot into the goal area.

Central defenders:

If it is not possible to stop the attacking player:

a) maximum shifts (in contact with the pivot), which obstruct freedom of deflection or loss of balance (using the body in accordance with the regulations);
b) attempt to block the hand, hindering the freedom to throw. This forces the pivot to deflect further and makes it impossible for him to feint (with a hand). This course of defender's action significantly reduces the attacker's operating time at the time of obtaining the throwing position (intercepting the ball – taking the position – throw).

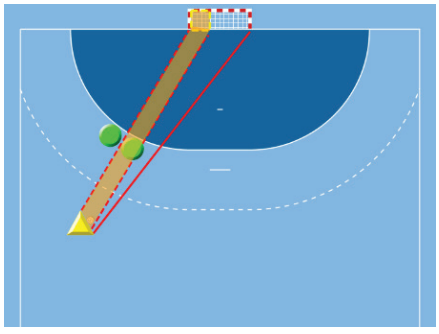

Figure 5. Reduction of goals using defenders

In teams with a low level of training, it is difficult to achieve cooperation and this often leads to confusion. Certain modes of action should be expected of blocking defenders, but they must be treated by the goalkeeper only as auxiliary.

In teams at the highest level according to the solutions adopted by coach or players, collaboration between the defence and the keeper is based on very precise rules and the full responsibility of each player.

It usually depends on the direction of the thrower's run-up and his position at the moment of the throw.

Often when the principles of cooperation prove to be ineffective, they are adjusted during the match. However, this requires of players a lot of experience and the ability to adapt (Nowiński, 2000; Nowiński, 2002).

Rules of goalkeeper's conduct – intervention

The fundamental issue in the process of goalkeeper training is teaching correct positioning in the goal, i.e. position in relation to the trajectory of the ball at the moment of the throw. The ball's trajectory towards the goal can be represented as a triangle whose apex is the ball and base is a line connecting the goal posts. The correct position of the goalkeeper involves a perpendicular alignment of the torso (hips) and feet in relation to the ball, so that the imaginary line connecting the centre of the goal and location of the ball runs centrally between goalkeeper's feet, which are pointing towards the ball.

The rules of handball goalkeeper conduct depend on the following factors:

a) time that a player has to make a throw and observe the goalkeeper,
b) space in the goal.

Three situations can be distinguished:

1. Sufficient time and large space

– one-on-one throw (e.g. a counterattack),
– penalty.

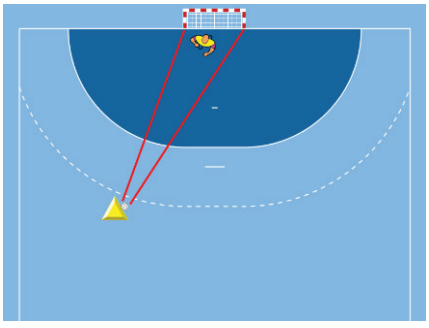

Figure 6. Sufficient time and large space

In such a situation the goalkeeper should keep attacking while misleading the opponent, who has time to observe his further actions, seek to provoke the enemy to throw into the spot chosen by the goalkeeper.

Courses of action:

a) reducing the available area of the goal by moving forward, which forces the throwing player to perform a more precise throw, e.g. imposition of operating conditions;
b) shift and exposing a part of the goal;
c) numerous changes of position (penalty), lowered position in the goal and standing up suddenly;
d) significantly raising the position – arms raised high up diagonally and sudden lowering at the time of a throw;
e) positioning on one leg and rapid change of legs with a jump, assuming that the opponent will throw properly towards "the loaded leg";
f) jumping and changing the arrangement of the arms and legs in the air;
g) standing with legs very wide apart and sudden joining of legs in the moment of the throw.

Most common mistakes:

a) passive behaviour of a goalkeeper before the throw;
b) constantly repeating the same method of intervention;
c) stepping out of the goal prematurely and too far out.

2. Sufficient time and little space – ***throw from the wing***

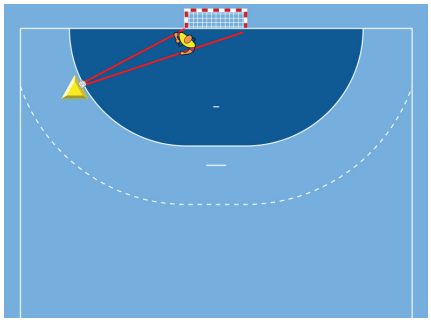

Figure 7. Sufficient time and little space – throw from the wing

Goalkeeper should:

a) with proper positioning prevent shooting "through", i.e. within goalkeeper's range (e.g. into the short corner, next to the head, between or under the raised leg);
b) wait calmly without making premature moves (after making one step forward with a foot closer to the post in order to cover the "short" corner of the goal);
c) shift while watching the ball, basing the range of motion on its position, in a situation when a wingman tries to jump past the goalkeeper, increasing the angle of the throw;
d) wait (after moving forward and shifting – both feet on the ground) with the intervention to the last moment, i.e. when the opponent does not have time and must throw towards the goal.

Most common mistakes:

a) incorrect position, e.g. lowered hand next to the post, leaving space between the torso and the post, etc.;

b) premature lifting of one leg;
c) moving too far forward;
d) rotating the torso;
e) premature reaction, before shifting, allowing wingman to pass jumping goalkeeper.

At the top level of play, one can observe jumping on both feet with a shift forward-slantwise, while maintaining an upright posture. It becomes the primary means of defending throws from the wing. Goalkeepers wait to the last moment, and then suddenly shift with a jump, trying to use hands and torso to cover the surface of the goal. Both of the goalkeeper's feet are in contact with the ground. This replaces frequently used defence using positioning on one leg (closer to the post).

3. Insufficient time and large space

Throw from pivoting position (assisted by defenders) – player throwing from this position often has to – after catching the ball while sideways or back to the goal – to make half or full turn. Simultaneous pressure from defenders forcing him to act with maximum speed, therefore he does not have the time or possibility to carefully observe the goalkeeper.

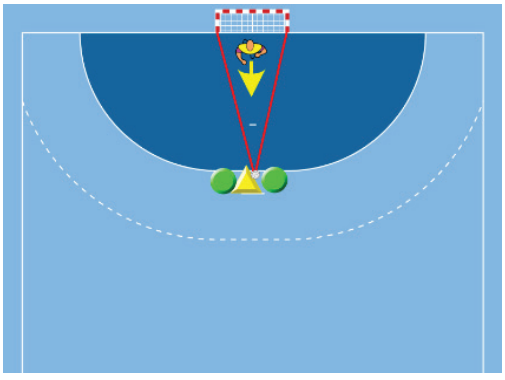

Figure 8. Insufficient time and large space

The goalkeeper should:

a) move forward quickly while reducing the angle of the throw, using the throw to the pivot and the moment of the pivot's action with the ball;
b) while moving forward keep the alignment in the line of ball – goalkeeper's torso – the centre of the goal (shifting if needed);
c) try to reduce the goal space available for the thrower through simultaneous use of arms (upper corners of the goal), and one or both legs (lower corners of the goal) after waiting for the moment of the throw;
d) in the case of throws from the side sectors, especially when a player is being pushed, one should not move forward too much;
e) make it as difficult as possible to shoot into the place that the throwing player deflects towards, i.e. throw in a straight line (forcing the throwing competitor to "drag out" the throw).

The most common mistakes:

a) late reaction (ball passes the forward-moving goalkeeper, who did not manage to get into position);
b) positioning in front of the thrower's body and not the throwing hand. Ball out of the goalkeeper's range;
c) premature lowering (legs wide apart, lowered hands) or raising (straight legs, hands up over the head).

Throws from the second line:

When defending these shots, there are two types of goalkeeper reactions. A well-trained player in this position should master both, and choosing one over the other is determined by the situation on the court. These are the defence along the goal line and moving forward:

1. Defence along the goal line – goalkeeper is positioned in the goal, the direction of the intervention is parallel to the goal line so that he has more time to observe the ball, but the area of the defended goal is bigger. Defence often used by smaller dynamic goalkeepers.

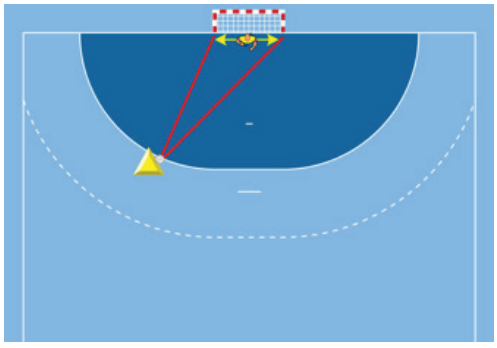

Figure 9. Defence along the goal line

2. Defence by moving forward – goalkeeper in front of the goal (moved forward), the direction of the intervention oblique to the goal line, shorter observation of the ball, but the goal space is limited by the positioning; this defence is more often used by tall goalkeepers playing positionally.

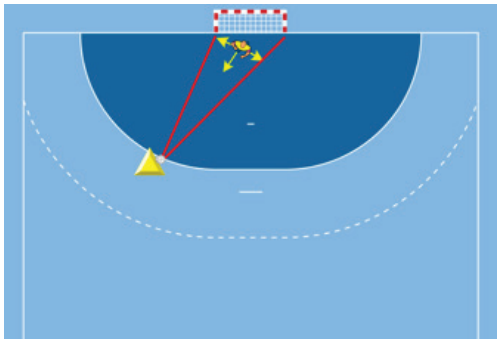

Figure 10. Defence by moving forward

Further premises when throwing from the second line are:

1. Throw performed after run-up in front of the goal – when analysing the situation, the goalkeeper can assume that the throwing player running perpendicular to the goal has a greater ease of throwing towards the closest post (it should be treated as additional information).

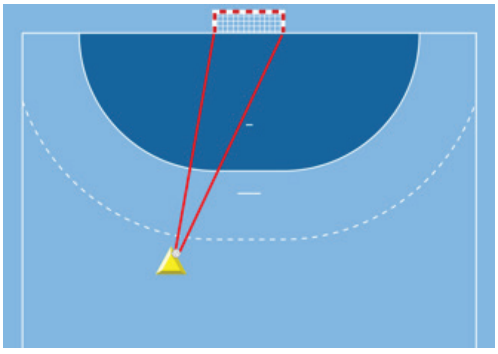

Figure 11. Throw performed after run-up in front of the goal

2. Throw performed after non-perpendicular run-up of a throwing player – in such situations, the goalkeeper can assume that the player moving parallel to the goal after crossing the centre will tend to perform throws towards the post closest to him, (of course it depends on many factors, among which the large role played by the degree of freedom and speed of a throw).

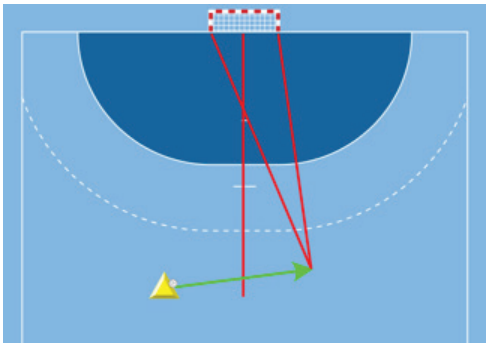

Figure 12. Throw performed after non-perpendicular run-up of a throwing player

Acting in situations of limited visibility of the throwing player's movements, which often occurs in the case of close contact with a defender, the goalkeeper should assume that the hand with the ball or the ball should appear in the gap between the defenders and it is there that he should position himself.

The above courses of action apply to all players at that position, regardless of how they play.

One should also distinguish between two different types of goalkeeper behaviour in the phase preceding the throw, i.e. static defensive actions and aggressive offensive actions.

1. Static defensive goalkeeper – waits for the action of the throwing player while retaining position and adjusting the position in relation to the ball, tries to intervene at the last moment; he leaves the choice of the place of a shot to the thrower, but, in turn, limiting the space in the goal often allows for effective defence.
2. Aggressive offensive goalkeeper – anticipates the throwing player's action, trying to force him to change his decision, goalkeeper induces uncertainty in the attacker's actions and in a sense provokes him to shoot in the direction the goalkeeper chooses; such behaviour often proves to be effective, but it requires a lot of control of the situation by the goalkeeper, and too far-reaching provocative actions may make proper intervention impossible.

Organisation of training

Training methods

The variety of situations during the game require that a goalkeeper presents a high degree of specialized skill, courage and the will to fight. The specialized skills include special speed, innate and developed reflex, which is one of the most important factors influencing the effectiveness of the goalkeeper's performance. Goalkeepers' movements are the result of responses to visual signals, i.e. incoming ball, throws performed by a shooting player and power. Dexterity and agility are required from a goalkeeper not only for the purpose of effective defence, but also in order to avoid injuries. Flexibility is particularly useful during interventions requiring a large range of movement of the joints. Stamina allows the use of all the technical measures during the whole match, and further facilitates concentration. Goalkeeper training should include methods (repetitive, variable, interval, intense variant in particular, starting, continuous), which reflect the specifics of playing in the goal. The specificity of the goalkeeper's function requires the development of high non-lactate anaerobic capacity, characterised additionally by a highly efficient regeneration of utilised energy substrates (Norkowski, 2002).

Forms of training

All movements in the goal should be performed according to the principle of a "screen" covering the face of the goal (arms, torso, legs). During training one must remember to properly develop both the tactical and technical skills of the goalkeeper. It must also strongly emphasize the diversity and accuracy of selection of the technique. Goalkeeper training should include four different forms of training:

1. Specialised training – separate, only with goalkeepers. Emphasis: performance-oriented, technical and high-speed.
2. Individual training with the team:
   - different tasks during training from other players in specific time units,
   - practice is either led by a second coach or goalkeeper exercise alone (under supervision of a coach) after receiving individual tasks.
3. Throwing training with the team:
   - planned series of throws,
   - throws from position without a defender,
   - throws in parts of the game (with a defender).

The coach should immediately correct mistakes regarding positioning, technique or premature anticipation.

Game or attack-defence parts:

– individual tactics of the game,
– cooperation with the defence,
– throwing for quick attack.

The next stage of the goalkeeper's know-how is anticipation of false information – provocation.

Anticipation. Goalkeeper intervention precedes the throw. He starts to move before the ball leaves the throwing player's hand. The direction and method of intervention chosen by the goalkeeper should be the result of an analysis of the situation on the court (block, the position of the throwing hand, the position of throwing and defending players). Often, they react knowing the habits of a particular attacking player.

False information – provocation. This includes actions such as deliberately exposing part of the goal (e.g. a short corner when shooting from the wing) or starting a movement or intervention to signal a planned action and immediate changing the action (Nowiński, 2002).

Conclusions

1. Changes in a goalkeeper's technique, his physical and mental preparation are ongoing, forced by the increasing power of the throw, speed of the game, improved players' throwing capability; throws with rotation and other technical innovations involved in this element:

a) deflecting balls thrown in the upper areas of the goal with both hands, not only within the goalkeeper's range, in order to cover a bigger area of the potential shot;
b) blocking the lower parts of the goal with the whole body through a dynamic shift on the legs and sitting with legs apart with the hands above the legs or defence through half-split with dynamic shift on the legs in the goal's area into which the shot will be directed;
c) forcing the throwing player to perform a more difficult throw (straight line throws are defended);
d) cooperation with the attackers;
e) during counterattack (one-on-one situation) this is particularly evident with the Danish and Swedish goalkeepers: at the moment of the throw, the goalkeeper dynamically sits with legs apart and hands raised above his head; this is due to the fact that in this
f) situation the throwing players are aiming at the lower parts of the goal (statistical calculations).

2. The goalkeeper's tasks are not only limited to defending the goal. He participates in launching a quick attack or quickly resuming play after conceding a goal.

3. The goalkeeper's training should be varied in order to mobilize the body's full energy potential and shape the elements of the technique.

4. Selection: goalkeepers should be intelligent, courageous, endowed with the excellent physical condition and above all physically fit.

In conclusion, one can recall the statement of one of the best goalkeepers in the history of handball, multiple medallist of the World Cup and Olympics, Yugoslavian/Croatian Mirko Bašić: "in order to be a quality goalkeeper one has to have technical and tactical skills, and physical and psychological advantages built up to the maximum, but intelligence and composure are necessary and most important".

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