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Physical activity profile of the referee and the assistant referee during official football matches

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Authors' Contribution:

- A Study Design
- B Data Collection
- C Statistical Analysis
- D Data Interpretation
- E Manuscript Preparation
- F Literature Search
- G Funds Collection

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abstract

- Background** The aim of this study was to determine physical activity profiles of the main referee and the assistant referee during official championship matches.
- Material/Methods** Motor activity of 10 referees and 10 assistant referees was studied during 10 matches of the championship rank in the period from April to November 2016. Using a *POLAR M400* heart rate monitor with a built-in *GPS* sensor, the total distance covered during refereeing, the mean and the maximum speed, and the intensity of the refereeing effort were analyzed.
- Results** It was found that the main referee covered the mean distance of 7.75 km, while the assistant referee 4.40 km. The main referee's mean heart rate was higher by 25 bt/min than that of the assistant, and the mean maximum heart rates were 184.9 bt/min and 166.6 bt/min, respectively. The assistant referee had the mean maximum running speed of 19.97 km/h. In general, the mean running speed of the main referee was higher than the assistant referee's mean speed.
- Conclusions** Differences in physical activity between the main referee and the assistant referee indicate a need for different fitness training in order to prepare them for presiding over a match.
- Key words** football, activity profile, referee, assistant referee

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INTRODUCTION

Football is one of the most popular sports disciplines in the world. Spectators' attention mostly focuses on players and coaches, but referees play no less important role in a football show. Refereeing a football match is associated with performing interval efforts of varying intensity and duration by both the main referee and his assistants. Referees very often take decisions in a situation of psychomotor discomfort [1], hence they are expected to have motor preparation, adequate to the tasks which they perform on the pitch [2, 3]. On the other hand, it is argued that walking and trotting, which are low-intensity efforts, are the most common forms of football referees' motor activity. For example, Krustup & Bangsbo's research [4] shows that Danish referees are inactive for 21.8% of the total duration of the match, and on average they stand for 7–8 s in each 35-second period. However, one must remember that referees' motor activity profiles during a match, expressed in the distance covered by them, are similar to the effort structure of professional football players [5].

Undoubtedly, modern football makes increased demands on the players and referees. In response to the increasing pace of game, they are expected to make effective decisions under extraordinary physical effort, often in situations of mental discomfort [6].

Research on referees' psychomotor efficiency in the realities of sports competition allows rationalizing their preparation to refereeing, i.e. adjusting training loads to the requirements which they have to face during a match. Therefore, motor demands on refereeing in football have often been analyzed [3, 4, 7–14]. From the point of view of the efficiency of refereeing, studies on evaluating mistakes in relation to the loads and the referee's activity time during a match are extremely valuable. Actions taken by the referees are frequently situated in the zone in which cognitive functions may be disturbed [15]. For example, studies conducted during FIFA Confederations Cup 2009 matches in South Africa show that the percentage of the main referees' wrong decisions in the central part of the pitch increased from 9.3% to 17.0% between the first and second half of the match (13 and 25 wrong judgments per 140 and 147 decisions, respectively), and in the last 15 minutes of the matches they made the most errors (23%). On the other hand, among assistant referees, the proportion of wrong decisions amounted to 12.7% of all of their judgements [16].

The purpose of this study was to define motor activity profiles of the main referee and the assistant referee during official championship matches organized by European football federations. The following research questions were put forward:

- What distance do the main and the assistant referees cover during a match?
- What is the difference in the intensity with which the main and the assistant referees cover this distance during a match?
- What is the mean speed at which the main and the assistant referees cover this distance during a match?
- What maximum speeds do the main and the assistant referees achieve during a match?

MATERIAL AND METHODS

Motor activity of 10 main referees and 10 assistant referees was studied during 10 matches of the championship rank in the period from April to November 2016. The age of referees was in the range 26–30 years. Their body height was in the range of 177–183 centimeters and their body weight was 68–78 kilograms. Their field experience was in the range of 7–10 years. In turn, the age of assistant referees was in the range of 25–28 years. Their body height was in the range of 183–190 centimeters and their body weight was 76–83 kilograms. Their field experience was in the range of 5–7 years. All of them received written consent to participate in the research from the Department of Referees of the Polish Football Association. All referees and assistant referees did the same training program. A detailed list of matches in which the measurements were made is presented in Table 1. In every match we measured results achieved by the main referee and assistant referees. We chose the matches between teams which were at a similar level. Duration of matches was 90 minutes with additional time.

Table 1. List of matches in which referees' motor activity was analyzed

No.	Match	Type of match	Date of analysis	Start the match
1.	Jura Sud Foot - Olympique Lyon II	4 th French league	30 Apr. 2016	18:00
2.	Chojniczanka Chojnice - MKS Kluczbork	1 st Polish league	29 May 2016	15:00
3.	Wda Świecie - Puszcza Niepołomice	1/32 of the Polish Cup	23 July 2016	17:00
4.	Górnik Zabrze - Stal Mielec	1 st Polish league	5 Aug. 2016	20:30
5.	Miedź Legnica - GKS Katowice	1 st Polish league	17 Sep. 2016	18:00
6.	Chojniczanka Chojnice - Wisła Kraków	Quarterfinal of the Polish Cup	27 Sep. 2016	17:45
7.	GKS Tychy - GKS Katowice	1 st Polish league	1 Oct. 2016	15:00
8.	FC Bern - S.C. Binningen	2 nd Swiss league	8 Oct. 2016	16:30
9.	Górnik Zabrze - Stomil Olsztyn	1 st Polish league	16 Oct. 2016	18:00
10.	Olimpia Elbląg - Polonia Bytom	2 nd Polish league	26 Nov. 2016	13:00

To measure the tested referees' motor activity and the intensity of effort, heart rate monitors *POLAR M400* with a built-in GPS sensor were used. M400 was produced in Kempele in Finland by POLAR company. M400 consists of a watch and a heart rate sensor. They enable measuring the heart rate, the distance covered, the mean speed and the maximum speed in the course of refereeing matches. Each of the referees had his individual heart rate zones defined in reference to their maximum heart rate. M400 is compatible with a satellite, so all referees found a GPS signal before the match. Watches recorded the distance which they covered, and the running speed during the match. After the game they uploaded all results to the computer by means of polar flow program. Referees' heart rate was registered by a watch which was synchronized with the heart rate sensor which positioned was on an extra belt on the chest.

To verify the compatibility of the obtained results with the normal distribution, the Shapiro-Wilk test was used, and to determine the homogeneity of variance of comparable results, the Levene test was applied. Statistical significance of differences in means was tested with Student's t-test for independent samples and, in the absence of compliance with the normal distribution, with Mann-Whitney U test.

RESULTS

The data presented in Table 2 show that the differences between the main referee and the assistant referee, both in terms of motor activity (the total distance covered during a match, the mean speed and the maximum speed) and the effort intensity (the maximum heart rate, the mean heart rate) are significant. The test results were calculated using Microsoft Excel 2010 and Statistica 12, Stat Soft Polska, Kraków.

Table 2. Descriptive statistics of data (as mean \pm SD and range) and significance differences in means (as p value) of the covered distance, speed and heart rate obtained by the tested referees during matches

	Main referee	Assistant referee	p value (p)
Distance covered (km)	7.75 (6.80-8.89)	4.40 (4.15-5.01)	0.0002***
Mean heart rate (bt/min)	162 (155-172)	137 (124-146)	0.0001***
Max. heart rate (bt/min)	184.9 (174-201)	166.6 (156-178)	0.0001***
Mean speed (km/h)	4.92 (4.55-5.70)	2.78 (2.55-3.19)	0.0001***
Max. speed (km/h)	18.08 (15.2-20.1)	19.97 (16.8-22.7)	0.0465*

*p \leq 0.05 ***p \leq 0.001

It appears from the data presented in Table 2 and Figure 1 that during a match the main referees ran a mean distance of 7.75 km and assistant referees 4.40 km (a mean distance shorter by 3.35 km, gives a difference of 43.2%). Depending on the match, the differences in the distance ranged from 2.65 km to 4.39 km. Analysis with a use of the Mann-Whitney U test proved that the main referees ran significantly longer distances during matches than assistant referees (p = 0.0002).

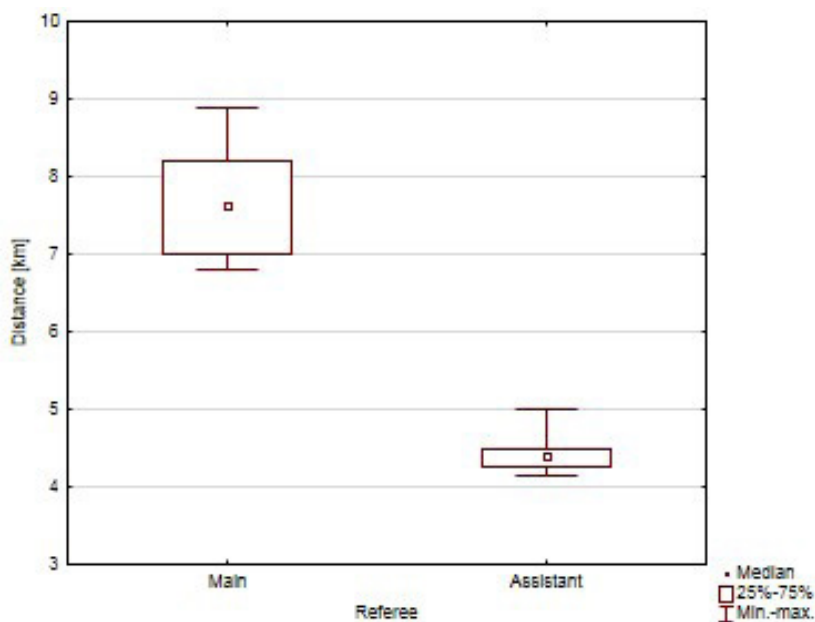


Fig. 1. Quartiles of the distance covered by the main and assistant referees during matches

In the case of main referees, the mean heart rate was 162 bt/min, while in assistants 137 bt/min (Table 2, Figure 2). These differences proved to be highly statistically significant ($p=0.0001$).

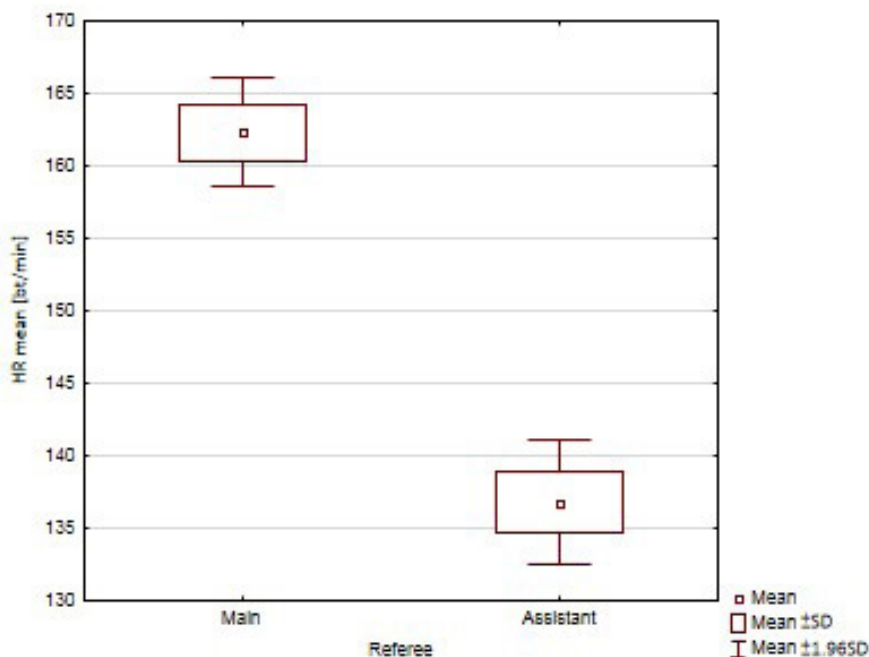


Fig. 2. Values of the arithmetic mean and standard deviation of the average heart rate in the tested main and assistant referees

In turn, the maximum heart rate was in the range of 174–201 bt/min in main referees and 156–178 bt/min in assistants (Table 2, Fig. 3). The mean maximum heart rate was lower by 18.3 bt/min in line referees (a difference of 10%). Statistical analysis with a use of Student's t-test for independent samples showed significant differences ($p = 0.0001$) between the tested referees.

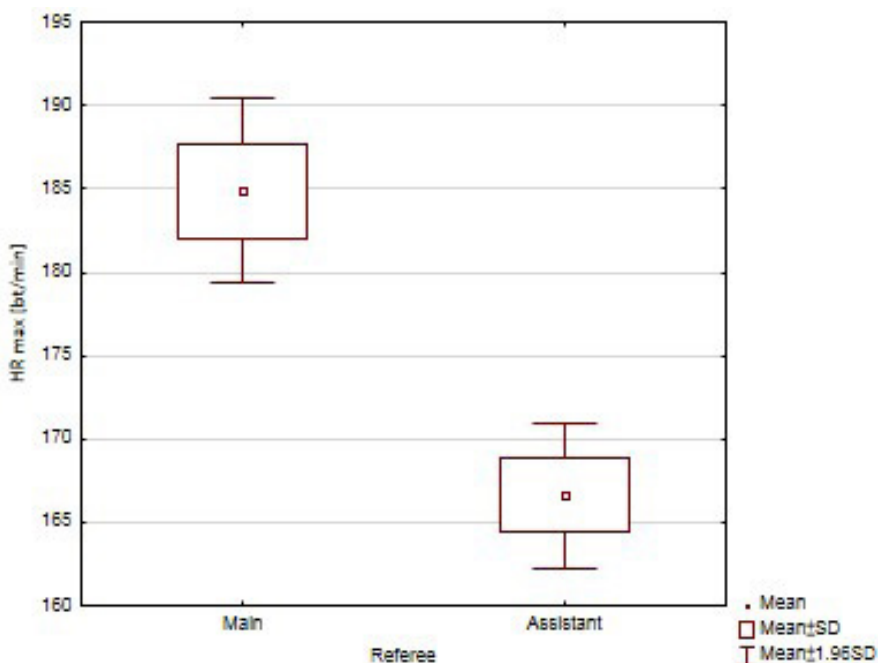


Fig. 3. Values of the arithmetic mean and standard deviation for the maximum heart rate in the tested main and assistant referees

It follows from the data presented in Table 2 and Figure 4 that main referees achieved a higher mean speed than assistant referees also in any of the conducted matches, on average higher by 2.14 km/h. These differences were statistically highly significant ($p = 0.0001$).

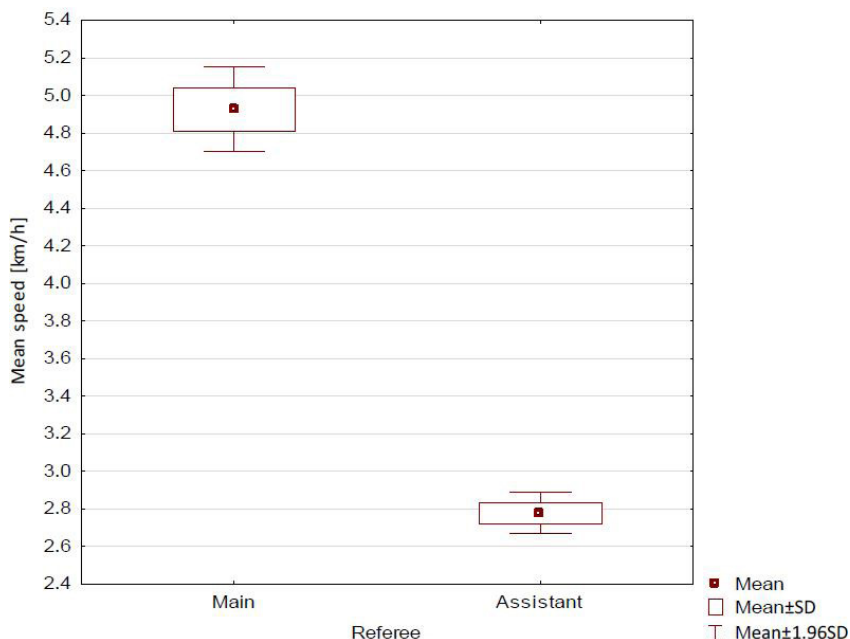


Fig. 4. Values of the arithmetic mean and standard deviation of the mean speed of the tested main and assistant referees

In turn, in most of the analyzed matches (seven) assistant referees achieved higher maximum speeds than main referees, on average by 1.89 km/h (Table 2, Fig. 5). Analysis of the significance of differences in mean arithmetic results (Student's t-test for independent samples) revealed statistically significant differences between the studied groups of referees ($p = 0.0465$).

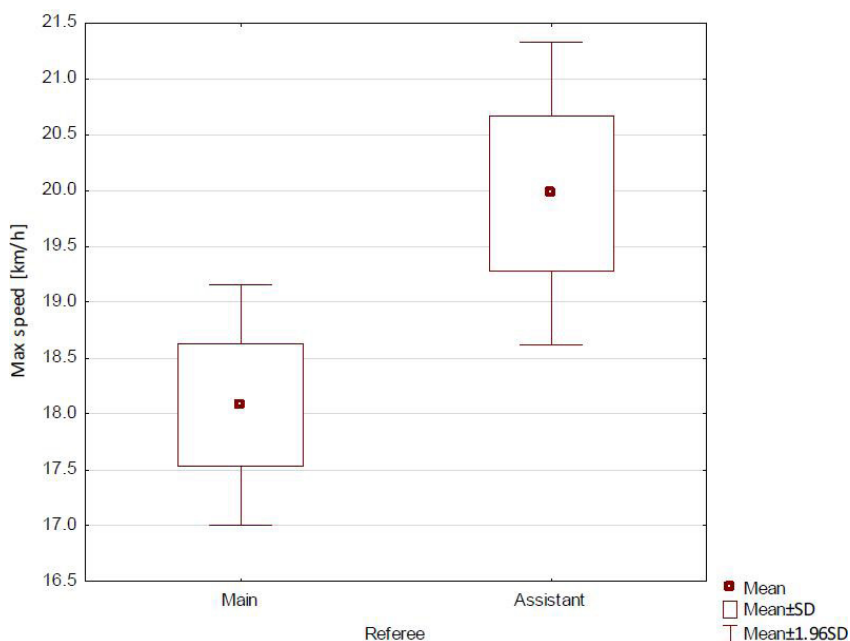


Fig. 5. Values of the arithmetic mean and standard deviation of the maximum speed of the tested main and assistant referees

DISCUSSION

The aim of the study was to define motor activity profiles of the main referee and the assistant referee while conducting official football matches and to indicate the differences in the total distance covered, the mean speed, the maximum speed, and the values of the maximum and the mean heart rate between the studied groups of referees.

The differences in the covered total distance between the studied groups of referees amounted to over 3 kilometers and they were statistically significant ($p = 0.0001$). The results of our tests correspond with Reilly & Gregson's findings which show that main referees cover 10,000 m on average during a game and assistant referees cover approximately 7,500 m [17]. They proved that an assistant referee faces less demands in terms of physical effort, because his motor activity is limited to moving along the side line of one half of the pitch, and this significantly affects the distance covered by him during a match. The main referee moving around the whole pitch covers a much longer distance than the assistant referee.

Research conducted by Krstrup, Helsen, Randers et al. [18] shows that the mean distance covered by the main referee is 10.27 km (± 0.90 km) and 6.76 km (± 0.83 km) by the assistant referee and they are different than ours. In turn, according to Weston, Castagna, Impellizzeri, Bizzini, Williams & Gregson [19], main referees cover 11.77 km (± 0.81 km), of which 0.89 km (± 0.33 km) with high velocity (> 19.8 km/h). The reasons for these quite significant discrepancies obtained in our study and by other research teams may result from the pace of game achieved in a particular match, referees' individual preferences for motor activity and their experience in refereeing (only in the case of main referees; assistants' activity is forced by the game situation), the sports level of the competing teams (e.g. in the Polish leagues the dynamics and the players' pace of game highly deviates from top-level players' motor activity), rank of the competition (players' different involvement, and hence the referees' activity depending on whether this is a cup, league or international match).

As regards the second research question, concerning differences in the intensity of the main referees and the assistant referees' effort, our results point to a significantly higher intensity of efforts performed in a match by main referees than assistant referees (the mean heart rate higher by 25 bt/min). Also the ranges in which the values of the maximum heart rate fell indicate a much higher intensity of efforts of main referees in comparison to assistants (174-201 bt/min and 156-178 bt/min, respectively). Moreover, the mean maximum heart rate value was lower by 18.3 bt/min in the case of assistants. This should be explained by the specifics of arbitration of both groups of referees. The main referee many times runs longer distances, with varied intensity and in more frequent periods than the assistant referee, which determines the higher values of the analyzed indicators [4].

We have shown in the studies that the mean speed of the referees presiding over matches was 4.92 km/h in the case of main referees and 2.78 km/h for assistant referees. The difference was statistically highly significant ($p = 0.0001$), and its causes have been identified above. It is worth adding here that the assistant referee's activity significantly differs from that of the main

referee in terms of the share of high and medium intensity running in the total distance covered during a match [18]. This indicates the reason for the lower mean values of the analyzed indicators: the total distance covered, the heart rate and the achieved speed.

We have obtained interesting results for the maximum speed achieved by the tested referees. Thus we have shown that in most of the analyzed matches assistant referees achieved a higher maximum speed than main referees (respective mean values were 19.97 km/h and 18.08 km/h). These differences were statistically significant ($p < 0.05$). These facts indicate the specific nature and the diversity of tasks related to their refereeing. The assistant referees run along the sideline and they position themselves at the level of the offside player, and this necessitates running at high and very high intensity, with speeds similar to the maximum. But it has also been shown [18] that the distances covered with sprint by both the main referee and the assistant referee are similar, respectively: 0.22 km (± 0.13 km) and 0.26 km (± 0.10 km). Therefore, sprinting does not differentiate between main and assistant referees' motor activity.

Finally, it should be added that interpretation of the presented here results has limitations arising from the small sample size. The presented by us profile of referees' motor activity should still be verified, also with distinguishing between groups of referees presiding over matches of a different rank and at different levels of sports competition (international matches, continental leagues, national leagues and classes). Furthermore, one needs to emphasize that referees' motor activity profiles should be the basis for modification or development of new fitness tests that would constitute a mandatory eligibility criterion for refereeing at appropriate levels of competition.

CONCLUSIONS

Differences in motor activity between the main referee and the assistant referee point to the need for different preparation of both groups of referees to preside over a match. Rational motor training of main referees and assistant referees should reflect both the kinematic structure and the characteristics of intensity specific to their efforts performed while refereeing.

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