

Relative pitch area plays an important role in movement pattern and intensity in recreational male football

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ABSTRACT: Recreational football has been shown to be an effective health-promoting activity, but it is still unclear how changes in game formats affect external and internal load. The aim of this study was therefore to evaluate the effect of area per player in recreational small-sided football games. Ten recreational active male football participants (mean±standard deviation, age: 20.1±1.1 years; height: 182.2±7.4 cm; body mass: 75.9±9.8 kg) completed two sessions comprising 2x20 min of 5v5 football with 80 and 60 m² per player, during which heart rate (HR) and movement pattern were measured. In 80 m², mean HR (167±9 vs. 160±10 b.p.m., P<0.001, ES=0.70) and peak HR (192±8 vs. 188±9 b.p.m., P=0.041, ES=0.50) were significantly higher than in 60 m². Percentage playing time with HR >90%HR_{peak} was higher in 80 m² than 60 m² (45±14 vs. 29±16%, P=0.004, ES=1.07). Moreover, a higher number of sprints (8.0±4.8 vs. 3.0±1.3, P=0.014, ES=1.41) and a greater distance in the highest speed zones (>13, >16 and >20 km·h⁻¹) were covered in 80 m² than 60 m². Peak running speed was also higher in 80 m² (24.3±1.7 vs. 22.3±1.4 km·h⁻¹, P=0.011, ES=1.27), whereas no statistically significant differences were found in total distance covered, player load, or the acceleration-deceleration profiles. In conclusion, the internal and external loading was higher for recreationally active male football players when playing on a pitch with 80 m² area per player compared to 60 m².

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INTRODUCTION

Recreational football organized as small-sided games is an intense activity consisting of endurance, strength, aerobic, and anaerobic high-intensity interval training elements [1]. As a multifaceted training type that simultaneously stimulates several fitness areas [2], an increasing bulk of evidence suggests that small-sided recreational football is very effective in providing broad-spectrum fitness and health effects for untrained individuals across the life-span [3] and can be used as an effective non-pharmacological treatment of lifestyle diseases [1]. On that basis, a “Football is Medicine” platform has recently been established, which could become part of the wider movement “Exercise is Medicine” [3]. As a part of this work it is of great interest to conduct research studies that can provide evidence-based recommendations on how to organize the optimal training setting for various participant groups to maintain the optimal intensity and load.

Varied movement patterns, with ~900 intermittent activity changes per session, including more than 100 high-intensity runs, stop-and-go actions, accelerations, decelerations, sprints, and other sport-specific actions such as tackles, dribbles, passes and shots are performed during one recreational football session [4, 5, 6]. Moreover, during a 60-min recreational football session the average intensity is 80-85% of maximal heart rate (HR_{max}), with 15-50% of total training time in the highest aerobic training zone above 90% HR_{max} regardless of age or health status [7]. However, several parameters such as number of players, boards, absolute and relative pitch area, total duration and periods (4x10 min vs. 2x20 min) could determine movement pattern and intensity in recreational football [1, 4-11]. Randers and colleagues [6] concluded that mean heart rate (HR) is higher in 3v3 (86% HR_{max}) and 5v5 (84% HR_{max}) than in 7v7 (81% HR_{max}, P<0.05) and percentage time >90%HR was higher

in 3v3 (43%, $P < 0.05$) than in 5v5 (28%) and 7v7 (18%). Additionally, significantly greater total distance and high-speed distance ($> 13 \text{ km h}^{-1}$) were covered during 3v3 than 5v5 and 7v7 when the absolute pitch area was fixed (40x20 m). In contrast, total and high-speed distance and mean HR were similar during 3v3, 5v5 and 7v7, when the relative pitch area was kept constant at 80 m^2 per player [4]. However, differences in movement pattern and intensity between 60 and 80 m^2 relative pitch area per player with a fixed number of players and fixed length-to-width ratio of 2:1 are still unknown. Obviously, to be able to plan effective training intervention in recreational football there is a requirement to investigate how to control overall movement pattern and intensity using different relative pitch area with a constant number of players.

In practice, several formats of recreational football have been used (1v1 to 9v9) but the most common is four versus four plus goalkeeper (4v4+GK) on a 40x20 m pitch similar to futsal [12]. However, little is known about how relative pitch area (60 vs. 80 m^2 per player) influences movement pattern and intensity in the standard (4v4+GK) recreational football game format. Some studies [10, 13, 14] performed in professional and amateur football players showed that relative pitch area influences movement pattern and intensity but it is not comparable with recreational football because there is no coach encouragement in recreational football, which has also been shown to influence movement patterns and intensity [4, 15]. Additionally, Sarmiento *et al.* [16] stated that the requirements of specific small-sided games with the same conditions are different for elite players compared to amateur players. Randers, Brix, Hagman, Nielsen and Krstrup [9] reported that boards in

recreational football increased time with ball in play, comparable to additional balls, and affected movement pattern and physiological demands, producing a higher number of accelerations, player load, and mean HR but lower total distance, number of intense runs, and peak speed due to the limited movement area caused by the boards surrounding the pitch.

Therefore, the purpose of this study was to determine differences in movement pattern and intensity between 60 and 80 m^2 of relative pitch area without boards in the standard 5v5 (4v4+GK) recreational football game format. We hypothesized that a larger relative pitch area will elicit a higher number of high speed runs and sprints.

MATERIALS AND METHODS

Participants

Ten healthy recreationally active football participants took part in the study (mean \pm standard deviation, age: 20.1 ± 1.1 years; height: 182.2 ± 7.4 cm; body mass: 75.9 ± 9.8 kg). Participants completed two training sessions comprising small-sided football games seven days apart. The participants were non-smokers, free from injury and medical conditions and had not been involved in any type of other physical exercises within four days before as well as during the study. Participants were instructed to maintain their normal daily routines including dietary habits. Before enrolling in the study, all participants were notified of procedures and risks and they all gave their informed consent. The study was carried out in accordance with the guidelines set out in the Declaration of Helsinki and approved by the local ethics committee of the University of Split, Croatia.

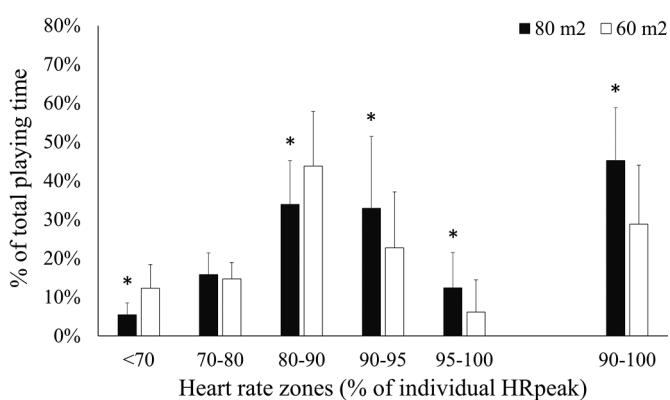


FIG. 1. Heart rate distribution presented as percentage of total playing time in heart rate zones of <70%, 70-80%, 80-90%, 90-95%, 95-100% as well as 90-100% of individual peak heart rate (%HR_{peak}) in small-sided recreational football games with 80 and 60 m^2 area per player. * denotes significant difference ($P < 0.05$) between game formats. Data are presented as mean \pm SD.

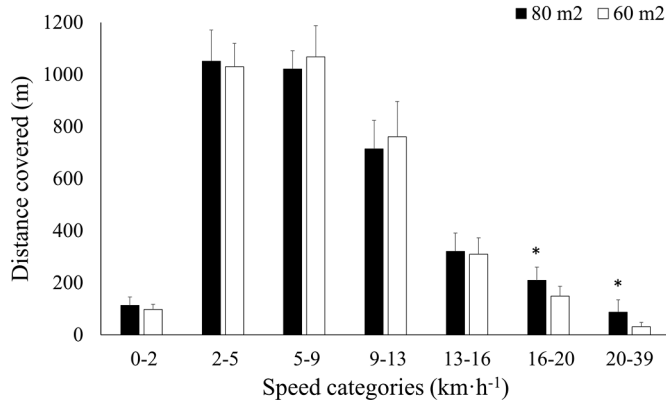


FIG. 2. Distance covered in speed zones of 0-2, 2-5, 5-9, 9-13, 13-16, 16-20 and $> 20 \text{ km h}^{-1}$ in small-sided recreational football games with 80 and 60 m^2 area for player. * denotes significant difference ($P < 0.05$) between game formats. Data are presented as mean \pm SD.

Experimental design

The participants completed two training sessions 4v4+GK one week apart with different relative pitch areas on an artificial grass pitch under similar environmental conditions (temperature: 27.1±0.3°C humidity: 41±3%) at the same time of day (10:00-11:00 am). Both training sessions lasted approximately 60 min, including a 10-min low-intensity warm-up followed by 2x20 min periods of play interspersed with 5 min of passive rest and ending with a 5-min cool-down. Before both sessions participants performed the same standardised warm-ups consisting of moderate-intensity jogging (4 min), static and dynamic stretching (4 min), and acceleration running (2 min). Warm-up, half time and cool-down periods were not included in the analysis. Both sessions were played without allocation of playing positions to each participant. After every five minutes of each half, the goalkeeper was substituted by one player to make a balance between time in play and time as goalkeeper. The size of the goals was 3 m wide and 2 m high. Sessions were supervised by one of the investigators who was the referee at the same time, and there was no encouragement other than from the players themselves during sessions. Several extra balls were placed around the pitch. The first recreational football session was conducted on a 40x20 m pitch, with a relative pitch area of 80 m² per player and length to width aspect ratio of 2:1. During the second session the pitch dimensions were 35x17 m, with a relative pitch area of 60 m², while the length to width aspect ratio was ~2:1.

Heart rate monitoring

Heart rate was recorded at 1-s intervals using short-range radio telemetry (Polar Team System 2, Polar Electro Oy, Kempele, Finland). Exercise intensity during each recreational football session was assessed using HR, expressed as absolute and relative to the individual HR_{max}, measured as the highest observed HR during the two sessions. Relative HR is presented in HR zones <70, 70-80, 80-90, 90-95 and 95-100% HR_{max} according to Krstrup et al. [17]. The data were then presented as the percentage of time spent within each intensity zone during the small-sided games.

Time-motion analysis

GPS-units (MinimaxX S4, Catapult Sports, Canberra, Australia) at a 10-Hz sample rate were used to measure player movements. A GPS unit was placed into a harness on the player's upper back as described by the manufacturer. Players wore the same GPS units in the two game sessions. The number of satellites was 13.4±2.4 and 13.7±1.8 and the horizontal dilution of precision was 0.89±0.15 and 0.82±0.10 in the small-sided games with 80 m² per player and 60 m² per player, respectively. Maximal speed, total distance, number of efforts (speed zone entries) and distance covered at 0–2, 2–5, 5–9, 9–13, 13–16, 16–20 and >20 km h⁻¹ were measured according to Randers et al. [8]. Player load (PL) was measured by the accelerometers built in the GPS units at a 100-Hz sampling rate. PL is an estimate of physical demand combining the instantaneous rate of change in acceleration in three planes. The validity and reliability of the GPS units and accelerometers have been described by Boyd, Ball, and Aughey [18].

Statistical analyses

Data are presented as means ± SD. Data analyses were performed using IBM SPSS software (v25.0, IBM Corporation; Armonk, NY, USA). Differences between 60 and 80 m² relative pitch area in movement pattern and intensity were assessed using Student's t-test. The alpha level was set at < 0.05 to indicate statistical significance. The magnitude of difference between 60 and 80 m² relative pitch area was measured using Hopkins' effect size (ES) and interpreted using previously established criteria: trivial = < 0.20; small = 0.2–0.59; moderate = 0.60–1.19; large = 1.20–1.99; very large = > 2.0 [19].

RESULTS

Mean and peak heart rate (HR_{peak}) were higher during 80 m² than 60 m² (167±9 vs. 160±10 b.p.m., P<0.001, ES=0.70; 192±8 vs. 188±9 b.p.m., P=0.041, ES=0.50). Furthermore, relative to the HR_{peak} values were higher during 80 m² than 60 m² (HR_{mean}: 86.3±1.6 vs. 82.9±2.8%, P<0.001, ES=1.48; HR_{peak}: 99.3±1.2 vs. 97.2±2.8%, P=0.040, ES=0.99). Significant differences were

TABLE 1. Total distance covered, work rate (total distance covered per minute), player load, absolute heart rate, relative heart rate and peak speed for recreational football game formats with 80 m² and 60 m² area per player.

	80 m ²	60 m ²	P	ES
Distance covered (m)	3517±152	3444±293	0.283	0.31
Work rate (m min ⁻¹)	88±4	86±7	0.272	0.32
Player load (AU)	349±23	348±54	0.934	0.02
Player load per min (AU min ⁻¹)	8.7±0.6	8.7±1.4	0.934	0.02
Peak speed (km h ⁻¹)	24.3±1.7	22.3±1.4	0.011	1.27

Data are presented as mean±SD, ES = effect size.

found between 80 m² and 60 m² for several HR zones (Figure 1) with a moderate effect (ES range 0.77-1.07).

Effect of area per player on distance covered in the highest speed zones was moderate to high with greater distance covered during 80 m² than 60 m² with running speed >13 km·h⁻¹ (617±126 vs. 489±108 m, P=0.003, ES=1.09), running speed >16 km·h⁻¹ (297±96 vs. 180±48 m, P=0.006, ES=1.53) and sprinting >20 km·h⁻¹ (87±51 vs. 31±15 m, P=0.011, ES=1.48). No differences were found in the lowest speed categories (P>0.05; Figure 2).

A higher number of high speed runs (16-20 km·h⁻¹) and sprints (>20 km·h⁻¹) was observed during 80 m² than 60 m² (16-20 km·h⁻¹: 25±7 vs. 20±5, P=0.038, ES=0.84, >20 km·h⁻¹: 8±5 vs. 3±1, P=0.014, ES=1.41). The mean length of each run was not significantly different between 80 m² and 60 m² (8.1±0.9 vs. 7.2±0.6 m, P=0.068, ES=1.18) with no differences in mean length of the sprints (10.9±2.7 vs. 9.8±2.4 m, P=0.170, ES=0.43) or the length of runs in the lower speed zones (P>0.05). Higher peak speed was reached in 80 m² than 60 m² (Table 1).

No differences were found in the distance covered while accelerating or decelerating (P=0.224-0.953). Moreover, percentage of the total distance covered while accelerating and decelerating was similar between 80 m² and 60 m² (62.6±1.1 vs. 62.4±1.1%, P=0.220, ES=0.18, 37.4±1.1 vs. 37.6±1.1 %, P=0.220, ES=0.18). Total player load was similar in 80 m² and 60 m² (Table 1) and no differences were found in any player load zone (P=0.265-0.917).

DISCUSSION

The main findings were that peak and mean heart rates as well as time spent with heart rate above 90% HR_{peak} were higher during 5v5 small-sided recreational football games with 80 m² compared to 60 m² per player. Moreover, a higher number of intense runs and a greater distance in the highest speed zones were covered during recreational small-sided games with 80 m² per player compared to 60 m² per player. In addition, peak running speed was higher in the small-sided recreational football games with 80 m² than with 60 m² per player, whereas no differences were found in total distance covered, player load, or the acceleration-deceleration profile.

Mean HR was high (160-167 b.p.m.) during both game formats, and using the peak HR during games to calculate individual relative mean HR, these values corresponded to 83-86% HR_{peak}. This is within the same range (81-89%) as previously reported for recreational small-sided games and 11v11 games for elite football players [10, 11, 20] and recreational football players [5]. A large effect of game format was found on relative mean HR, whereas the effect on relative peak HR was moderate. Differences in HR response between game formats have also been found in a number of studies on recreational [4], amateur [15] and elite football players [21, 22] and in general, HR increases with increasing area per player, in line with our findings [10, 11]. We observed that HR was above 90%

HR_{peak} in 45% of the total playing time, which is higher than usually observed during 5v5 – 9v9 small-sided games [5, 6]. It should be noted, however, that the maximal heart rate used to calculate the relative HR was measured from small-sided games and not an incremental test to ensure maximal HR. Thus, relative HR and time spent in HR zones may be overestimated, but several studies have shown that HR reaches near maximal values during small-sided games and the overestimation is therefore expected to be minor [5, 11]. The higher physiological strain typically observed in small-sided games on larger pitches is likely to be due to the possibility to make longer offensive and defensive runs [6]. In a recent study, we found, however, that HR was very high although played on a very small pitch surrounded with boards (3v3, 20x13 m, ~43 m² per player) leading to very low total distances covered and almost no runs with speed above 13 km·h⁻¹ [9]. It was suggested that the elevated HR response was due to a very high number of intense actions, a high number of accelerations and many changes of direction. Taken together, these results imply that the high HR response observed in small-sided games is caused by the myriad of different movements including repeated high-speed runs, accelerations, decelerations and changes of direction and that the different game formats impose different movement patterns.

In this study we found no difference in the total distance covered between 80 and 60 m², with average values around 3500 m per session for both game formats. The work rate was 88.0 and 86.1 m·min⁻¹, which is higher than we observed in other studies on recreationally active football players playing 5v5 with 80 m² per player (~74 m·min⁻¹) [4, 6]. This difference may be explained by the fact that only one ball was used in these studies in contrast to the present study, where several balls were used, thereby keeping the time with the ball out of play to a minimum. The studies by Randers and colleagues [4, 6] also revealed that total distance covered and work rate may be manipulated by changing the game format. Changing the number of players while keeping area per player constant had little effect on these variables [4], whereas changing the number of players while keeping playing area constant (and thereby also manipulating area per player) affected total distance covered and work rate [6]. The latter study showed that when increasing area per player (and decreasing number of players), total distance covered and work rate increased, whereas no effect on these parameters was observed when increasing the number of players (and thereby decreasing area per player) from 5v5 (80 m²) to 7v7 (~57 m²), which is similar to the observations in the current study.

Game format had a moderate effect on distance covered with running speed >13 km·h⁻¹, which was 26% higher in 80 than 60 m². This is in line with the findings in the study by Randers and colleagues [6], in which greater distance with speed >13 km·h⁻¹ was observed during small-sided games on a 40x20 m pitch with 80 m² (5v5) compared to 57 m² (7v7). In that study, even greater distances were covered during small-sided games with 133 m² (3v3). Thus, the findings in the current study support the observation that

the area per player is important for the possibility to cover long distances in the highest speed zones. This is supported by the finding that area per player had a large effect on peak speed, which was higher in 80 m² than 60 m². A large effect of area per player on peak speed was also observed by Randers and colleagues [6], with the highest peak speed during games with the largest area per player. Castellano and colleagues [23], however, kept area per player constant at 122 m² and found higher peak speed during games on the largest pitches (7v7 and 5v5 > 3v3), whereas another study found no difference in peak speed between small-sided games on different pitch sizes and number of players when area per player was kept constant at 80 m² [4].

In line with these findings, a higher number of runs with 16-20 km·h⁻¹ and sprints (>20 km·h⁻¹) was observed in 80 m² than 60 m². An increasing number of intense runs with increasing area per player has also been observed by others [6]. To support a higher number of intense runs, blood lactate response has been used to reflect the periods with high intensity, although only a moderate correlation between blood and muscle lactate concentration has been observed in football matches, in contrast to the very large correlation during continuous exercise [24]. Blood metabolites were not measured in the present study, but previous studies have shown a higher blood lactate response to small-sided games with larger area per player [6, 15]. In the study by Randers and colleagues [6], blood plasma ammonia was also higher during games with the highest area per player, supporting a higher number of periods with very high anaerobic energy turnover.

The movement pattern characterizing small-sided football games includes not only a high number of intense runs and sprints, but also a high number of changes of direction and accelerations and decelerations. We did not find any differences between 80m² and 60 m² in the distance covered while accelerating or decelerating. Player load is a measure of accelerations in three planes derived from the accelerometer built into the GPS unit. Therefore, player load summarises all the small movements and impacts on the body; these are not registered by the GPS, which only registers displacements. Large to very large correlations have been reported between player load and session-RPE (rating of perceived exertion), Edwards method and total distance covered [25, 26]. Moreover, Montgomery and colleagues reported correlations between player load and blood lactate and HR in small-sided basketball games, thus player load seems to summarise all the factors influencing the intensity during small-sided games. However, no significant differences were observed in player load between 80 m² and 60 m² games, although HR response, distance covered, number of intense runs and sprints were higher during 80 m². This may be due to the fact that no difference was observed in total distance covered and large to nearly perfect correlations between player load and total distance have been reported [25, 27]. Very large correlations have also been reported between

player load and distance covered with low, moderate and high speed [28]; thus more often high-speed runs and sprints as well as the higher distance covered with the highest speed during 80 m² would be expected to lead to higher player load. In a study on the effects of boards surrounding the pitch, higher player load was observed during games with boards, although the distance covered with high speeds was markedly higher during games without boards [9]. It was suggested that the boards limited the possibility to reach high speeds and thereby caused a lower distance with high speed, but in contrast kept the ball in play and led to several intense accelerations and rapid changes of directions increasing the player load. It may be speculated that the smaller area per player during 60 m² compared to 80 m² sessions increases the number of short intense actions to create free space to enable ball contact, which thereby counteract the impact on player load from the greater distance covered with high speed running during 80 m². In support of this, a moderate correlation has been found between total accelerations > 1.5 m/s² and accumulated player load [4].

The main limitation of this study is associated with the method used to determine the maximal heart rate. The maximal heart rate of each player was not determined during the incremental treadmill test or any field test but only during the small-sided games. Additionally, having in mind that reliability could be affected by several factors, more than two sessions would be preferable for better understanding of workload parameters in recreational football. Nevertheless, to the authors' knowledge, this is the first study to provide internal and external workload information, associated with different relative pitch sizes, while keeping the number of players consistent.

Randers et al. [8] and Randers et al. [6] have previously highlighted the effects of various game formats in recreational football training and the importance of understanding such effects to organize effective and efficient small-sided football training with positive effects on a broad spectrum of health parameters [3]. This study adds important evidence to this knowledge base and contributes to give practitioners valuable guidelines on how to organize recreational small-sided football training for improving health status.

To summarize, the internal and external loading was higher for recreationally active football players when playing on a pitch with 80 m² area per player compared to 60 m², with very high heart rates stimulating the cardiovascular system and many repetitions of high-intensity actions stimulating the musculoskeletal fitness. Considering that high-intensity interval training is very time-effective, these findings suggest that it is a good idea to use an 80 m² per player game format when organising small-sided recreational football aiming at broad-spectrum improvements in fitness and health profile.

Competing interests

The authors declare that they have no competing interests.

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