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Heart rate and movement pattern in street soccer for homeless women

Introduction

It is well established that morbidity and mortality rates are higher in homeless compared to the general population (Nilsson, Laursen, Hjorthoj, & Nordentoft, 2018; Hwang, Orav, O'Connell, Lebow, & Brennan, 1997). Homeless men and women at the age of 15–24 years have a remaining life expectancy of 21.6 and 17.4 years lower than the general population, respectively (Nielsen, Hjorthoj, Erlangsen, & Nordentoft, 2011).

One of more major contributors to the elevated mortality rates among homeless individuals is cardiovascular disease (CVD; Gozdzik, Salehi, O'Campo, Stergiopoulos, & Hwang, 2015). The interaction between traditional cardiovascular risk factors and risk factors associated with homelessness including smoking, undiagnosed or poorly controlled hypertension and diabetes, mental illness and substance abuse play a major role (McCary & O'Connell, 2005; Szerlip & Szerlip, 2002). It is a general misperception that homelessness primarily affects men (Feldman et al., 2018), and the relative effect of experiencing social exclusion and marginalisation on a wide range of health parameters has been shown to be greater in women than in men (Aldridge et al., 2018).

Recently, studies have shown that street soccer is an effective intervention to improve cardiovascular and musculoskeletal fitness in homeless men (Helge et al., 2014; Randers et al., 2012). A training intervention lasting 12 weeks improved maximal oxygen uptake by 3.9 ml kg^{-1} min^{-1} for 25- to 48-year-old homeless men and had favourable effects on low-density lipoprotein (LDL) cholesterol and body composition (Randers et al., 2012). Similar improvements have also been found in several other subject groups playing recreational football independent of sex, age, social background and prior football experience (Krustrup, 2017). Recreational football and street soccer in particular are characterised by high heart rates (HR) and several intense actions such as accelerations, decelerations, changes of direction etc. (Helge et al., 2014; Pedersen, Randers, Skotte, & Krustrup, 2009; Randers, Brix, Hagman, Nielsen, & Krustrup, 2017a; Randers, Nielsen, Bangsbo, & Krustrup, 2014; Randers et al., 2012), which lead to the conclusion that recreational football is an all-round training encompassing high-intensity interval training (HIIT), endurance training and strength training with broad-spectrum health effects (Krustrup, 2017; Krustrup et al., 2018; Milanovic et al., 2018).

During recreational football participants experience flow and a low degree of worry (Elbe, Strahler, Krustrup, Wikman, & Stelter, 2010). Moreover, recreational football has been shown to develop social capital and creating network among participants (Ottesen, Jeppesen, & Krustrup, 2010). In addition, recreational football seems to be intrinsically motivating through the social interaction and play, and is therefore likely to lead to higher adherence and longer participation (Nielsen et al., 2014).

The internal and external load during street soccer for homeless women have not yet been investigated; thus the purpose of the current study was to evaluate the movement pattern, HR response and psychological factors such as rate of perceived exertion, flow and worry during street soccer for homeless women. We hypothesize that street soccer elicits high HR and several intense actions for homeless women as observed for other population during recreational football.

Methods

Participants

Fifteen homeless women (age 30.3 ± 5.0 years [± standard deviation, SD], height 1.65 ± 0.08 m, body mass 65.1 ± 11.0 kg, 5 ± 4 years of prior football experience) from three countries (Denmark, Norway and Belgium) participated in 4-a-side street soccer at Women's Homeless World Cup in Amsterdam 12–15 December 2015. All participants were fully informed about the study before giving their informed consent to participate. The study was approved by the local ethics committee and carried out in accordance with the Declaration of Helsinki.

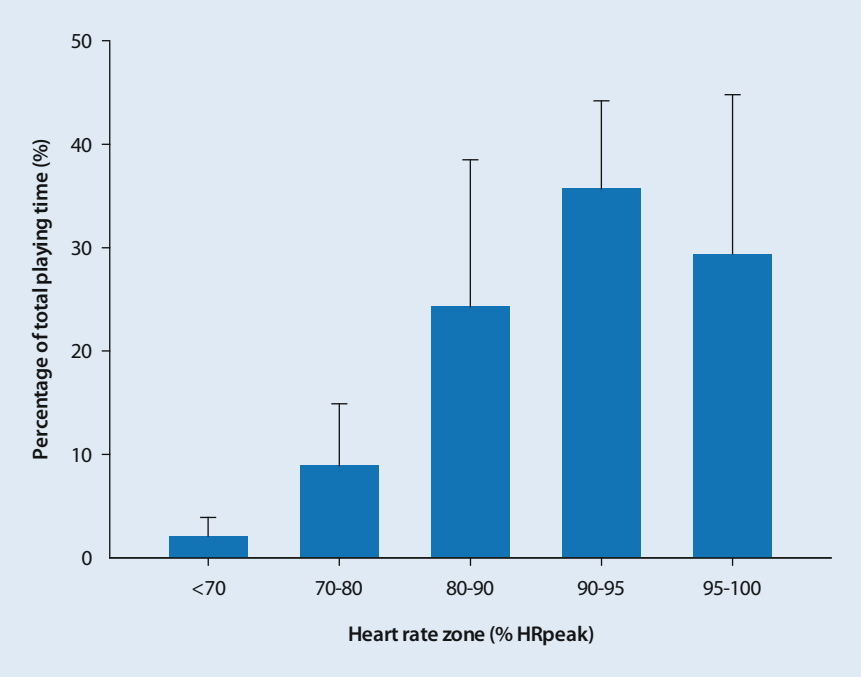

Fig. 1 ▲ Heart rate distribution, expressed as percentage of total playing time in selected heart rate zones (%HR_{peak}), during street soccer for homeless women. Data are presented as means ± standard deviation

Game format and rules

Games were played as 2 halves of 7 min interspersed with a 1-min halftime break. All games were played outside (temperature: 12–20 °C) as four-a-side street soccer on artificial turf. Pitch size was 22 × 16 m with 4 m wide and 1.3 m high goals in each end. In addition, 1.1 m high boards surround the pitch and behind each goal a 3 m high net help to keep the ball in play. Around each goal a half circle with a 4 m radius forms a penalty area in which no outfield players were allowed to enter, and the goalkeepers are not allowed to leave the penalty area. Another special rule applied to the game was that at least one player had to remain in the opposition half at all time. A full specification of the rules can be found at https://cdn-hcw.pressidium.com/wp-content/uploads/2017/05/oslo-2017-rules.pdf.

Heart rate measurement

Heart rate (HR) was recorded at 1 s intervals using short-range radio telemetry (Polar Team2 System, Polar Electro Oy, Kempele, Finland). HR is presented as absolute values and HR distribution as time spent with HR < 120 bpm (beats per minute), 120–160 bpm, 160–180 bpm and >180 bpm. Only data obtained while players were on the pitch are included in the analysis. HR data is also presented relative to the highest HR observed during matches (HR_{peak}) in HR zones <70, 70–80, 80–90, 90–95 and 95–100% of HR_{peak}.

Movement pattern

Movement pattern was measured during games using portable global positioning system (GPS) units (MinimaxX S4, Catapult Innovations, Canberra, Australia). One GPS unit was placed into the manufacturer-designed harness on the top of the back between scapulas as prescribed by the manufacturer. High number of satellites (13.8 ± 1.2) and low horizontal dilution of precision (0.85 ± 0.07) were observed for GPS data. A sample rate of 10 Hz was used. Data were analyzed using Catapult Sprint version 5.1.7 (Catapult Innovations, Canberra, Australia). Total distance, number of efforts and distance covered at 0–2, 2–5, 5–9, 9–13, 13–16, 16–20 and >20 km h^{-1} were measured (with minimum effort duration set to 1 s). The bands were summarized to low-speed movement (<9 km h^{-1}), moderate-speed running (9–13 km h^{-1}) and high-speed running (>13 km h^{-1}). Moreover, peak speed and Player Load (PL) were measured. PL was measured by the accelerometers in the MinimaxX S4 at a 100 Hz sampling rate. Player Load is an estimate of the physical demands combining the instantaneous rate of change in acceleration in three planes (forward/backward, side/side and up/down). PL is presented as time spent in PL zones 0–0.1 arbitrary unit (AU), 0.1–0.3 AU, 0.3–0.6 AU, 0.6–1.0 AU, 1.0–1.5 AU, 1.5–2.0 AU, >2.0 AU as percentage of total time and total accumulated PL. The validity and reliability of the GPS units and accelerometers have been described by Boyd, Ball, and Aughey (2011). Accelerations were measured and summarized as low (1.50–2.14 m s^{-2}), moderate (2.14–2.78 m s^{-2}) and high (>2.78 m s^{-2}) accelerations.

Rating of perceived exertion, flow and worry

After each game rating of perceived exertion (RPE) was individually rated on a visual analogue scale from very, very easy (0) to very, very hard (10). To measure flow, a 13-item Flow Kurz Skala (Rheinberg, Vollmeyer, & Engeser, 2003) was applied. Flow Kurz Skala assesses the flow total score (10 items) on a seven point Likert scale with values close to 7 indicating very high flow, whereas values closer to 1 indicate very low flow experience. As flow can be counteracted by worry, this was also assessed by Flow Kurz Skala in three items. Players filled out the questionnaires just after the game.

Statistics

All data are presented as mean ± SD. HR is presented as absolute values and relative to HR_{peak} during matches and distances covered as absolute values and relative to playing time.

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Heart rate and movement pattern in street soccer for homeless women

Abstract

Street soccer has been shown to be effective in improving cardiovascular and musculoskeletal fitness in homeless men, due to high heart rate (HR) and multiple intense actions. The purpose of this study was to investigate HR, movement pattern, rating of perceived exertion (RPE), flow and worry during street soccer for homeless women. Fifteen homeless women (30.3 ± 5.0 years [± standard deviation, SD], 1.65 ± 0.08 m, 65.1 ± 11.0 kg, 5 ± 4 years football experience) from three countries participated in 4-a-side street soccer games in Women's Homeless World Cup 2015. Mean and peak HR were 174 ± 7 and 188 ± 10 beats per minute (bpm), respectively, and >160 bpm 76 ± 23% of the playing time (11.1 ± 2.6 min). Distance covered per minute was 68.6 ± 8.9 m of which 82 ± 14, 15 ± 6 and 3 ± 3% were covered with low- (0–9 km/h), moderate- (9–13 km/h) and high-speed (>13 km/h) running, respectively. The 43 ± 5, 45 ± 3 and 12 ± 3% of the distance were covered running forward, sideways, and backward, respectively. Player Load was 9.2 ± 1.7 arbitrary units (AU) per minute and the number of accelerations >1.5 ms^{-2} was 15.3 ± 2.7 per minute. The score for flow was high (5.5 ± 0.8), whereas rating of perceived exertion (RPE) values (4.8 ± 2.5) and the score for worry (4.6 ± 1.3) were moderate. Street soccer for homeless women elicits high HR and a movement pattern comparable and for some parameters even higher than street soccer and recreational football for homeless and untrained men. Street soccer may be a suitable training intervention for homeless women, and especially moderate RPE and high flow score speaks in favour of an expectation of high participation and adherence.

Keywords

Small-sided games · Recreational football · Activity profile · Intensity · Global positioning system (GPS) · Socially deprived

Herzfrequenz und Bewegungsmuster im Streetsoccer für obdachlose Frauen

Zusammenfassung

Studien zeigen, dass Streetsoccer positive Effekte auf die kardiovaskuläre und muskuloskeletale Fitness obdachloser Männer hat – bedingt durch eine hohe Herzfrequenz (HF) und viele intensive Handlungen.
In der vorliegenden Studie sollten HF, Bewegungsmuster, die Bewertung der empfundenen Anstrengung (RPE) sowie Flow und Besorgnis während Streetsoccer-Spielen obdachloser Frauen untersucht werden. Fünfzehn obdachlose Frauen (30,3 ± 5,0 Jahre [± Standardabweichung], 1,65 ± 0,08 m, 65,1 ± 11,0 kg, 5 ± 4 Jahre Fußballerfahrung) aus drei Ländern nahmen im Rahmen der Weltmeisterschaft für obdachlose Frauen 2015 an Streetsoccer-Spielen mit je 4 Spielerinnen pro Mannschaft teil. Die Durchschnitts- und Maximal-HF betrugen 174 ± 7 bzw. 188 ± 10 Schläge pro Minute. Für 76 ± 23 % der Spielzeit (11,1 ± 2,6 min) lag die HF bei >160 Schlägen pro Minute. Die zurückgelegte Wegstrecke pro Minute lag bei 68,6 ± 8,9 m, davon 82 ± 14 %, 15 ± 6 % und 3 ± 3 % in langsamem Lauf (0–9 km/h), mäßigem Lauf (9–13 km/h) bzw. Hochgeschwindigkeitslauf (>13 km/h). Vorwärts-, Seitwärts- und Rückwertslaufen machten 43 ± 5 %, 45 ± 3 % und 12 ± 3 % der zurückgelegten Strecke aus. Die Spielerbelastung („Player Load") betrug 9,2 ± 1,7 dimensionslose Einheiten (AU) pro Minute und die Anzahl der Beschleunigungen >1,5 m • s^{-2} pro Minute lag bei 15,3 ± 2,7. Der Flow-Score war hoch (5,5 ± 0,8), während die RPE-Werte (4,8 ± 2,5) und der Besorgnis-Score (4,6 ± 1,3) mäßig waren. Streetsoccer für obdachlose Frauen führt zu hohen HF und einem Bewegungsmuster, das mit dem von Streetsoccer und Freizeitfußball für obdachlose und nichttrainierte Männer vergleichbar und in manchen Parametern sogar höher ist. Streetsoccer könnte eine geeignete Trainingsintervention für obdachlose Frauen sein. Insbesondere mäßige RPE-Werte und der hohe Flow-Score lassen eine hohe Teilnahme und Adhärenz erwarten.

Schlüsselwörter

Spiele auf Kleinfeld · Freizeitfußball · Aktivitätsprofil · Intensität · Globales Positionsbestimmungssystem (GPS) · Sozial schwächer gestellte Menschen

Results

The mean playing time was 11.1 ± 2.6 min. Mean HR and peak HR were 174 ± 7 and 188 ± 10 bpm equal to 91.6 ± 2.3 and 98.6 ± 0.7% HR_{peak}, respectively. HR was <120 bpm for 1 ± 2%, 120–160 bpm for 23 ± 22%, 160–180 bpm for 45 ± 21% and >180 bpm for 31 ± 28% of the playing time. Percentage time spent with HR < 70, 70–80, 80–90, 90–95 and 95–100% HR_{peak} is presented in **Fig. 1**.

Total distance covered was 757 ± 214 m equal to 68.6 ± 8.9 m min^{-1} of which 82 ± 14% (600 ± 145 m), 15 ± 6% (128 ± 81 m) and 3 ± 3% (29 ± 38 m) were covered with low-, moderate- and high-speed equal to 54.2 ± 2.3, 11.0 ± 5.7, 2.4 ± 2.8 m min^{-1}, respectively (**Fig. 2**). Distance covered while moving forward was 323 ± 82 m, whereas distance covered while moving sideways and backward was 340 ± 107 m and 94 ± 34 m, respectively, which is equal to 43 ± 5, 45 ± 3 and 12 ± 3% of the total distance, respectively.

The number of low-, moderate- and high-speed efforts was 115 ± 27, 20 ± 12, 4 ± 5 equal to a low-, moderate- and high-speed effort every 6, 34 and 190 s, respectively. Peak speed reached 14.9 ± 2.4 km h^{-1}.

Total accumulated Player Load was 103 ± 31 AU equal to 9.2 ± 1.7 AU per min. Percentage of playing time spent in Player Load zones was 0.0–0.1 AU: 7.1 ± 3.5%, 0.1–0.3 AU: 31.7 ± 5.8%, 0.3–0.6 AU: 20.8 ± 5.5%, 0.6–1.0 AU: 17.1 ± 2.9%, 1.0–1.5 AU: 14.6 ± 2.6%, 1.5–2.0 AU: 6.1 ± 1.6% and >2.0 AU: 2.6 ± 1.5% (**Fig. 3**).

Total number of accelerations >1.5 m s^{-2} was 171 ± 52 of which 113 ± 34, 38 ± 12 and 19 ± 11 equal to 10.2 ± 2.7, 3.4 ± 0.7 and 1.7 ± 0.8 acceleration per

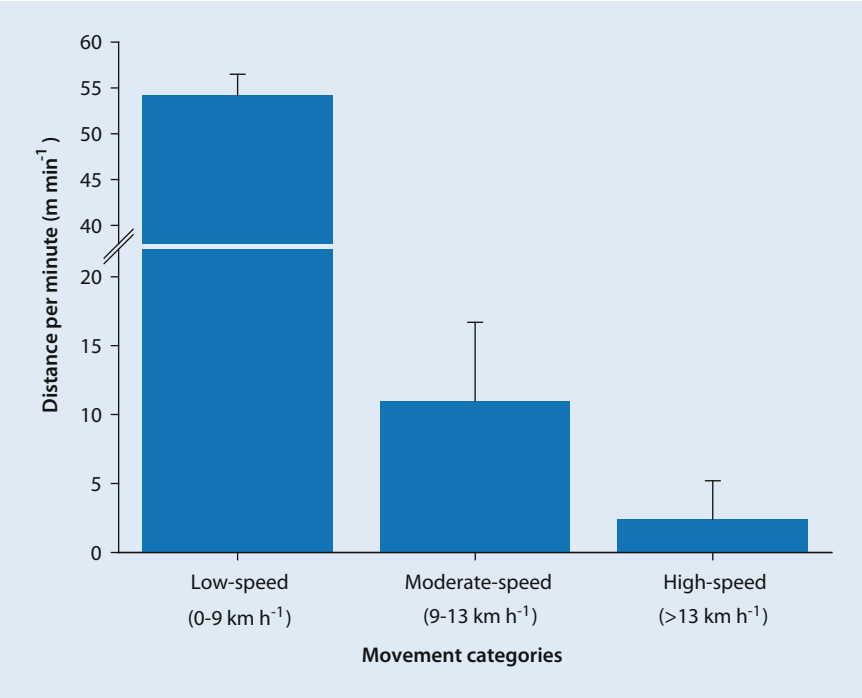


Fig. 2 ▲ Distance covered per minute with low-speed (<9 km h^{-1}), moderate-speed (9–13 km h^{-1}) and high-speed (>13 km h^{-1}) running during street soccer for homeless women. Data are presented as means ± standard deviation

minute were low, moderate and high, respectively.

RPE was 4.8 ± 2.5. The score for flow was 5.5 ± 0.8, whereas the score for worry was 4.6 ± 1.3.

Discussion

The main findings of the present study were that heart rate was high during street soccer for homeless women. Distance covered per minute was similar to recreational football on larger pitches, with more distance covered per minute with low speed but markedly lower distance covered per minute with high speed compared to recreational football on larger pitches (Randers et al., 2017a; Randers et al., 2014; Randers, Orntoft, Hagman, Nielsen, & Krustrup, 2018). A high number of accelerations and percentage of sideways and backward running were observed. Despite the high HR and multiple intense actions during the street soccer activity, the players reported moderate rate of perceived exertion and a high flow score.

Mean HR during street soccer (174 ± 7 bpm ~92% HR_{peak}) was higher than observed in other studies (144–161 bpm ~79–85% HR_{max}) during recreational small-sided football (2v2-7v7) for untrained women (Bowtell et al., 2016; Connolly et al., 2014; Flotum, Ottesen, Krustrup, & Mohr, 2016; Krustrup et al., 2010) and other subject groups during small-sided games (Randers et al., 2010). Lower mean HR values (154 bpm ~82% HR_{max}) were also observed in a study on homeless men playing street soccer on a similar pitch (Randers et al., 2012). The difference between the men and women may be due to the level of the games as the observations on men were training sessions of street soccer games compared to World Cup games in the present study.

HR values should preferably be related to individual maximal HR, but unfortunately this was not possible to conduct a test to stress HR maximally, but we have presented HR data in relation to the individual highest measured HR during matches. Previous studies have shown that peak HR during small-sided football typically reaches 93–98% of HR_{max} (Krustrup et al., 2018; Randers et al., 2010). The relative HR and time spent in HR zones may therefore have been overestimated. Time spent with HR higher than 90%HR_{peak} was 65% of the total playing time, which is markedly higher than typically observed (10–30% of playing time). One recent study showed, however, that mean HR and time spent with HR > 90% HR_{max} are markedly elevated during street soccer with boards keeping the ball in play (Randers et al., 2017a). As stated, HR should preferably be presented relative to the individual maximal HR, but the high absolute HR values (mean HR: 174 bpm, and 31% time with HR > 180 bpm) underline that street soccer for women is highly taxing the cardiovascular system. High mean HR and periods with near maximal HR characterizing football are considered to have major effects on cardiovascular fitness leading to increase of 3.5 ml min^{-1} kg^{-1} in VO_{2max} and a reduction in blood pressure of 4.2/3.9 mm Hg after a 12–24 week of training (Krustrup et al., 2018; Milanovic, Pantelic, Covic, Sporis, & Krustrup, 2015; Milanovic et al., 2018).

Distance covered per minute during street soccer matches was 69 m min^{-1}, which is similar to values observed during one-hour session with recreational small-sided football for untrained women (Bowtell et al., 2016; Krustrup et al., 2018; Randers et al., 2010). It should however be noted that mean playing time was only about 11 min (of the 14 min match-time), and that the intensity may have been higher than what would have been seen with longer match durations. In men, it has recently been reported that distance per minute during 4 × 12 min sessions of street soccer was 56 m min^{-1}, which was markedly lower than during small-sided games on larger pitches (73–84 m min^{-1}; Randers et al., 2017a; Randers et al., 2014; Randers et al., 2018). The lower distance per minute observed during street soccer in men compared to women may be due to the differences between street soccer modes in the two studies (rules, pitch size, number of players). A major difference between street soccer with boards and recreational small-sided games is distance covered with moderate (9–13 km h^{-1}) and high speed (>13 km h^{-1}). In the current study dis-

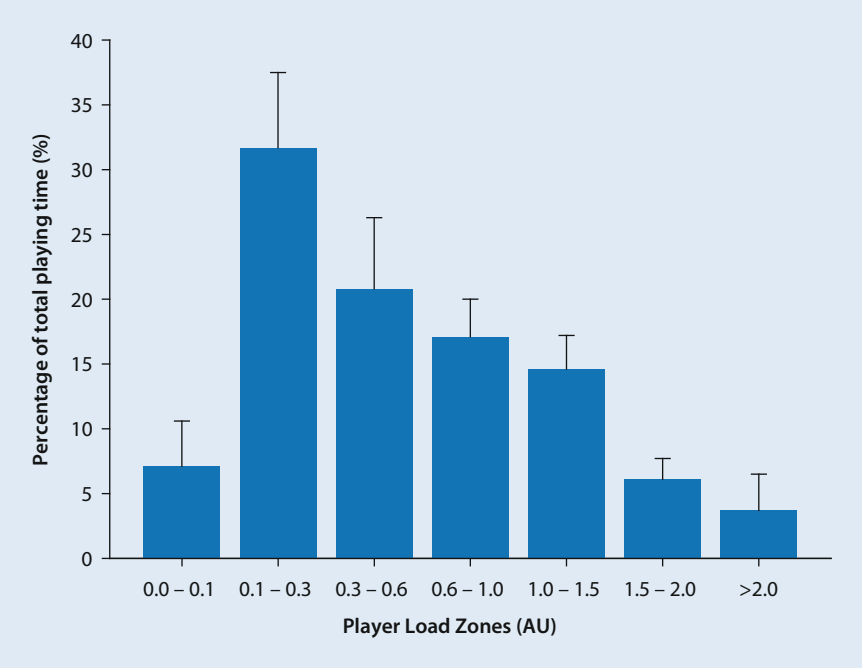


Fig. 3 ▲ Player Load, expressed as percentage of total playing time in selected Player Load zones, during street soccer for homeless women. Data are presented as means ± standard deviation. *AU* arbitrary units

tance covered with moderate and high speed was 11.0 and 2.4 m min^{-1}, respectively, which are higher than observed in men during street soccer (5.1 and 1.0 m min^{-1}, respectively), but markedly lower than during recreational small-sided games on larger pitches (13–17 and 7–12 m min^{-1}, respectively; Randers et al., 2014; Randers et al., 2018). Peak speed was also low during street soccer in the current study (14.9 km h^{-1}), which is similar to the finding that boards around the pitch limit top speed and the possibility to cover distance with high speed (Randers et al., 2017a).

The small pitch size and the area per player means that players need to accelerate, decelerate and change direction very often. The different movement pattern during street soccer is also underpinned by the observation that a longer distance was covered with sideways than forward running. Actually, forward running covered only 43% of the total distance. These specific movements such as sideways and backward running and dribbling/ball handling increase the energy cost above normal straight forward running (Reilly & Bowen, 1984; Reilly & Ball, 98), which also may be one of the explanations of the high HR response although running speed and high-speed running distance are limited during street soccer compared to small-sided games.

Player Load is a relatively new measure of the load imposed on the body during movements and summarizes the impact from running speed and all the short intense accelerations and decelerations (Casamichana, Castellano, Calleja-Gonzalez, San Roman, & Castagna, 2013). In the current study Player Load was 9.2 AU per min, which was similar to street soccer in men, but higher than observed in small-sided games for men (Randers et al., 2017a; Randers et al., 2018). Player Load in the present study was also higher compared to street basket for men on one (7.5 AU per min) and two baskets (8.4 AU per min; Randers et al., 2017b) and percentage time spent in Player Load zones >1.0 AU was also higher during street soccer (23.3%) compared to street basket (14.4–17.9%; Randers et al., 2017b). These differences between popular team sport activities may highlight the somewhat lower movement speed during basketball probably due to a need of higher technical skill to keep movement speed high during street basketball. In a study by Randers et al. (2014) using 3v3 to 7v7 recreational football, Player Load was above 1.0 AU for 18.9–21.2% of the time, which is also somewhat lower than we observed in the present study during street soccer for homeless women. Since running speed is low during street soccer, the high Player Load is a result of the many intense acceleration, deceleration and changes of direction. In the present study, number of accelerations >1.5 m s^{-2} as well as intense accelerations (>2.78 m s^{-2}) was similar to street soccer for untrained men (Randers et al., 2017a), but markedly higher than during small-sided games for untrained men (Randers et al., 2014; Randers et al., 2018), which highlights the different movement pattern related to pitch size with more accelerations and rapid movement over short distances during street soccer and other games with little area per player compared to the run-based games with higher speed but fewer accelerations and rapid changes of direction during football games on larger pitches.

Altogether these observations clearly emphasise that street soccer for homeless women is an intense training type, with high HR and many intense activities with impact on muscles and bones, thereby providing a broad-spectrum stimulus to the cardiovascular, metabolic and musculoskeletal fitness (Krustrup, 2017).

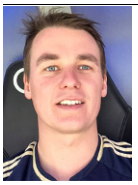
The homeless women reported a moderate rating of perceived exertion (4.8), which was lower than observed for untrained women during small-sided recreational football (Elbe et al., 2010). It is interesting that street soccer was perceived less hard than small-sided games although HR response was markedly higher during street soccer. It should though be taken into account that the subject groups are different and that street soccer games had a much shorter duration.

During street soccer homeless women reported a high score for flow (5.5), which was slightly higher than observed in untrained women (Elbe et al., 2010). In contrast, the score for worry was moderate (4.6) and higher than seen in untrained women, but may be related to this specific subject group combined with the difference between games during a Home-

less World Cup and recreational training among friends.

In conclusion, street soccer for homeless women elicits high HR and a high number of intense specific actions such as accelerations, changes of direction, backward and sideways running, but a low peak speed and low distance with high speed running. Although the intensity was high, street soccer seems as a feasible and motivating (i.e., moderate RPE and high flow score) training protocol for homeless and socially marginalized women, and it would be interesting to investigate short- and long-term training response on various important health variables as well as quality of life for this specific group.

Corresponding address



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Compliance with ethical guidelines

Conflict of interest. M.B. Randers Thomsen, J. Marschall, T.-T. Nielsen, A. Møller, M. Zebis and P. Krustrup declare that they have no competing interests.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

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