Title: The physiological, physical and biomechanical demands of walking football: implications for exercise prescription and future research in older adults

Abstract

The aim of this investigation was to profile the physiological, physical and biomechanical responses during walking football. Seventeen male participants (66 ± 6 years) participated. Heart rate (HR), blood lactate, accelerometer variables (biomechanical load [PlayerLoad^{TM}]; changes of direction [CoD]) and rating of perceived exertion (RPE) were measured. Participants mean % of HR_{max} was 76 ± 6% during the sessions, with RPE across all sessions at 13 ± 2. Blood lactate increased by ~157% from pre- (1.24 ± 0.4 mmol·l^{-1}) to post-session (3.19 ± 1.7 mmol·l^{-1}; $p \leq 0.0005$). PlayerLoad^{TM} values of 353 ± 67 a.u were observed, as well as ~100 CoD per session. In conclusion, walking football is a moderate-to-vigorous intensity activity. The longitudinal health benefits of walking football remain to be elucidated, particularly on bone health, cardiovascular fitness, and social and mental wellbeing.

Keywords: soccer; exercise intensity; elderly; gerontology; physical activity

1. Introduction

The world's population is getting older, posing fiscal and societal challenges for governments, particularly as older adults are at a greater risk of chronic health conditions than their younger counterparts (Beard et al., 2016). Ageing can lead to cardiovascular and metabolic diseases, chronic inflammation, loss of muscle mass, poor bone health, cognitive decline and neurodegenerative disorders, and reduced social and mental wellbeing (Börsch-Supan et al., 2013; Cruz-Jentoft et al., 2010; Ferrucci & Fabbri, 2018; Goodpaster et al., 2006). Physical activity and exercise have been shown to positively affect some of these deleterious effects of ageing (Cartee, Hepple, Bamman, & Zierath, 2016; Fox, Stathi, McKenna, & Davis, 2007; Hamer, Muniz Terrera, & Demakakos, 2018; Lancaster & Febbraio, 2014; Santos, Elliott-Sale, & Sale, 2017). One form of exercise that has been researched extensively, due to its worldwide ubiquity and popularity, is association football (herein called football), or soccer. The health benefits of participating in recreational football are extensive (see Bangsbo, Hansen, Dvorak, & Krustrup, (2015) for a review); however, in older adults, the physical demands of playing football may be a barrier to participation. Therefore, a more accessible form of the sport has been designed in recent years, termed walking football.

Walking football is a sport targeted towards older people (>55 years), but played by those who are younger too. It is a relatively new sport, formed in the early 2010's, gaining publicity in the United Kingdom in 2013 through an advert from Barclays plc. The sport is now played around the world, with recreational sessions through to national and international tournaments. Walking football is usually contested by two small-sided teams (5 to 7-aside), with strict rules regarding running and slide tackling. This is to make the sport safer, and as such, more accessible and engaging for older populations. As walking alone has many physiological and psychological benefits (Hanson & Jones, 2015; Murphy, Nevill, Murtagh, & Holder, 2007), it is suggested that walking football may provide similar benefits. Previous small-scale investigations have shown that walking football is a feasible and sustainable exercise intervention that may improve participants' mental wellbeing (Lamont, Harris, McDonald, Kerin, & Dickens, 2017; McEwan et al., 2019; Reddy et al., 2017), as well as their body composition and physical fitness (Arnold, Bruce-Low, & Sammut, 2015). An ethnographic study of walking football suggested that walking football also provides intangible benefits, including increasing participants' 'appetite for life' and enhancing their social engagement as part of a wider supportive community (Loadman, 2017).

To date, studies assessing the demands of walking football have only used two matches (Heil, Newton, & Salle, 2018) or have only measured heart rate (HR) and rating of perceived exertion (RPE) in 11 participants who participated in at least seven of 12 matches during a 12-week intervention (Reddy et al., 2017). Therefore, there is scope to expand on these findings, as well as investigate other measures of exercise intensity. The monitoring of internal training loads, using methods including HR and RPE, is commonplace in exercise prescription for the general population, to ensure that training sessions have been correctly designed and conducted (Roy, 2015). In sporting domains, particularly at the professional level, there has been a substantial increase in the use of wearable devices, allowing for the measurement of external loads (see Chambers, Gabbett, Cole, & Beard, (2015) for a review). Consequently, individuals are monitored through the use of an accelerometer-based variable termed PlayerLoad™ (PL). This metric is a software derived movement parameter (Catapult Innovations, Australia), calculated as the summation of forward, sideways and vertical accelerations (Boyd, Ball, & Aughey, 2011). It is essentially utilised as a measure of external workload (i.e., biomechanical stress) and can be quantified alongside numbers of changes of direction (CoD), accelerations (ACC) and decelerations (DEC). As PL and the number of CoD, ACC and DEC are related to the intensity of an exercise bout (McLaren et al., 2018) and frequent CoD may have benefits for bone health in older adults (Santos et al., 2017; Turner & Robling, 2003), it is pertinent to measure these parameters during walking football.

The aim of this present investigation was to assess the demands of walking football in older adults across a greater number of matches than previously investigated, including measures of exercise intensity that are physiological, biomechanical, and physical in nature. We also aimed to assess the variability of response in these measures, in order to investigate if there were noticeable fluctuations in exercise intensity between matches.

2. Methods

2.1 Study design and participants

Following institutional ethical approval, informed consent was obtained from 17 male participants (66 ± 6 years) who had volunteered to partake in the research. All participants were over the age of 55, had at least one year of walking football experience, and were already participating regularly in walking football sessions. No other inclusion/exclusion criteria were applied (except for blood lactate, which is described below). Participants were observed between November 2018 and May 2019 for a total of 25 sessions of walking football. Measures of HR, blood lactate, accelerometery data and RPE were collected during this period. Table 1 outlines at which of the 25 sessions these different measures were collected. Sessions typically began at the same time of day (~11 am) and were ~60 min in duration, although two matches were commonly played simultaneously on different pitches. This was often dependant on the number of players that attended a given session, as were the session structure, which comprised a number of different formats (i.e., 5, 6, & 7-a-side) and matches (i.e., 1-3). All matches were played on an indoor artificial grass pitch, whereby teams were counterbalanced for age and subsequently selected at random. Matches were played under official FA rules (FA.com), which were officiated by a qualified walking football referee. As matches were played on an enclosed indoor pitch, no throw-ins were required, except for goalkeepers who were instructed to throw under-arm and were rotated approximately every 5 min. Participants continued with their habitual daily living (i.e., customary diet and physical activity) between sessions. Owing to the observational nature of the research, no intervention or feedback was sought or provided during the entirety of data collection.

INSERT TABLE 1

2.2 Measures

Throughout each session, HR was collected using Polar M200 HR monitors (Polar Electro, Kempele, Finland). Researchers downloaded the session data onto a PC via brand specific software (Polar Flow™, Polar Electro, Kempele, Finland). Once exported and analysed, mean (HR_{mean}) and peak

(HR_{peak}) HR values were obtained for each participant during each individual session. In addition, Tanaka, Monahan, & Seals, (2001) equation (208 − 0.7 × age) was employed to predict the theoretical maximum HR (HR_{max}) for each participant. Medical screening was conducted to determine eligibility for blood sampling, with the following exclusion criteria employed: i) were taking blood thinning medication, ii) had a health condition affecting blood flow iii) had a blood-borne virus.

. For blood lactate, capillary samples were taken pre and immediately post session from the fingertip, stored in tubes (20μl) containing heparin so as to prevent the blood coagulating and analysed within ~2 h of extraction (Biosen C-Line; EKF-diagnostic GmBH, Wales; coefficient of variation [1.5%]). Preceding each test, the machine was calibrated in line with manufacturer guidelines.

A Global Positioning System tracking device (OptimEye S5, Catapult Innovations, Australia) which housed a tri-axial accelerometer (Kionix KX94, Kionix, Ithaca, New York, USA), recorded accelerometry data at 100-Hz sampling frequency. This device was positioned along the thoracic spine and stabilised within a neoprene vest (Catapult Innovations, Scoresby, Australia) to limit movement. Where possible, participants maintained the use of the same device throughout sessions, as intra-device has demonstrated excellent reliability (CV = 0.01% to <3.0%) (Nicolella, Torres-Ronda, Saylor, & Schelling, 2018). However, because the number of participants was greater than the number of devices, the device retention rate for participants was 84.0 ± 13.3% across all applicable sessions. Data were downloaded using the manufacturers software (version 5.14, Catapult Sprint, Catapult Sports, Australia). Accordingly, tri-axial PL values were obtained and calculated from the summation of the vertical anterior-posterior (PL-AP), medial-lateral (PL-ML) and vertical (PL-V), planes of motion. This parameter is essentially, the instantaneous rate of change of acceleration of the above three vectors divided by a scaling factor of 100. This is used to measure external load for a given activity and is expressed in arbitrary units (a.u.) (White & Macfarlane, 2015).

Additionally, inertial movement analysis (IMA) data was retrieved during analysis, which consisted of number of ACC, DEC, and CoD. Thresholds for ACC, DEC, and CoD were characterised as low (1.5-2.5 $m \cdot s^{-2}$), medium (2.5-3.5 $m \cdot s^{-2}$) and high (>3.5 $m \cdot s^{-2}$) intensity. The change in direction is quantified in degrees (±180°) relative to the accelerometer orientation and measured in $m \cdot s^{-1}$. This metric is often defined as an instant one-step movement (i.e., CoD) and used to detect the magnitude and direction of a given acceleration. Accelerometry data was collected for the entire 60 min session and stationary periods (i.e., rest between matches) were omitted from analyses for accelerometry-based data. Following each session, RPE was taken as a subjective measure of exercise intensity using the Borg 16-point linear scale (6-20) (Borg, 1982) as it is a valid and sensitive measure of exercise intensity, including in older adults (Chung, Zhao, Liu, & Quach, 2015; Shigematsu, Ueno, Nakagaichi, Nho, & Tanaka, 2004).

2.3 Statistical analysis

Unless stated otherwise, data are reported as mean and standard deviation (SD). Data analysis was completed using commercially available software (Microsoft Excel®) and SPSS version 24 for Windows (IBM® SPSS® Statistics; SPSS Inc., Chicago, IL, USA). A paired-sample t-test was employed to determine whether differences existed between pre- and post-session for blood lactate. Coefficient of variation (CV) was completed to ascertain absolute reliability between sessions with <10% considered good (Atkinson & Nevill, 1998) and 95% confidence intervals (CI) were also reported. Statistical significance was established at $p \leq 0.05$ prior to analyses.

3. Results

Analysis was conducted individually for HR values (participants n = 11; sessions n = 11 [6-11 sessions per participant), blood lactate (participants n = 9; sessions n = 11 [4-10 sessions per participant]), accelerometer variables (participants n = 7; sessions n = 16 [6-9 sessions per participant]) and RPE (participants n = 7; sessions n = 25 [13-16 sessions per participant]).

3.1 Heart rate

Participants' average response over 11 sessions are displayed in Figure 1A for HR_{peak} (155 ± 16 bpm; CV = 3.3%; CI% = 2.2, 7.1) and Figure 1B for HR_{mean} (124 ± 13 bpm; CV = 7.4%; CI% = 4.9, 16.2); both variables demonstrated good reliability (CVs <7.5%). Participants mean % of HR_{max} was 76 ± 6%, with a range of 63-86% of their theoretical maximum HR. In comparison, an increased range was observed (77-106%) for peak % of HR_{max} for which mean values were 95 ± 8% (Table 2).

*****INSERT TABLE 2*****

*****INSERT FIGURE 1*****

3.2 Blood lactate

Mean changes in blood lactate are outlined in Figure 2, with a ~157% increase observed from pre- (1.24 ± 0.4 $mmol \cdot l^{-1}$) to post-session (3.19 ± 1.7 $mmol \cdot l^{-1}$; p <0.0001) across 11 sessions.

*****INSERT FIGURE 2*****

3.3 Accelerometry variables

3.3.1 PlayerLoad (PL)

Average PL values of 353 ± 67 a.u were observed with contributions from the PL-AP (84 ± 17 a.u), PL-ML (104 ± 16 a.u) and PL-V (164 ± 35 a.u) planes of motion. When expressed as relative contributions, PL-AP%, PL-ML% and PL-V% were established as 24 ± 2%, 30 ± 2% and 46 ± 2%, respectively. Typical error reported as CVs ranged from 4.3 to 44.2%. Means, CVs and CIs for PL variables are displayed in Table 3.

***** INSERT TABLE 3*****

3.3.2 Change of direction (CoD)

Participants completed 85 ± 23 CoD at lower intensities, with much fewer observed for medium- (8 ± 4) and high-threshold (2 ± 1) actions. As a collective, CVs ranged from 49.5 to 149.7%; these are displayed in Table 4 along with CIs.

3.3.3 Decelerations (DEC) and accelerations (ACC)

We observed an average of 24 ± 9 DEC_{LOW} and 9 ± 5 ACC_{LOW} across the sessions, with medium thresholds being alike for DEC (4 ± 2) and ACC (3 ± 2) and high thresholds for DEC (1 ± 1) versus ACC (1 ± 2). The absolute reliability for the DEC and ACC metrics ranged from 38.6 to 139.9 % (CVs) as outlined in Table 4.

***** INSERT TABLE 4*****

3.3 Ratings of perceived exertion (RPE)

Average RPE across all sessions was 13 ± 2 (range = 8–18). Good absolute reliability was detected for RPE (CV = 7.8 %; CI% = 4.6, 24.2) and individual RPE values across each session are presented in Figure 3.

*****INSERT FIGURE 3*****

4. Discussion

The aim of this study was to investigate the physiological, biomechanical and physical demands of walking football, in participants who had been playing the sport for one year or more. The average RPE across the 25 sessions was 13 ± 2, equating to the verbal anchor 'Somewhat Hard' on the 6-20 Borg Scale. However, as shown in Figure 3, there was some intra-session and inter-individual variability, with ratings ≥15 (Hard) in 11 of the 25 sessions, and ratings of ≤11 (Light) in 13 of the 25 sessions. These RPE values are similar to a previous investigation on walking football (Reddy et al., 2017). The American College of Sports Medicine position stand on the quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal and neuromotor fitness states that an RPE of 13 equates to a moderate intensity, with participants working at 64-76% and 46-63% of their $\%HR_{max}$ and $\%\dot{V}O_{2max}$, respectively (Garber et al., 2011). Within this study, we observed participants exercising at an average of 76% of their theoretical HR_{max} during the sessions. Four participants were exercising at an average of ≥80% of their theoretical HR_{max}; however, as we were unable to measure HR_{max} directly, the accuracy of the equation used and individual variation in HR_{max} should be considered (Tanaka et al., 2001). Nonetheless, the two measures of internal load (i.e., $\%HR_{max}$ and RPE) seemed to be fairly well aligned.

Our observed HR values are comparable to those previously reported in recreational small-sided football training (i.e., 6v6) across a range of ages (Bangsbo et al., 2015). Evidence suggests that football-based training performed at such intensities provides significant benefits to the cardiovascular system (Bangsbo et al., 2015). Cardiovascular disease is a leading course of mortality, particularly in older adult males, and as such, data from our and previous investigations (Loadman, 2017; Reddy et al., 2017) suggests walking football is a socially enjoyable mode of exercise that could potentially reduce the risk of cardiovascular disease. However, longitudinal studies are required to confirm this supposition.

In absolute terms, HR_{mean} for the eleven sessions was 124 ± 13 bpm. Previous research has investigated the effects of a 2-week interval walking (3 mins high intensity [90% VO_{2peak}], 3 mins low intensity [60% VO_{2peak}] alternating for 60 min) intervention in a similar age group to our study (65 ± 2 years), in which comparable HR_{mean} values were reported during the high intensity periods (119 ± 3 bpm) to those of the present study (Karstoft et al., 2017). The comparable HR_{mean} data may suggest that walking football sessions have a relative intensity of ~90% $\dot{V}O_{2peak}$, which would support the notion that walking football for older adults can be considered an intermittently vigorous-intensity activity (Reddy et al., 2017). This is also supported by our RPE values, as participants often rated sessions ≥15 (Hard; Figure 3). As we only collected RPE at the end of a session, the participant's rating may have been reflective of the last 10-15 minutes of the session, rather than the session as a whole. However, the participants were verbally instructed to consider the whole session when providing their rating.

The benefits of walking alone on risk factors for cardiovascular disease are well established, with the potential to improve aerobic capacity, reduce systolic and diastolic blood pressure, and positively alter body composition (Hanson & Jones, 2015; Murphy et al., 2007). Furthermore, there may be additional benefits of intermittent, or interval walking, which walking football can be considered a type of. Indeed, Karstoft et al., (2017) observed significant improvements in glycaemic control in type 2 diabetics following an intermittent walking intervention compared to a volume-matched continuous walking intervention, and Nemoto, Gen-no, Masuki, Okazaki, & Nose, (2007) found significantly greater increases in aerobic capacity and upper leg muscle strength in an intermittent walking group compared to a moderate-intensity continuous walking training group. Other authors have also observed reductions in lifestyle disease risk factors and improvements in peak aerobic capacity following long- (Masuki et al., 2015) and short-term (Murphy, Nevill, Neville, Biddle, & Hardman, 2002) intermittent walking interventions. However, future studies comparing walking football to traditional interval walking are required.

Walking football has the potential to be of greater benefit than intermittent walking interventions due to the frequent changes of direction required to react to the movement of opposition players and the ball. We observed an average of just under 100 changes of direction at a speed of 1.5 $m \cdot s^{-2}$ or above per walking football session, and ~45 accelerations and decelerations at speeds ≥1.5 $m \cdot s^{-2}$. Previous interventions with continuous walking have observed no discernible improvements in bone mineral density (Gába et al., 2016; Palombaro, 2005), which is unsurprising as walking is a part of normal day-to-day activities, and does not provide a large ground/joint reaction force. However, frequent changes of direction may elicit a greater strain magnitude and osteogenic stimulus than linear movement alone (Hart et al., 2017). There is currently a lack of evidence and consensus about the optimal exercise modalities to slow down age-related loss of bone and increase bone strength. However, it has been suggested that multidirectional activity may be of benefit (Santos et al., 2017). Nevertheless, it is also recommended that the exercise be of high intensity and impact in nature (Santos et al., 2017), and so whether walking football meets all these criteria remains to be elucidated. Furthermore, we observed very high CVs for CoD, ACC and DEC, suggesting that there are large inter-session differences in these metrics. The variability in the accelerometery variables across sessions may be due to intra- and inter-device variability, different sizes of teams, participants spending longer in the goalkeeper role (which requires less movement) and the dynamic, random nature of football in general. Therefore, it is important to account for potential differences in the biomechanical load of walking football sessions when prescribing walking football as an exercise intervention. Nonetheless, the HR response to the sessions demonstrated relatively low variability (CV: <7.5%) and so it would appear that walking football consistently imposes a moderate-to-vigorous intensity stimulus.

Limitations such as, but not limited to, individual variances, inter-unit reliability and placement, and disparate sampling frequencies must be taken into account when comparing individual accelerometery data (Malone, Lovell, Varley, & Coutts, 2017). In acknowledgment of these potential errors, Casamichana, Castellano, & Dellal, (2013) observed PL values that ranged from 219.5 ± 63.7 to 257.7 ± 39.8 a.u in third division Spanish players over 16 min of 5 vs 5 small-sided soccer matches. As such, our PL data (353 ± 67 a.u) suggests that 60 min of walking football equates to the same relative biomechanical load as approximately 25 min of a 5 vs 5 small-sided soccer match. Additionally, we observed increases in PL-ML (~9 %) and concurrent reductions in PL-V (~10 %) contributions compared to 90 min of simulated soccer (Page, Marrin, Brogden, & Greig, 2015). This is unsurprising given that running is prohibited in walking football, although it may suggest that the reduced impact may provide a safer alternative towards mitigating age-related losses in bone mineral density, when compared to regular football in older populations (Hagman et al., 2018).

Just reacting to the changes in the movement of opponents and the ball may offer benefits for the neuromuscular system. Falling in older adults is often precipitated by the inability of the neuromuscular system to react quick enough to an unexpected stimulus (Sawers & Bhatt, 2018). Reactive stepping interventions and perturbation-based balance training in older adults have been shown to reduce the risk of falling by 40-50% (Mansfield, Wong, Bryce, Knorr, & Patterson, 2015; Okubo, Schoene, & Lord, 2017; Weerdesteyn et al., 2006). As quick stepping in different directions is required during trips and falls, exercise stimuli that can improve sensorimotor skills and create stored motor programmes that can be utilised during fall situations may be of benefit (Okubo et al., 2017). Therefore, the requirement to respond stochastically to a dynamic game of walking football may potentially protect older adults from risk of falling. Falling itself is a leading cause of bone fractures in older adults, creating a large financial burden (Stevens, Corso, Finkelstein, & Miller, 2006), and potentially leading to a reduction in physical activity following a fall due to fear of future falls. As long-term bed rest due to fracture recovery can accelerate sarcopenia and loss of bone (Cruz-Jentoft et al., 2010; Leblanc, Schneider, Evans, Engelbretson, & Krebs, 2009), future studies assessing the impact of walking football on fall risk and bone metabolism are warranted.

Unfortunately, we were unable to measure step count and distance covered in the present investigation. To the authors' knowledge, we are unaware of any published research reporting step count and distances covered during walking football. Future research assessing these variables is necessary, as knowledge about the extent to which an hour of walking football contributes to daily step count can help exercisers and those who prescribe exercise. Current recommendations suggest a walking cadence of 100 steps·min^{-1} to elicit moderate intensity activity (Tudor-Locke et al., 2018), so ~5500 steps during an hour of walking football if accounting for a brief break during the session. However, recent research by Abt and colleagues suggests that to achieve a $\dot{V}O_2$ reserve ($\dot{V}O_2R$) of 40%, participants need a walking cadence of 138 to 140 steps·min^{-1} (Abt, Bray, Myers, & Benson, 2019). However, this is moderated by fitness status, with those of lower fitness able to achieve a similar $\dot{V}O_2R$ at a slower cadence. Moreover, current guidelines on overall daily step count (10,000 steps a day) may not be reflected by research outcomes, with more dose-response studies required in a variety of populations (Kraus et al., 2019).

That said, current recommendations suggest older adults should aim for 150 minutes of moderate-to-vigorous physical activity per week, with 3000-6000 steps per day at those intensities (Sparling, Howard, Dunstan, & Owen, 2015). Therefore, participating in walking football will not only likely help older adults meet daily step count recommendations, but also help them achieve the recommended amount of moderate-to-vigorous intensity activity.

This is the first study to measure the blood lactate response during walking football. We observed a mean increase of ~157% from pre- to post-session (1.24 ± 0.4 vs 3.19 ± 1.7 mmol·l^{-1}). This relatively high post-session blood lactate concentration suggests that walking football places a significant demand on the anaerobic system, in particular the glycolytic pathway, supporting the notion that walking football is a vigorous-intensity exercise for older adults. As expected, the observed concentrations were not as high as previously observed during small-sided recreational football matches in young (early 30's) untrained males (Randers, Nielsen, Bangsbo, & Krustrup, 2014; Randers et al., 2010; Randers, Ørntoft, Hagman, Nielsen, & Krustrup, 2018) but comparable data in older adults is not available. Due to logistical constraints we were unable to measure blood lactate at regular intervals (e.g., every 15 min) during the sessions, which would have allowed us to assess transient changes in blood lactate. Football is intermittent in nature, and as such, the flux of the anaerobic and aerobic energy systems will be in constant change, mimicking that of high intensity interval training (HIIT) protocols. In older adults, HIIT has been shown to improve metabolic (Søgaard et al., 2018) and cardiovascular health (Izadi, Ghardashi Afousi, Asvadi Fard, & Babaee Bigi, 2018), as well as muscle mitochondrial content (Wyckelsma et al., 2017). However, high dropout rates have been observed during HIIT programmes (Reljic et al., 2019). Therefore, the physiological and psychological benefits of walking football compared to traditional HIIT warrants further investigation, including adherence to the program of exercise, and affective responses during sessions.

Future intervention studies investigating walking football may benefit from collaborating with professional football clubs, as this has been shown to assist in attracting hard-to-reach males and increasing adherence to an exercise program (Curran, Drust, Murphy, Pringle, & Richardson, 2016; Hunt et al., 2014; Pringle et al., 2013). This was particularly successful in the large-scale European Fans in Training (EuroFIT) programme (Wyke et al., 2019). A similar programme utilising walking football as an intervention may help establish the usefulness of walking football as a form of exercise prescription for health professionals and exercise referral specialists. Furthermore, more data is required on the benefits of walking football for females, and individuals suffering from clinical conditions, *inter alia*, cardiovascular disease, diabetes mellitus, cancers, and chronic obstructive pulmonary disease (COPD).

In conclusion, we have shown that walking football is a moderate-to-vigorous intensity activity, that has a similar biomechanical load to 25 minutes of 'running' football and requires a relatively high number of changes of direction. The longitudinal health benefits of walking football remain to be elucidated, particularly on bone health, cardiovascular fitness, metabolism, and social and mental wellbeing. Furthermore, the benefits of walking football compared to, and in combination with, other types of training, such as HIIT and resistance training, requires further investigation.

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6. Figure Captions

Figure 1 Mean peak (HR_{peak}; panel A) and mean heart rate (HR_{mean}; panel B) values across 11 sessions of walking football (n = 11). The upper dashed line represents the average theoretical maximum heart rate of the participants, and the lower dashed line represents 80% of that value. See weblink for interpretation of violin plots: https://datavizcatalogue.com/methods/violin_plot.html.

Figure 2 Changes in blood lactate concentrations from pre- to post-session across 11 sessions of walking football (n = 9).

Figure 3 Individual rating of perceived exertion (RPE) values across 25 walking football sessions (n = 7).

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