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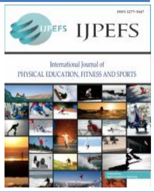

Characterizing the Metabolic Intensity and Cardiovascular Demands of Walking Football in Southeast Asian Women

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Abstract: Given that the recent rise in obesity rates throughout Southeast Asia is disproportionately driven by women, part of the regional solution may be to encourage more habitual physical activity within this population. Taking advantage of the regional popularity of walking football, this study sought to characterize the cardiovascular demands and metabolic intensity of Southeast Asian women competing in walking football matches to determine the sports' suitability for promoting physical health. It was hypothesized that both cardiovascular and metabolic intensity measures (≥65% HR% and ≥3.0 METs, respectively) would meet or exceed established thresholds for improving fitness and health. *Methods:* Women's teams from Singapore (Mean±SD: 42±11 yrs age; 29.2±7.0 kg/m² BMI; n=14) and Malaysia (40±10 yrs age; 32.9±5.7 kg/m² BMI; n=8) competed in two successive matches within a single day during which measures of heart rate (HR) and GPS (from portable handheld device) were recorded for each player, while relative HR was computed as a percent of each player's age-predicted maximal HR (HR%, %). The GPS data were later converted to walking distance and metabolic intensity (i.e., metabolic equivalents, or METs). One-sample t-tests at the 0.05 alpha level were used to compare variables to their respective thresholds. *Results:* Both Malaysian and Singaporean teams had mean relative HRs (91-95% of HR_{MAX} [P=0.008] versus 77-80% of HR_{MAX} [P<0.001], respectively) that exceeded the 65% threshold for improving cardiovascular fitness. Both teams also maintained an average metabolic intensity that was statistically similar to the 3.0 MET threshold that decreases one risk for non-communicable diseases (3.2±0.9 METs [P=0.0510] versus (3.3±1.0 METs [P=0.288], respectively), and both teams walked an average of 2.2-2.4 kms/match. *Conclusions:* These results support the idea that competitive walking football is of sufficient intensity to promote positive changes in both cardiovascular and metabolic fitness in this population of Southeast Asian women.

Key Words: GPS, heart rate, MET, Singapore, Malaysia, Physical Activity

Dan Heil is a professor in applied exercise physiology in the Department of Health and Human Development at Montana State University and has been awarded Fellow status by the American College of Sports Medicine. Dr. Heil's research focuses on determinants of human health, energy expenditure, and work performance during free-living, recreational, occupational, and sport-related activities. As such, his research often includes the use of wearable electronic monitoring devices, novel analytical strategies, as well as mathematical and statistical modelling. Dr. Heil's research interests are often inspired by his own personal interest and participation in a variety of sports that include triathlons, cross country skiing, open water swim racing, and taekwondo.

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Robert U. Newton is the Associate Dean, Medical and Exercise Sciences and Research Professor, Exercise Medicine Research Institute at Edith Cowan University Perth, Western Australia. Current major research directions include: reducing decline in strength, body composition and functional ability in cancer patients; cancer related fatigue and the influence of exercise; exercise medicine and tumour biology. Dr. Newton has published over 350 refereed scientific journal articles, 450 conference abstracts and papers, two books, 16 book chapters and has a current Scopus h-Index of 69 with his work being cited 16,000 times. As of 2018 his research had attracted over $35 million in competitive research funding. In 2018 he received the career achievement award from the Cancer Council WA and was a Finalist for West Australian of the Year.

1 Introduction

According to a 2017 report, obesity prevalence has steadily increased over the past three decades in every ASEAN (Association of South-East Asian Nations) country sampled (i.e., Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam) [1]. While the absolute rates of obesity for these ASEAN countries are still much lower (3.6% for Vietnam to 13.3% for Malaysia in 2014) than other countries like the United States (33.7%) and the United Kingdom (28.1%), the *change in obesity rates* for ASEAN countries from 2010 to 2014 are much higher (24-38% versus 8-10% for U.S. and United Kingdom). Furthermore, the same report shows that a disproportionate burden of the obesity trends in ASEAN countries are caused by women. Every ASEAN country represented in the report, for example, found women to have higher rates than men for both overweight and obese classification status. Thus, not only have the obesity rates increased at an alarming rate in this region of the world, but the rates are being driven disproportionately by women.

While many factors are known to contribute to changes in regional obesity rates (e.g., regional economic development, personal and family socioeconomic status, local urbanization, availability of food, genetic predisposition, etc.), the increasing prevalence of sedentary behaviors, as well as less active occupational demands, are common threats to obesity trends world-wide. A lack of sufficient habitual physical activity (PA), which is commonly defined as any bodily movement that significantly increases metabolic rate above resting levels, is known to significantly increase risk for many chronic non-communicable diseases [2]. To help address this issue, the World Health Organization (WHO) recommends that all adults (18-64 years of age) accumulate at least 150 minutes of *moderate* intensity PA weekly (or 75 mins of *vigorous* intensity) [3]. This PA standard, which is the same as that promoted in the U.S. [2], is based upon moderate and vigorous metabolic intensity thresholds defined as 3.0 and 6.0 metabolic equivalents (METs), respectively. While a MET value of 1.0 represents the population average for resting metabolic rate (RMR), MET values of 3.0 and 6.0 represent aerobic *metabolic intensity* levels that are 3x and 6x greater than that of RMR, respectively.

Not all physical activities, however, will satisfy the lowest threshold of 3.0 METs. Slow walking over flat terrain, for example, will be <3.0 METs, but slow walking up a steep hill, or slow walking while carrying a moderately heavy backpack, can both exceed 3.0 METs, as will brisk walking over flat terrain. Exhaustive lists of MET values for specific PA's can be found on-line [4], but MET values usually do not exist for new or uncommon activities. In such cases, it is up to researchers and clinicians to directly or indirectly determine a MET value range that can be anchored to the PA of interest.

One such activity is the relatively new team-based sport of walking football, which, as the name implies, is the walking-only version of regular football. While many of the rules and practices are the same between walking and regular football, many others are not, such as walking football's use of smaller fields and fewer players per team, as well as all players being restricted to walking. The popularity of walking football has grown quickly throughout Europe in just the last few years [5], while new clubs/teams and competitive leagues have also started in the North America and Southeast Asia. The sport of walking football is optimally suited for people who want to participate in a team-based sport, are healthy enough to engage in moderate-to-vigorous PA, but who either cannot or do not want to run. In the spring of 2017, the *Walking Football Healthy Asia* program was launched to encourage Singaporean and Malaysian women to adopt a more physically active lifestyle by training and competing in a walking football league. Given that both countries have relatively high incidence of obesity and obesity-related comorbidities when compared to other Southeast Asian countries [6], this program represents a publicity-driven community intervention designed to encourage adult women of all ages to participate in a team sport that is traditionally dominated by men.

While the potential health benefits of regular football participation (both recreational and competitive) are well established [7-9], the same cannot be said for walking football and especially with any focus on women. Hubball and Reddy [10], for example, in a study of Canadian "veteran players", reported upon the "physiological psycho-social and health benefits" of walking football, but the players were all men and pedometer steps counts were the only physiological measure. Reddy et al [11] went much further with a 12-week trial that tracked 20 walking football players with measures of resting blood pressure, body composition, blood measures, and match-play heart rate, but only 3 of the players were women. Thus, very few published studies have focused on physiological health issues related to walking football, and there appears to be no focus whatsoever on women participants, as well as no strong focus on the physiological demands of competitive walking football.

The purpose of the present study was to characterize both the cardiovascular (CV) and energetic demands (i.e., metabolic intensity) of Southeast Asian women competing in walking football matches. Specifically, it was hypothesized that measures of relative heart rate (HR%) would exceed the 65% threshold recommended for improving CV fitness [12]. It was also hypothesized that the average metabolic intensity of walking football match play would meet or exceed the 3.0 MET threshold for promoting metabolic health and minimizing non-communicable disease risk. Finally, given that the Malaysian team had trained together longer (6+ months) than the Singaporean team (< 1 month), it was hypothesized that the Malaysian team members would maintain a higher average CV demand than the Singaporean team members while maintaining a similar or higher metabolic intensity during match play.

2 Methods

2.1 Experimental approach

Walking football teams from both Singapore and Malaysia participated in a series of demonstration matches as part of the *Walking Football Healthy Asia* program that began in spring of 2017. All team members agreed to participate and provided consent in accordance with approved procedures by the Montana State University (Bozeman, MT USA) Internal Review Board (IRB). To record the measures planned for this study, each team member wore several types of electronic monitoring devices that would record aspects of CV demand and body motion without controlling or hindering the players' ability to participate. Direct measures of body height and mass were measured on a separate day using standard procedures.

2.2 Measurement Procedures

All match play measurements occurred on a single day in November of 2017 in Singapore at an elevation of 8 m above sea level. Each match took place on the same outdoor regulation mid-sized walking football field (40 m x 23 m) under partly sunny and generally hot and humid conditions that progressively worsened from early (First match: 26-28° C and 87% RH) to the late morning (Second match: 29-30.5° C and 90% RH). Prior to each match and before the team warmup, the members of each team were outfitted with the electronic devices that would record continuously until the devices were removed after the last match. The first and second half of each match lasted 15 mins with a 10-min break for halftime and about 20 mins break between successive matches.

Each player wore two types of measurement equipment: A heart rate (HR) monitor and a global positioning satellite (GPS) monitor. To measure HR, each player wore a coded chest strap transmitter and telemetry-based HR wrist watch (Polar RS400; Polar Electro Inc., Bethpage, NY USA) set to record average HR every 60 seconds. Once recording was complete, the data from each HR watch was downloaded to a computer (Polar ProTrainer 5; Polar Electro Oy, Finland) and then exported as a text file for post-collection processing. To measure body movement, each player also wore a small GPS monitor (Gecko 201; Garmin International, Inc., Olathe, KS USA) within a tight-fitting neoprene waist pack with the monitor located at the lower back. Prior to being assigned to players, each GPS was powered on and allowed to sit stationary for 30+ minutes adjacent to the playing field that was unobscured by anything to block GPS signals (e.g., tall buildings, or tall and dense trees). Set to record GPS coordinates each one second (1 Hz) using differential GPS (dGPS), the GPS data were later downloaded to a computer using third-party software (OziExplorer V3.95.6F; D&L Software Pty Ltd; oziexporere.com). The downloaded GPS data was then exported with the raw GPS coordinates (latitude, longitude, altitude) with each 1-second time stamp as a text file for post-collection processing. The extra mass of all the equipment worn by each participant (HR and GPS monitor + waist pack) totaled 0.35 kg and was included with body mass in the computation of energy expenditure.

2.3 Post-Collection HR and GPS Data Processing

The HR text file data were imported into a spreadsheet program and then summarized as an average HR (HR_{AVG}, BPM) for each participant for each half of each match, as well as for each entire match. These same HR data were also expressed as a percentage (HR%) of each participant's age-predicted maximal HR:

(1) $HR\% = (HR_{AVG} / HR_{MAX}) \times 100$

where HR_{MAX} was calculated as (220 – Age) with age expressed as years. The computation of both HR_{AVG} and HR% thus provided both absolute and relative expressions of cardiovascular demand, respectively. Each of these cardiovascular variables (HR, HR%) were then summarized as an average over the first half (HR_{H1}), the second half (HR_{H2}), as well as an average for the full match (HR_{M}), for both first and second matches between the teams.

The GPS text file data were imported into a spreadsheet program where successive GPS coordinates were transformed into an arc length (i.e., displacement) between points using spherical trigonometry to calculate the great circle distance (d, m) (i.e., the shortest distance between two points on the surface of a sphere). Given measures of latitude (ϕ) and longitude (λ) for successive pairs of points (i.e., 1 and 2), then the haversine of the angle (θ) between these two points relative to the center of the earth is given by:

(2) $\text{hav}\ \theta = \text{hav}\ \Delta\phi + (\cos \phi_1)(\cos \phi_2)(\text{hav}\ \Delta\lambda)$

where $\Delta\lambda = \lambda 1 - \lambda 2$, and $\Delta\phi$ is the difference in latitude measures. This formula is based upon spherical trigonometry and is derived from the spherical law of cosine. Once the value for θ is determined, then:

(3) $d = R \times \theta$

where d is the distance between successive latitude and longitude coordinate pairs and R is the average radius of the earth (6378140 m).

As such, the outcome for the above computation was walking distance for each one second of match play, the values of which were then summed each successive 60 seconds of match play (D, m):

(4) $\text{Distance (D)} = \sum_{k=1}^{60} d_k$

These 60-sec walking distance values were then used to compute cumulative distance (D_C, m) and average speed (s, m/min) for both the first and second halves of both matches. Values for D_C were computed as the sum of all D_C values within the period of interest:

(5) $\text{Cumulative Distance } (D_C) = \sum_{k=1}^{j} D_k$

where j is the number of minutes within the period of interest. Specifically, *D_C values were summarized as an average over the first half (D_{CH1}), the second half (D_{CH2}), as well as an average for the full match (D_{CM}), for both first and second matches between the teams.* Given that values for D_C were computed for each 60-secs, these same values also represented the average walking speed (SPD) in units of m/min. Finally, the minute-by-minute relative energetic cost of match play for each player was calculated as a function of average walking speed (SPD, m/min) as described below.

2.4 Predicting MET Intensity

The last step for post-collection data processing was to convert GPS-derived walking speed into units of METs. However, while there are many published formulae relating treadmill walking speed to energy cost in healthy adults [13, 14], there is strong evidence to suggest that the energetic cost of treadmill waking is not the same as that for overground walking [15]. Given the present study's need to convert GPS-derived overground walking speed into METs, a new prediction equation was derived. Data was pooled from two of our own previously published projects [16, 17] for a total of 72 subjects. This pool of subject data included 47 women (Mean±SD: 32±13 yrs of age; 73.4±20.6 kg body mass; 27.2±7.4 kg/m^2 for BMI) and 28 men (26±4 yrs of age; 83.4±10.6 kg body mass; 25.5±2.4 kg/m^2 for BMI) and included BMI classifications of 1 underweight, 38 normal, 22 overweight, and 14 obese (n = 75). Common to both studies was the direct assessment of overground walking energy expenditure. While the methodology for the collection of these data has been reported previously in detail [13], a brief outline will be provided below.

Subjects warmed up by walking for 10-15 min around an indoor oval track (201 m circumference). During the warm-up, subjects determined their self-selected "slow" and "fast" walking speeds. At each self-selected speed, while still warming up, stride rate was measured by repeated timing of 10 consecutive strides. These stride rates were subsequently the basis for controlling subjects' over-ground walking speeds during data collection. Next, subjects were fit with the metabolic instrumentation to be worn during data collection. Testing of the three overground speeds occurred successively with each condition lasting six mins and separated by a break of two mins. Subjects were paced while walking with an audible metronome (Seiko Clip Metronome, Model DM-33) clipped to their shirt collar that corresponded to the stride rates determined during the warm-up. The subjects were instructed to choose a stride length that best corresponded to the audible metronome rate. The energy expenditure for overground walking was assessed using standard indirect calorimetry procedures using the portable KB1-C Ambulatory Metabolic Measurement System (Aerosport, Inc., Ann Arbor, MI). This light weight (2 kg) portable system was worn by each subject during all walking trials. After data collection was complete, the data were downloaded to a computer for further processing.

The average oxygen consumption (VO_2; L/min) value for the last three mins of each 6-min walking bout were converted first to relative VO_2 (RVO_2; ml/kg/min):

(6) $RVO_2 = [(VO_2 \times 1000) / M_T]$

Where M_T (kg) was the total, or summed, values of the subject's body mass and the equipment mass. Next, the RVO_2 values were converted to METs assuming that 1.0 MET = 3.5 ml/kg/min:

(7) $METs = [RVO_2 / 3.5]$

Finally, Standard step-forward multiple regression analysis procedures were used to derive a single equation for predicting METs from a pool of possible independent variables that included overground walking speed (SPD, m/min), age (years), body mass (kg) and height (cm), gender (coded "0" for women and "1" for men), as well as potential interaction and polynomial terms. The significance of each independent variable, and the potential interactions between independent variables, were verified with partial F-tests [17] at a p-value of 0.15 while the overall model significance was evaluated at the 0.05 level of significance.

The result of this analysis was a third-degree polynomial using overground walking speed (SPD, m/min) as the only significant independent variable (R^2 = 0.85, SEE = ±0.19 METs):

(8) $METs = 0.143 + 0.091 \times SPD - 1.236E\text{-}3 \times SPD^2 + 7.086E\text{-}6 \times SPD^3$

Using Equation 8, average overground walking speed for each minute of match play for each subject was converted to a MET value and then averaged over the first half (MET_{H1}), the second half (MET_{H2}), as well as an average for the full match (MET_M), for both first and second matches between the teams. Finally, the time spent at an intensity ≥3.0 METs (T3M, mins) during match play was also summarized over the same periods – i.e., $T3M_{H1}$, $T3M_{H2}$, $T3M_.$

2.5 Statistical Analyses

Mean values for demographic variables (age, body mass and height, BMI), heart rate (HR_{H1}, HR_{H2}, HR_M; $HR\%_{H1}$, $HR\%_{H2}$, $HR\%_M$), cumulative walking distance (D_{CH1}, D_{CH2}, $D_{CM,}$), MET intensity (MET_{H1}, MET_{H2}, MET_M), and match time spent at ≥3 METs ($T3M_{H1}$, $T3M_{H2}$, $T3M_M$), were all summarized descriptively as Mean±SD. In addition, two-way ANOVAs with Tukey's HSD post-hoc analysis was used to evaluate differences in cardiovascular (HR, HR%) and GPS-derived (D_C, MET, T3M) variables across measurement periods and teams. Lastly, one sample t-tests were used to compare the mean MET intensity for each measurement period and team to the 3-MET thresholds. All statistical analyses were conducted using Statistix V10 (Analytical Software; Tallahassee, FL USA). Given the exploratory nature of this study, as well as the relatively small sample sizes dictated by team sized, an 0.05 alpha level was applied to all post-hoc tests.

3 Results

3.1 Demographics

Demographic data were included for all team members who completed at least one entire match (first and second halves) and successfully recorded heart rate and/or GPS for the same match. As such, there was no overlap in players for the Singaporean team between the two matches (i.e., different players for each match; n=14), but the Malaysian team had the same six players in both matches and two others in one match each (n = 8). Thus, the demographic summary shown in Table 1 is for all 22 players who satisfied the above-stated inclusion criteria (Table 1). Statistically, the teams were similar to each other for each demographic variable listed in Table 1. In addition, when classified according to the World Health Organization international BMI standards [18], the players included 12 women classified as obese, another 5 as overweight, 4 as normal, and 1 as underweight.

Similarly, average MET intensity was statistically similar between matches (P=0.414), between halves within a match (P=0.450-0.771), as well as between teams (P=0.677).

Table 1. Summary of demographic data for members of both Singaporean and Malaysian walking football teams. All values expressed as Mean±SD (Range).

Team	Age (years)	Body Height (cms)	Body Mass (kg)	BMI (kg/m²)
Singapore (n=14)	42 ± 11 (26 – 61)	155.5 ± 8.3 (141.0 – 174.0)	70.4 ±17.2 (47.4 – 102.8)	29.2 ± 7.0 (16.9 – 43.9)
Malaysia (n=8)	37 ± 6 (26 – 48)	157.6 ± 6.8 (148.0 – 165.5)	81.7 ± 14.6 (65.3 – 106.5)	32.9 ± 5.7 (26.5 – 43.8)
Both Teams (n=22)	40 ± 10 (26 – 61)	156.3 ± 7.7 (141.0 – 174.0)	74.7 ± 16.9 (47.4 – 106.5)	30.6 ± 6.6 (16.9 – 43.9)

3.2 Heart Rate Data Analyses

A summary of the HR data is provided in Table 2. Mean absolute HR was statistically lower (P<0.05) for the Singaporean team (137-141 BPM) than the Malaysian team (162-168 BPM) for both matches. When expressed as relative HR, values for HR% during the first match tended to be higher in both halves for the Malaysian team (90-93% vs 78-83%), though not statistically. During the second match, however, an even wider and statistically significant trend was apparent (P=0.03) with Malaysian and Singaporean players averaging 95-96% and 77-80%, respectively. The relative HR values for both Malaysian (P<0.001) and Singaporean (P=0.008) teams exceeded the 65% threshold recommended for promoting cardiovascular fitness.

3.3 GPS Data Analyses

A summary of the GPS-derived variables of interest are provided in Table 3. The distance walked by both teams was statistically similar (P=0.703) for both matches, averaging 2.3-2.4 km and 2.2-2.4 km for the first and second matches, respectively.

In addition, while all mean MET values expressed in Table 3 were statistically similar to the 3.0 MET threshold value (2.6 – 3.9 METs; P=0.288-0.510), none of the values were statistically greater than the 3.0 threshold. However, when all data was pooled from both matches and both teams, the average intensity of 3.2±0.1 METs was significantly greater than the 3.0 threshold (P=0.032). After transforming this MET intensity data into the amount of time spent ≥3.0 METs, it appears that the Malaysian team tended to spend more time ≥3.0 METs than the Singaporean team for both first (18.0 vs 10.8 mins) and second matches (17.2 vs 8.6 mins), though only the difference for the first match was barely significant (P=0.049).

4 Discussions

This study is the first to describe the metabolic intensity and cardiovascular demands of walking football for Southeast Asian women. The metabolic intensity, for example, averaged 3.2 METs across both matches and both teams which exceeds the 3.0 MET PA intensity threshold for minimizing non-communicable disease risks [2, 18]. Further, the average relative HR maintained by both Singaporean (77-80% of HR_{MAX}; P=0.008) and Malaysian (91-95% of HR_{MAX}; P<0.001) teams across both matches exceeded the 65% threshold often recommended for promoting improvements in CV fitness [12]. Collectively, these results strongly suggest that competitive walking football in this population of Southeast Asian women has the potential to cause positive changes in both metabolic and cardiovascular fitness. Given that the Malaysian team members had trained together as a team longer than the Singaporean team, it was hypothesized that the Malaysians would be able to maintain a higher CV intensity during match play. This, in fact, is exactly what was observed for both absolute and relative expressions of heart rate (Table 2).

In addition, this higher CV intensity maintained by the Malaysian team was complimented with spending more time above the 3.0 MET threshold than the Singaporean team (17-18 mins/match vs 10-11 mins/match, respectively; Table 3) despite maintaining a statistically similar MET intensity and walking distance for each match (Table 2). These observations compliment the limited reports on walking football in the research literature. Hubball and Reddy [16], for example, reported that highly experienced players walked 0.8-1.6 km during 10-min matches which extrapolates to 2.4-4.8 km for 30 mins of match play at the same intensity. The current study, using far less experienced women players, found a walking range of 2.2-2.4 km/match for successive 30-min matches (Table 3). Given the difference in experience and likely fitness of the players that these two studies represent (i.e., highly experienced players walking further than less experienced players), it is likely that walking football practice and competition will improve the capacity for walking distance during match play, though this is yet to be verified with further research. Reddy et al. [11] also reported an average HR intensity of 76% during match play which is similar, though a little lower, than the average match values reported for this study (79-95%; Table 2).

Table 2. Summary results for heart rate (HR) data analysis from women's walking football matches (November 2017 in Singapore) that include average heart rate (BPM) and average relative heart rate (HR expressed as a percent of age-predicted maximal HR; %) during two separate football matches played on the same day. Each measure was summarized as Mean±SD for each full match, as well as separately for the first and second halves of each match

Match	Heart Rate Measure	Measurement Period	Singapore Team (n = 7)	Malaysia Team (n = 7)
First Match	Average HR (BPM)	*First Half*	145 ± 25	†160 ± 15
		Second Half	137 ± 29	†164 ± 17
		Full Match	141 ± 27	†162 ± 16
	Average Relative HR as a percentage of HR_{MAX} (%)	*First Half*	82.9 ± 14.8	90.1 ± 6.3
		Second Half	78.3 ± 17.1	93.1 ± 6.4
		Full Match	80.6 ± 15.7	91.6 ± 6.1
Second Match	Average HR (BPM)	*First Half*	140 ± 22	†168 ± 15
		Second Half	134 ± 26	†169 ± 16
		Full Match	137 ± 24	†168 ± 16
	Average Relative HR as a percentage of HR_{MAX} (%)	*First Half*	79.9 ± 14.4	†94.6 ± 7.2
		Second Half	76.8 ± 16.6	†96.0 ± 8.0
		Full Match	79.4 ± 15.3	†95.3 ± 7.5

Table 3. Summary of results from GPS data analysis for women's walking football matches (November of 2017 in Singapore) that includes the average distance walked, the average metabolic equivalent (MET) intensity, as well as the average number of minutes spent at ≥3.0 MET intensity during two separate football matches played on the same day. Each measure was summarized as Mean ± SD (Range) for each full match, as well as separately for the first and second halves of each match.

Team & Match	Measurement Period	Distance Walked (m)	MET Intensity (unitless)	Time ≥3-MET Threshold (mins)
Singapore - *First Match* *(n = 6)*	*First Half*	1169 ± 273 (871 – 1624)	3.2 ± 0.9 (2.5 – 4.8)	5.7 ± 4.6 (2.0 – 14.0)
	Second Half	1152 ± 250 (796 – 1546)	3.9 ± 2.3 (2.4 – 8.5)	5.2 ± 4.6 (2.0 – 14.0)
	Full Match	2322 ± 489 (1667 – 3170)	3.5 ± 1.1 (2.4 – 5.5)	10.8 ± 8.9 (2.0 – 26.0)
Malaysia - *First Match* *(n = 5)*	*First Half*	1192 ± 257 (844 – 1537)	3.1 ± 0.7 (2.6 – 4.3)	8.8 ± 6.1 (3.0 – 16.0)
	Second Half	1260 ± 336 (931 – 1659)	3.5 ± 1.0 (2.6 – 4.6)	9.2 ± 4.9 (4.0 – 16.0)
	Full Match	2452 ± 581 (1774 – 3196)	3.3 ± 0.8 (2.6 – 4.4)	† 18.0 ± 10.6 (7.0 – 30.0)
Singapore - *Second Match* *(n = 6)*	*First Half*	1212 ± 195 (870 – 1424)	3.1 ± 0.6 (2.4 – 4.1)	7.5 ± 3.8 (1.0 – 11.0)
	Second Half	942 ± 309 (449 – 1268)	2.6 ± 0.5 (1.6 – 3.0)	3.5 ± 3.5 (0.0 – 9.0)
	Full Match	2155 ± 383 (1695 – 2591)	2.8 ± 0.4 (2.3 – 3.5)	11.0 ± 6.3 (1.0 – 18.0)
Malaysia – *Second Match* *(n = 5)*	*First Half*	1136 ± 339 (741 – 1664)	3.3 ± 1.1 (2.4 – 5.2)	8.6 ± 4.2 (4.0 – 15.0)
	Second Half	1278 ± 350 (892 – 1824)	3.5 ± 1.2 (2.3 – 5.7)	8.6 ± 3.7 (2.0 – 11.0)
	Full Match	2414 ± 663 (1816 – 3488)	3.4 ± 1.2 (2.4 – 5.4)	† 17.2 ± 7.2 (6.0 – 26.0)

While the collective results from this study strongly support the use of walking football as a PA for promoting both metabolic and cardiovascular fitness in Southeast Asian women, the long-term physiological effects of walking football are not yet proven. The 12-week walking football intervention by Reddy et al [11] found little improvement in any physiological measure for their intervention group when compared to the control group. However, their experimental group only trained together for 60 mins one day/week which falls short of the 150 mins/week of moderate intensity (or 75 mins of vigorous intensity) suggested for all healthy adults [2,18]. The frequency of training also fell short of the 3-5 days/week recommendation for exercise that is targeting cardiovascular improvements [12]. Thus, even though the walking football activity for their study exceeded the recommended cardiovascular intensity threshold (HR% = 76%), the activity did not meet or exceed either the duration or frequency thresholds. Clearly, the influence of walking football on physiological and health parameters needs further study with higher doses of PA that meet or exceed all domains (intensity, duration, and frequency) of exercise prescription.

Finally, this study used GPS data as a means for computing average walking speed and then average metabolic intensity. In principle, this technique assumes that all energy expended during match play was directly associated with steady-state aerobic metabolism with negligible influence of accelerations and decelerations. While these assumptions are clearly not true for field sports like football or walking football, the technique did provide a starting point for understanding metabolic intensity in this setting in a completely indirect manner – i.e., the method of measurement did not influence how the participants played. In fact, others [19] have speculated that use of GPS to predict energy expenditure during field sports will tend to under predict energy cost during non-steady-state activities (like match play). If this is generally true, then it is likely that the metabolic intensity values reported in Table 3 are, in fact, underestimates of the actual intensity for walking football in this population. Thus, to get more accurate estimates of metabolic intensity using GPS monitors for field sports play, it may be necessary to focus on improving the GPS-based algorithms for converting the raw GPS data (i.e., latitude, longitude, and altitude) into more accurate measures of velocity, acceleration, and especially the part that converts GPS-derived variables into whole body energy expenditure. The present study, in fact, derived its own equation for converting steady-state walking speed into METs using data from two previous over ground walking studies [8, 9]. This model, of course, still suffers from the assumption that most of the energy expended during match play was that associated with steady-state aerobic metabolism. It would seem prudent to improve this model in the future to include a more accurate representation of anaerobic energy expenditure, as well as aerobic energy expenditure associated to recovery between acceleration bouts.

5 Conclusions

Given that a disproportionate burden of Southeast Asia's recent change in obesity rates can be attributed to women, physical activity interventions should specifically focus on this population. As such, this study was the first to focus on describing the metabolic intensity and cardiovascular demands of walking football competition for Southeast Asian women. The study participants, all of whom competed as part of the *Walking Football Healthy Asia* program, were representative off the target demographic in this region having a broad age rage (26-61 yrs), relatively little experience with physical activity or sports, and 77% of whom were classified as either overweight or obese. Using several types of electronic monitoring devices for data collection, this study found that both metabolic intensity and cardiovascular demands either met or exceeded thresholds established by international health and fitness organizations for the improvement of cardiovascular and metabolic health. Thus, the results from this study support the use of walking football as part of an intervention to increase habitual physical activity within Southeast Asian women such as to promote positive changes in both metabolic and cardiovascular fitness.

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Competing Interests

The authors declare that they have no competing interests.

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