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Tests of Walking Performance as Predictors of Physiological Work during Walking Football Tournament Match Play

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Abstract: Walking football (WF), the walking version of competitive football (i.e., soccer), is a team-based sport that is popular with middle-aged and older adults. While some research has focused on the potential health benefits of WF participation, little research has focused on evaluating walking fitness tests as correlates (i.e., predictors) of physical work during WF competitions. This study evaluated whether metrics of walking test performance could predict metrics of physiological work measured during match play. *Methods:* Men's (n=16; Mean±SD: 49±10 yrs age) and women's (n=20; Mean±SD: 55±14 yrs age) WF teams from England, Indonesia, Malaysia, and Singapore, all of whom were competing in an international WF tournament in Singapore, were recruited for this study. Participants performed two walking tests: 10m Walk Test to determine maximal walking speed (WS_{MAX}), and the 6-min Walk Test to measure maximal walking distance (6MWTD) in 6 mins. The 6MWTD was also transformed into a predicted maximal oxygen uptake (PVO_{2MAX}). During the tournament the next day, participants wore a neoprene waist pack with an accelerometry-based activity monitor (AM) that was used to derive three metrics from a single competitive match: Total activity counts (AC_{TOT}, counts/match), total steps ($STEPS_{TOT}$, steps/match), and a sum of MET-minutes (MET-mins/match). Multiple regression procedures were then used to predict the physiological work values (AC_{TOT}, $STEPS_{TOT}$, MET-mins) from the walking test metrics (WS_{MAX}, 6MWTD, PVO_{2MAX}) (0.05 alpha). *Results:* Neither 6MWTD nor PVO_{2MAX} were predictive of any physiological work variables (P=0.57-0.97), but WS_{MAX} was highly predictive of all physiological work variables – R^2=0.65 for AC_{TOT}, R^2=0.54 for $STEPS_{TOT}$, R^2=0.61 for MET-mins – with sex as a covariate. *Conclusions:* Walking test metrics related to cardiorespiratory fitness were not related to measures of physiological work during WF match play, but the metric of maximal walking speed (WS_{MAX}) seemed to be highly predictive. These results suggest that aerobic walking fitness (i.e., as determined by 6MWTD performance) may be less important than anaerobic bursts of walking speed (i.e., WS_{MAX}) to the needs of competitive WF match play.

Keywords: Fitness, MET, Singapore, Steps, Walking Speed

1. Introduction

Walking football (WF), the walking version of competitive football (i.e., soccer), is a relatively new team-based sport that often focuses on promoting healthy behaviors, inclusiveness, and a positive social environment as much as training and competition. While WF is a very recognizable form of competitive football, there are also some distinct differences such as being restricted to walking (no running or jumping), the use of fewer players and smaller pitches, as well as rules against body contact. The rules are intended to provide a safer and more inclusive environment for all adults wanting to participate and compete in WF. While England is given credit for giving birth to the sport of WF in 2011 and can even boast of having well over 1,000 active WF clubs, the sport has since spread worldwide with international tournaments happening annually.

Given WF's high participation rates by middle-aged and older adults, many researchers have focused on the potential health benefits of WF participation (Barreira *et al.,* (2025); Heil *et al.,* (2018); Heil *et al* ., (2021); Heil *et al.,* (2021); Pisa-Canyelles *et al.,* (2025); Price *et al.,* (2025); Reddy *et al.,* (2017)), as well as the potential health risks associated with WF participation (Price *et al.,* (2025); Reddy *et al.,* (2017)). However, there does not seem to be any focus on physiological determinants of WF performance. Physiological determinants could include any of the common physical abilities already well-known for many other field-based sports. Competitive futsal players, for instance, typically score high on maximal oxygen uptake (VO_{2MAX}), reactive agility, and running speed (Sekulic *et al.*, 2021). In fact, running speed, as well as variables related to running speed (e.g., running speed at ventilatory threshold) will scale with competitive levels – i.e., Those who participate as professionals have the highest running speeds, while non-professionals tend to have slower maximal running speeds. Similarly, VO_{2MAX} values for professional football players have been shown to correlate positively with total distance covered during a competitive match (Hoff *et al.,* 2005). Thus, specific physical abilities and/or capacities have been shown to correspond directly with greater on-field physical abilities that relate to the athlete's performance capacity.

Physical abilities directly related to walking would seem to be an obvious choice for testing capacities thought to relate to physiological determinants of WF performance. There are several walking-based performance tests that have already been thoroughly validated across a broad range of adult populations that could be used to evaluate WF players. Tests of walking speed (WS), for instance, are commonly measured in older and clinical adult populations because of its predictive ability for a variety of negative health conditions, including risk for mobility disability, future hospitalization and institutionalization, cognitive decline, cardiovascular events, all-cause mortality, as well as a general marker of overall health status, individual functional capacity, and even the presence of depressive symptoms (Middleton *et al.,* 2015). Common tests of walking speed include assessing either *self-selected* walking speed (WS_{SS}) or *maximal* walking speed (WS_{MAX}). Both tests involve walking a linear path overground through two sets of electronic timing gates that are 5-10 m apart. While measures of WS_{SS} are related to various health outcomes and functional status, WS_{MAX} is thought to be a better indicator of one's free-living functional capacity within the community (Middleton *et al.,* 2015). Another common walking test for adults is the 6-Minute Walk Test (6MWT), where the goal is to walk as far as possible within six minutes over level ground. The primary metric derived from performing the 6MWT is total distance walked (i.e., 6MWT distance, or 6MWD) and is known to be a good indicator of free-living walking capacity, as well as a reasonable predictor of maximal oxygen update (VO_{2MAX}) in healthy middle-aged and older adults (Sperandio *et al.,* 2015).

Given the current lack of focus on determinants of WF performance in the research literature, the current study was undertaken to explore the relationships between measures of physiological work performed during a WF match with measures of walking performance from both the 6MWT and a measure of maximal walking speed (WS_{MAX}).

We hypothesized that metrics from both walking tests would correlate positively and significantly predict measures of physiological work.

2 Materials & Methods

2.1 Study Design & Participants

Study participants were recruited from those attending the International Invitational Matches (Singapore) for teams from England, Indonesia, Malaysia, and Singapore. Participation in this research project was not a prerequisite to participating in the tournament. As such, this research project is best described as an observational correlation study of a convenience sample of middle-aged and older adults voluntarily participating in an international walking football tournament. All members of each participating team were invited to participate across two days of testing. Those who wished to participate in one or both days of testing read and signed an informed consent document approved by the Montana State University (Bozeman, MT USA) Institutional Review Board (IRB #2023-675).

2.2 Procedures

All testing for this project occurred across two days (hereafter referred to as Day 1 and Day 2, respectively) in suburban areas of the city of Singapore. Day 1 testing, which involved performing two types of walking performance tests, occurred at the St Wilfred Sports Centre under mostly sunny skies (31-32º C, 85% RH). Day 2 testing, which was the day for all tournament matches, occurred at a nearby football pitch (Toa Payoh Stadium) under mostly sunny (early matches) to overcast (later matches) conditions (30-31º C, 65-100% RH).

Day 1 testing focused on completing the approved Informed Consent Document, and the collection of demographic, anthropometric, and questionnaire data, as well as performing two different walking performance tests. Demographic and questionnaire information included self-reported age, sex, nationality, years of walking football experience, as well as their jersey numbers on tournament day (to assist with keeping track of the assignment of measurement equipment on Day 2). Anthropometric data included the measurement of body height and mass to the nearest 0.1 cm and 0.1 kg, respectively, using a standard medical examination scale. Questionnaire assessments included asking "*How long have you been playing competitive walking football?*" (Answer provided in years and/or months), "*During the past 3 months, how many days each week did you practice walking football?*" (Answers: 1 day/week, 2 days/week, 3 days/week, 4 or more days/week), and "*During the past 3 months, how many hours each week did you typically practice walking football?*" (Answers: Less than 1 hour/week, 1-3 hours/week, 4-6 hours/week, more than 6 hours/week).

After completing these assessments, participants moved to a nearby station to perform the 10m Walk Test to measure their fastest walking speed (WS_{MAX}). After verbal instructions and a demonstration by investigators, the participant was instructed to stand at the 0m starting line and then walk as fast as possible for 10m before slowing down. Using a wireless laser timing system with two gates (SPEED TECH S-001 Single Version Wireless Laser Timer; Dongguan Xuanying Sports Technology, China), the time required to walk through the timing gates from 2 m to 10 m was recorded (i.e., 8 m walking distance and timing window). The fastest walk time recorded from 2-3 trials were then used to calculate each participant's fastest walking speed, with at least 60 secs between trials to allow for full recovery. These testing procedures are consistent with those guidelines published by Middleton *et al*. (2015) For the measurement of walking speed in adults.

Next, participants moved to an adjacent artificial grass field to perform the 6-Minute Walk Test. This test was a measure of walking endurance and cardiovascular fitness – i.e., the further participants walked in 6 minutes the better their predicted cardiovascular fitness. Participants were tested in groups of 5-20 and performed this test by walking laps around a coned rectangle on the field (160 m circumference) in a counterclockwise direction. At the command "Go!", participants began walking at the fastest consistent pace that could be managed without breaking into a jog or run and were instructed to maintain a consistent pace the entire test duration. The goal for this test was for participants to complete as many walking laps around the field as possible until 6 minutes was completed. The test ended with the command "STOP!" and a loud whistle, at which point each participant waited for an investigator to record their total distance walked before leaving the field. Distance was recorded to the nearest 0.5 m.

Two days later, Day 2 testing was completed as part of the International Invitational tournament. Testing involved wearing a tight-fitting elastic waist pack that held an electronic activity monitor during each team's first match of the day. The pack was worn around the waist (like a belt) continuously until the end of the match with the activity monitor collecting data continuously during the entire day. While the waist pack could be worn either under or over the participant's clothes, the pack stayed around the waist until the match was completed. The pack was then collected by an investigator and transferred to the next participant in the next match. This process continued until all participants wore an activity monitor during match play. All matches occurred on one of two adjacent pitches of equal size (20m x 40m) and were played using the same rules and game schedule (i.e., 30 minutes of play with 15-minute halves separated by a 5-minute halftime).

2.3 Instrumentation and Data Processing

Each participant's fastest 10m Walk Test time through the 8 m timing window was recorded to the thousandth of a second and then transformed into measures of walking speed (WS_{MAX}) in both m/s and KPH. Each participant's 6-Minute Walk Test distance (6MWTD) was summarized as both a total distance walked (m), as well as being transformed into a predicted maximal oxygen uptake value (PVO_{2MAX}, ml/kg/min) using a published algorithm (Sperandio *et al*., 2015):

Predicted VO_{2MAX} (ml/kg/min) = 0.0563x6MWD – 2.863 (R^2 = 0.76) where 6MWD is the total distance walked during the 6MWT in meters.

The activity monitor data (Actical Z; Philips Respironics, Inc., Bend, OR USA) was downloaded to a personal computer using proprietary software (Actical Z V3.0; Philips Respironics, Inc., Bend, OR USA). The raw activity data were first summarized into 1-minute sample epochs before exporting the data as text files for further processing in a spreadsheet program. Once imported into the spreadsheet program, the data corresponding to each participant was extracted for further processing that included the transformation of each 1-minute epoch of activity counts (AC) into total steps taken each minute (Eslinger *et al.*, 2007) and metabolic equivalents (METs) (Heil *et al.,* 2006). Each participant's data in the spreadsheet program was then summed for the entire competitive match into three outcome (or dependent) variables: AC_{TOT} (total activity counts for the match; steps/match), $STEPS_{TOT}$ (total walking steps recorded for the match; steps/match), and MET-mins (a sum of the 1-minute MET values for the match; MET-mins/match).

2.4 Data Analysis

The variables related to walking performance (independent variables) – i.e., WS_{MAX}, 6MWTD, and PVO_{2MAX} – were used to predict measures of total work of playing a walking football match – i.e., AC_{TOT}, $STEPS_{TOT}$, and MET-mins – using standard multiple regression procedures. The overall goal of these regression analyses was to explore relationships between variables rather than the development of prediction equations. As such, step-forward multiple regression analyses were applied to determine a single equation for predicting each dependent variable from each independent variable with the possible inclusion of other variables as covariates – i.e., age (years), body mass (kg), body height (cm), sex (coded "0" for women and "1" for men), and interactions (e.g., sex by age). The residuals for each final regression analysis were evaluated for normality and heteroscedasticity using the Shaprio-Wilk Test for Normality and a visual evaluation of residual plots, respectively. The significance of each independent variable was verified with partial F-tests (Kleinbaum *et al.*, 1988) at a p-value of 0.15 while the overall model significance was evaluated at the 0.05 alpha level.

Using an a priori analysis, at least 27 participants would be needed to detect an effect size of 0.25 (f^2) with a 0.05 alpha and power of 0.80 (G*Power software, Version 3.1.9.4; Franz Faul, Universität Kiel, Germany). Effect sizes of $0.02 \leq f^2 < 0.15$ are generally considered to be "small", while $0.15 \leq f^2 < 0.35$ are considered "moderate", and $f^2 \geq 0.35$ are considered "large" (Cohen *et al.,* 2013). All statistical analyses were performed using a commercial software package (Statistix, Version 10; Analytical Software, Tallahassee, FL USA).

3 Results

A total of 21 women and 21 men from all teams participated in the Day 1 data collection, but two of the players chose not to participate in Day 2 testing and another three players self-identified as being the goalie for their teams. The goalies were omitted because the position-specific demands of walking during match play presumably differed from all other positions. Additionally, during preliminary screening of all raw data, one participant was found to have recorded a WS_{MAX} that was 3.3 KPH faster than any other participant (and >3 SDs above the group mean). To explain this observation, it was presumed that this 10mWT performance violated the rules for performing the walk test and was not caught by test administrators at the time of testing. As such, the data from all six of these players were excluded from further reporting. The remaining 20 women and 16 men were included for all subsequent numerical and graphical analyses.

From the questionnaire data, most of the women reported playing competitive walking football for 2.4±2.8 yrs (Mean±SD) while the men reported less experience with 1.5±1.1 yrs. However, most of the women and men consistently reported practicing walking football either 1 or 2 days/week with practices totaling 2.0±0.7 hrs/week. While both genders averaged in the 50's for age, the age range for both women (17-71 years) and men (34-69 years) were quite broad (Table 1). The greater numbers of middle-aged and older adults, as well as the broad range of BMI values, were similar to those reported previously for adults participating in two other international walking football tournaments (Heil, *et al.,* 2018; Heil, *et al.,* 2021).

Summary statistics for all key variables evaluated in the regression analyses (Table 2) are provided in Table 2 (walking performance related variables) and Table 3 (match play derived variables). Initial correlational analysis for both 6MWTD and PVO_{2MAX} (r = -0.006 to 0.099; P=0.57-0.97) indicated very poor and nonsignificant correlations with each independent variable of interest. This lack of significance was not improved with the introduction of any of the possible covariate variables (age, body height or mass, sex, or interactions). As such, further analyses with the 6-minute Walk Test variables were abandoned. The same correlational analyses for WS_{MAX}, however, were both statistically significant and moderate to strong in magnitude for AC_{TOT} (r = 0.68; P<0.001), $STEPS_{TOT}$ (r = 0.56; P<0.001), and MET-mins (r = 0.61; P<0.001).

Table 1. Demographic measures for walking football study participants (Mean±SD).

Gender	Age (years)	Body Mass (kg)	Body Height (m)	BMI (kg/m^2)	*BMI Classification UW	NW	OW	OB
Women (n=20)	55±12 (37-71)	67.1±12.0 (40.3-86.3)	1.58±0.07 (1.45-1.72)	27.4±5.2 (17.2-37.5)	0	10	6	4
Men (n=16)	49±10 (34-69)	73.8±13.4 (56.4-98.9)	1.65±0.06 (1.55-1.79)	27.2±4.7 (21.6-36.4)	0	5	4	7

* BMI (body mass index) classifications indicate number of participants who were rated as underweight (UW), normal weight (NW), overweight (OW), or obese (OB).

Table 2. Summary of metrics derived from the 6-Minute Walk Test (6MinWT) and the 10m Walk Test (Mean±SD).

Gender	⁎ 6MinWT Dist. (m)	⁎ PVO_{2MAX} (ml/kg/min)	⁎ 10mWT Time (s)	⁎ WS_{MAX} (m/s)	⁎ WS_{MAX} (KPH)
Women (n=20)	619±58 (505-749)	37.7±3.3 (31.3-45.0)	2.679±0.382 (1.916-3.179)	3.05±0.47 (2.52-4.18)	11.0±1.7 (9.1-15.0)
Men (n=16)	602±81 (392-750)	36.8±6.4 (24.9-45.1)	2.307±0.657 (1.749-4.427)	3.65±0.72 (1.81-4.57)	13.1±2.6 (6.5-16.5)

⁎ 6MinWT = 6-Minute Walk Test; PVO_{2MAX} = Predicted maximal oxygen uptake; WS_{MAX} = Maximal walking speed.

Table 3. Summary of metrics derived from walking football match play international tournament (Mean±SD).

Gender	⁎ AC_{TOT} (counts/match)	⁎ $STEPS_{TOT}$ (Steps/match)	⁎ MET-mins (MET-mins/match)
Women (n=20)	49,333±17,802 (14,513-81,740)	1903±498 (890-2552)	115.9±27.8 (41.9-162.8)
Men (n=16)	83,034±14,454 (50,616-102,790)	2719±306 (2099-3133)	163.5±14.2 (138.3-184.1)

⁎ AC_{TOT} = activity monitor activity counts/match; $STEPS_{TOT}$ = total step count derived from the waist-worn activity monitor; MET-mins = the sum of all 1-minute MET values derived from the activity monitor during match play.

Following this with multiple regression analyses determined that sex was a consistent and significant contributor to the explanation in variance between WS_{MAX} and each independent variable. The addition or substitution of the other possible covariates were all nonsignificant. When separate analyses were performed by sex, the same conclusions were eventually drawn – i.e., Correlations with both 6MWTD and PVO_{2MAX} were nonsignificant and low in magnitude, while correlations with WS_{MAX} with both significant and moderate to high in magnitude. As such, the regression models that included sex as a covariate were considered a better simplified reflection of the overall regression trends.

Summaries of the resulting regression analyses are provided in Equations 1-3 (below).

(1) AC_{TOT} = 1577.1 + 4352.9 x (10mWT Speed, KPH) + 23728.1 x Sex

(R^2 = 0.65, R = 0.81, SEE = ±4497, P<0.001)

(2) $STEPS_{TOT}$ = 1143.8 + 69.1 x (10mWT Speed, KPH) + 658.8 x Sex

(R^2 = 0.54, R = 0.74, SEE = ±408, P<0.001)

(3) MET-mins = 64.5 + 4.7 x (10mWT Speed, KPH) + 36.9 x Sex

(R^2 = 0.61, R = 0.78, SEE = ±21.2, P<0.001)

Each of the three dependent variables (AC_{TOT}, $STEPS_{TOT}$, and MET-mins) were regressed on WS_{MAX} with sex as a covariate. Using the procedures described by Cohen (2013), the calculated effect sizes for these regression models (f^2 range = 1.08 to 1.50) are all considered to be "large" effects. A graphical example of this relationship is shown in Figure 1 that shows the linear relationship between AC_{TOT} and WS_{MAX} by sex.

4. Discussion

This study administered two tests of walking performance – i.e., the 6-min Walk Test (6MWT) and a test of maximal walking speed (WS_{MAX}) – to competitive walking football (WF) players to explore whether walking test metrics could be predictive of physiological work performed during subsequent WF tournament matches. While we had hypothesized that metrics from both walking tests would correlate positively with measures of work performance, only metrics from the WS_{MAX} test satisfied this hypothesis. In fact, there seemed to be no statistical relationship whatsoever between metrics from the 6MWT (i.e., 6MWTD and PVO_{2MAX}) and any of the dependent variables (AC_{TOT}, $STEPS_{TOT}$, and MET-mins). In contrast, the measure of maximal walking speed (WS_{MAX}) correlated positively and were highly predictive of each of the same dependent variables.

There are several reasons why the lack of a relationship between the 6MWT metrics and the measures of physiological work were unexpected. First, walking is generally considered to be an "aerobic", or cardiovascular demanding, physical activity that has a metabolic equivalent to 3.0-6.5 METs (moderate-to-vigorous intensity) for healthy adults (Riebe *et al.*, 2018). Second, maximal cardiorespiratory fitness (i.e., VO_{2MAX}) is commonly predicted from walking performance tests by maximizing distance for given time (e.g., 6MWT; Sperandio *et al.*, 2015) or minimizing time for a given distance (e.g., 1-Mile Walk Test; Riebe, 2018). Third, VO_{2MAX} is known to be highly predictive of competitive race-walking speed (Yoshida *et al.*, 1989). Lastly, our own research has previously reported that WF match play heart rates will exceed the threshold for moderate intensity cardiovascular activity (Heil, 2018), as well as mean MET intensity levels for competitive WF match play ranging from 3.3 METs to 4.4 METs (Heil, 2021). Collectively, these data suggest that an aerobic performance-based walking test metric, such as 6MWD and PVO_{2MAX}) would be expected to correlate positively with measures of walking performance from a WF match. This, of course, was not observed in the present study.

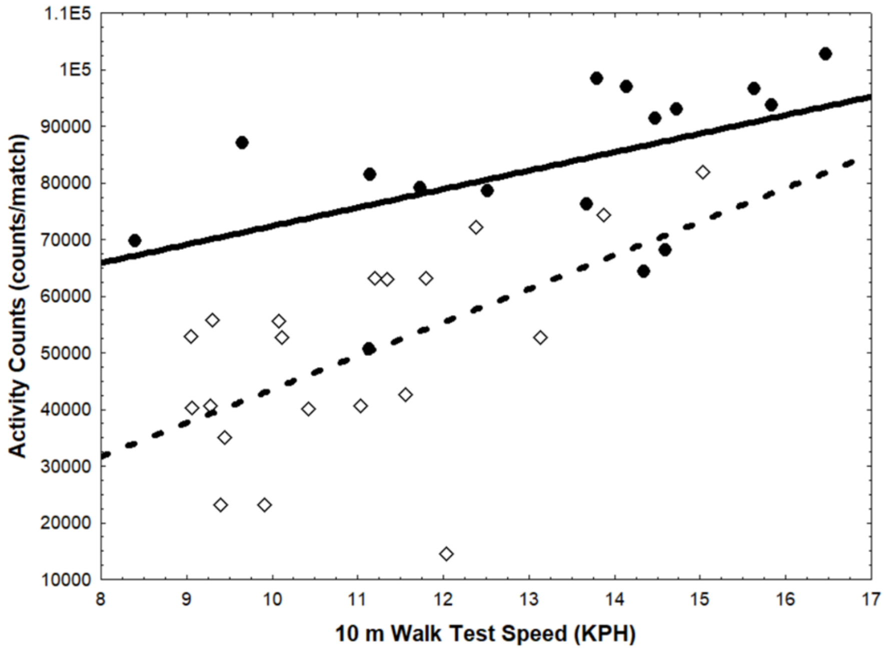

Figure 1. Scatterplot of the relationship between maximal speed (WS_{MAX}) from the 10m Walk Test and Activity Counts (AC_{TOT}) from a waist-worn activity monitor for both women (open diamonds and line) and men (solid circles). Each line represents the line-of-best-fit for the regression of AC_{TOT} on WS_{MAX} and demonstrates why sex (coded as "0" for women and "1" for men) was needed as a statistical covariate for the regression analysis.

It is possible, however, that the cardiorespiratory fitness levels of the participants of this study were very high relative to the actual metabolic demands of playing WF (i.e., the metabolic stress was low relative to their VO_{2MAX} values). Applying the cardiorespiratory fitness classification tables from the American College of Sports Medicine (Riebe, *et al.,* 2018) to the mean predicted VO_{2MAX} (PVO_{2MAX}) values reported in Table 2, the women's mean PVO_{2MAX} would rank as "Superior" and above the 95th percentile while the men's PVO_{2MAX} would rank as "Good" at the 70th percentile. Further, calculating the average MET value for the WF participants as a percentage of PVO_{2MAX}, the women averaged a metabolic rate of only 36% of their PVO_{2MAX} and men averaged 52%, where these values are classified as "Light" and "Moderate" metabolic intensities, respectively. What this latter analysis suggests is that for healthy adults with a "high" cardiorespiratory fitness level, competitive WF may not be very metabolically challenging. This reasoning would help explain why neither metric of the 6MWT – i.e., 6MWTD and PVO_{2MAX} – was a correlate of the physiological work metrics. If this is true for WF players with "high" cardiorespiratory fitness, then what about those players with "low" or "moderate" levels of cardiorespiratory fitness? While the current study cannot answer this question directly, it seems reasonable to suggest that correlations between these same variables are more likely to be significant for WF players with "Low" cardiorespiratory fitness. For instance, players with "Low" VO_{2MAX} values would need to play WF matches at a much higher percentage of their VO_{2MAX} than those with "High" VO_{2MAX} values. As such, the "Low" VO_{2MAX} players sustainable metabolic rate may be limited during match play whereas the "Higher" VO_{2MAX} players are not limited.

In contrast to the results for the 6MWT, the maximal walking speed metric – WS_{MAX} – was highly predictive of all physiological work variables. The typical demands of WF match play have previously been described as requiring frequent walking accelerations and decelerations, as well as a need to change walking direction, quickly and repeatedly throughout match play. As such, a higher WS_{MAX} would complement an ability to accelerate, decelerate, and change directions quickly to follow the ball and make plays happen effectively. The current WF research literature, however, does not seem to currently include direct measures of these physical abilities (i.e., quick accelerations or decelerations, or quick change of directions) as either part of a physical fitness test battery, or as indirect measures as part of match play WF competition. This observation is likely a result of the research literature's focus on WF's influence on healthy behaviors and well-known risks for chronic diseases (Barreira *et al.,* (2025); Heil *et al.,* (2018); Heil *et al.*, (2021); Heil *et al.,* (2021); Pisa-Canyelles *et al.,* (2025); Price *et al.,* (2025); Reddy *et al.,* (2017)). Thus, WF competition is usually considered more of a secondary goal around which to focus the WF training, whereas the physical training and social interactions inherent with WF team training are the primary goals for participants. There is one research team in Spain (Pisa-Canyelles, *et al.,* 2025), however, who is currently engaged in completing a 6-month WF intervention study for older adults that will include measures from both the 6MWT and a 30m walking test of speed. While this 30m walking test is going to provide measures of sustained fast walking, the speeds will be notably slower than those measured in the current study's 10mWT. Regardless, the current research literature simply does not have a tremendous focus on determinants of WF performance because of a preferred emphasis on how WF participation contributes to health outcomes. Thus, it will take more research to determine why and/or how strong the relationship really is between a measure of true walking speed – i.e., WS_{MAX} – and physiological measures of WF performance.

According to Middleton *et al* (2015), adults with WS_{MAX} values ≥1.3 m/s can be considered "extremely fit" relative to the entire adult population (including those with poor clinical health histories). Women and men in the current study averaged 3.1 and 3.6 m/s for WS_{MAX} (Table 2), respectively, which is more than double this 1.3 m/s threshold value. Even the lowest WS_{MAX} recorded for our WF players (2.2 m/s and 1.8 m/s for a woman and man, respectively) easily exceed the 1.3 m/s threshold value. Thus, it seems reasonable to characterize WF players who compete in international WF tournaments as tending to have relatively "healthy" WS_{MAX} values and this, in turn, may be related to the player's ability to meet the needs of WF competition (i.e., walking accelerations, decelerations, and quick changes of direction).

As a cross-sectional observational study of a convenience sample of participants, this study does have delimitations and limitations worth noting. Delimitations include the study sample – i.e., middle-aged and older adults who actively participate in WF international competitions. As such, the study sample likely represents a cross-section of adults who are more physically fit and better at walking tests relative to peers in their respective communities. These study results are also delimited to the collection of data as part of an international WF tournament. This characteristic of the study purposely took advantage of these teams coming together for the tournament, as well as the desire to collect measures of physiological work during real match play rather than simulated match play competition. Limitations to this study primarily revolve around the need to collect data around the WF tournament. For instance, while independent measures were collected for each team during a single match during the tournament, the independent measures themselves (as derived from the AC monitors) reflected who each team was competing against. In addition, since an emphasis of this tournament was the inclusion of all adults healthy enough to participate, both males and females were part of each team and they played in whatever position to which they were assigned by their team coach. As such, this study cannot definitively state that the observed relationships by sex are identical or not. Another possible limitation is the unknown influence of fatigue on any of the match play measurements. The study design did try to minimize this influence by always collecting AC measurements during each team's first tournament match, but some individual players could have fatigued by the end of the second half of their matches. As such, the result would have been to create more variability in the AC measures. While the results of this study did not focus on non-tournament match play, we would speculate that the same relationships still exist between measures of walking performance and physiological work. Finally, this study chose to focus exclusively on using well-studied walking tests (i.e., those with established measurement validity and reliability) that also had clear health-related links to middle-aged and older adults. It is possible that tests of other physical abilities, such as agility or balance, may also correlate with physiological measures of match play performance. To resolve at least some of these issues, a future study could focus on the administration of a broader collection of physical fitness tests (e.g., tests of walking performance, agility, dynamic balance, lower body power, multi-joint range of motion) during non-tournament match play both before and after a training intervention designed to improve physical performance during WF match play.

5 Conclusions

This study was designed to explore the relationships between measures of physiological work performed during a walking football match (AC_{TOT}, $STEPS_{TOT}$, MET-mins) with several measures of walking performance derived from both the 6MWT (i.e., aerobic walking performance) and a test of maximal walking speed (i.e., anaerobic walking performance). Though we had hypothesized that metrics from both walking tests would significantly predict each measure of physiological work, only the measure of maximal walking speed (WS_{MAX}) was able to predict each measure of physiological work significantly. We suspect that the 6MWT metrics were not related to the metrics of physiological work because the physiological demands of WF competition were relatively low when compared to the players' relatively high cardiorespiratory fitness levels. In contrast, WS_{MAX} was highly predictive of these same physiological work metrics for both women and men. We propose that the measure of WS_{MAX} is strongly related to each WF player's need to walk with quick accelerations, decelerations, and quick changes of direction during WF competitions. If causally linked by a future study, metrics of WF match play performance may be changed by improving maximal walking speed performance. To establish a causal link between these metrics, however, would require a future WF training intervention study that included measurements of pre- and post-measures of W_{MAX}.

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Author Contribution Statement

Both the authors equally contributed and approved the final version of this work.

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Ethics Approval Statement

This study was reviewed and approved by the Montana State University Institutional Review Board (IRB), Bozeman, Montana (IRB Approval Number: #2023-675).

Data Availability Statement

Additional data tables and raw data files are available upon reasonable request from the corresponding author.

Informed Consent

Written informed consent was obtained from all participants prior to their inclusion in the study.

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Yes