JOMH Journal of Men's Health

*J. Mens. Health* **2022**; 18(7): 153
https://doi.org/10.31083/j.jomh1807153

*Original Research*

# Locomotor Demands in Professional Male Football Players: Differences and Variability According to Halves and Playing Positions

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Submitted: 2 March 2022 Revised: 15 March 2022 Accepted: 13 April 2022 Published: 11 July 2022

**Abstract**

**Background**: The aims of the present study were three-fold: to (i) analyze between-position differences according to match activity; (ii) analyze within-position differences according to match halves; and (iii) test the variability of match activity according to both playing positions and match halves. **Methods**: This study followed an observational analytic prospective design. 21 elite football players participated in this study, where 25 league and 3 continental cup matches were analysed. The differences and consistency of all parameters in the two halves of the match were analyzed. The distances and metabolic power values of an elite football team were recorded using an optical camera technology during the observational period. Total distance (TD), walking, jogging, running and high speed running (HSR) measures were further analyzed. **Results**: Between-position differences for the overall locomotor measures per minute are present during both halves, except for walking intensity. Defenders (DF) and midfielders (MF) showed significant within-position differences between halves for TD (DF: $p$ = 0.000; $\eta^2$ = 0.127; MF: $p$ = 0.000; $\eta^2$ = 0.168), for jogging (DF: $p$ = 0.002; $\eta^2$ = 0.271, and for running (DF: $p$ = 0.000; $\eta^2$ = 0.067; MF: $p$ = 0.000; $\eta^2$ = 0.160). HSR and metabolic power (MP) had greater between-position variability differences. While, within-position differences were observed only for forwards (FW) during the 2nd half for HSR. **Conclusions**: The high-intensity locomotor measures produce higher between- and within-position differences between halves, and the HSR measure have higher between-position variability during the 1st half of a football match. For those reasons, coaches need to consider the variations that are present in high-intensity locomotor measures of each position to better adjust training.

**Keywords:** football; match activity; athletic performance; variability

## 1. Introduction

In modern elite football, the training process requires that both coaches and practitioners understand not only the weekly training intensity imposed on athletes, but also the specific activities produced during the official matches [1,2]. The training process assumes a relevant importance not only by considering the individualization prinicple, but also the role that each athlete has on each field-position [3]. Thus, a greater understanding of match activities according to playing positions and at different moments of a match (between halves), may improve training adjustments by regulating the stimulus imposed on athletes according to their needs [4].

To monitor the player's match activities, the use of global positioning systems (GPS) that house inertial measurement units allows coaches to analyze measures that include two different dimensions: (i) distance-based measures; and (ii) accelerometry-based measures [5,6]. These measures can be obtained during both training official football matches, which allows to produce an in-depth analysis of match activities of each athlete among the same team [7]. The most common and important GPS measures to analyze in modern football are the following: (i) High speed running (HSR); (ii) accelerations and decelerations; (iii) sprints and (iv) high-metabolic power metrics [8,9]. By these means, both coaches and practitioners may ensure more effective weekly training doses, that can determine higher levels of resilience among athletes in terms of their capacity to cope with match demands [10].

Recent research has shown that during a professional modern football match, there are different patterns of player's behaviors and activities in different passages of play [11,12]. Older research has also shown that the between- and within-halves match intensity suffer significant changes in elite football [13]. Indeed, it was observed that during an official football match, professional players tend to decrease their performance after short high-intensity actions in both halves, at the beginning of the second half, and at the final minutes of the match [4]. However, it is expected that positional differences regarding player's activities are present during a match, as they are dependent on the different physical demands and tactical roles according to each field-position [14]. For example, midfielders and wingers tend to cover greater total distances and high metabolic distances than defenders and forwards, in professional football [15]. Also, both midfielders and wingers seem to produce greater high-intensity accelerations and decelerations than other positions, while wingers and forwards cover greater HSR distances during professional football matches [16,17].

Lago-Penas *et al*. [18] analyzed the between-halves and between-position differences in football match activities of 127 professional football players during 18 Spanish premier league matches. The authors found that there are no significant differences between halves in distances covered at submaximal and maximal intensities [18]. A more recent study conducted on 23 professional football players, revealed that the differences between the first and second half increased as the duration increased for the overall external match intensity measures analyzed [19]. Although there is extensive research regarding between-halves and between-position differences in football match activities, there is a lack of studies focusing on within-position differences according to match halves. In fact, the majority of the studies examining football match activities, analyzed the between-match running activities considering the whole team and/or the between-position differences considering only the total match [20]. To the best of our knowledge, only two studies analyzed the locomotor activities during games for each position, groups of players and team average [13,21]. However, one of the mentioned studies focused more on the acceleration and deceleration profiles [21]. The within- and between-playing positions heterogeneity during official matches can be high during both halves [13].

For all the above-mentioned reasons, the aims of the present study were to (i) analyze between-position differences according to match activity; (ii) analyze within-position differences according to match halves; and (iii) test the variability of match activity according to both playing positions and match halves.

## 2. Materials and Methods

### *2.1 Study Design and Experimental Approach*

This research belongs to one season data of a champion team in Turkish Super League. The team from which the data was obtained consisted of elite players.The elite team from which the data was obtained trained six days a week. Besides the weekly training sessions, the team played matches every weekend. Matches played every weekend were recorded with the Sentio Sports optical tracking system. This study was approved by the Ethics Committee of the local ethics committee. The entire study follows the Helsinki Declaration for Humanities.

### *2.2 Data Collection and Measurement*

All the data of the team were collected through optical cameras. The Sentio Sports optical tracking system consists of two cameras with 4K resolution, a notebook and a Sentio Scope software. It is reported that the Sentio system provides valid and reliable data in previous studies [22–26]. After the cameras were connected to the computer, Sentio software made the sharpness adjustment and calibration on the field image of the cameras and controlled the obtained data. After the device and software installation, a technician provided instant control to get the data. In order to minimize the margin of error in corners and crown points, the technicians instantly controlled the data flow.

### *2.3 Data*

The dataset contains individual match variables of football players for the 2019–2020 season from a Turkish Super League team. Data contains 25 league and 3 continental cup matches between August 2019 and July 2020. The distribution of the player positions is defenders (DF, n = 8), midfielders (MF, n = 9), or forwards (FW, n = 4). The median games per player are 9 within the range of 2–27, and a total of 247 individual match observations are recorded. Only data for the outfield players who played at least 70 minutes in a match are considered in the analysis. Data has been standardized per minute to eliminate the effect of played time.

In this paper, four locomotor categories are used according to the limitations in the sentio sports optical tracking system data. In similar fashion, total distance, walking (from 0 to 7.2 km/h), jogging (from 7.2 to 14.4 km/h), running (from 14.4 to 20 km/h), high speed running (>20 km/h) and power are the considered variables for the analysis. All those variables are recorded for the first and second halves of the matches and the match total.

### *2.4 Statistical Analysis*

The distribution of performance parameters is first checked with the Shapiro-Wilks test, which suggests normally distributed variables. The mean and standard deviation are used to report each position's performance metrics in each half. Power Analysis for Repeated Measures

ANOVA calculated with "WebPower" package in R software (R Core Team, New Zealand). The power is computed as 0.81 for sample size 247, three number of groups, 21 measurements, effect size 0.2. Mixed ANOVA analysis is employed to check whether match activities show differences in the first half, second half, and total match for each playing position and to find whether performance in various positions differs in the different halves of the matches. If any significant result is detected with the mixed ANOVA analysis, then the Bonferroni posthoc test to find the source of difference. Intra-class correlation (ICC) is calculated to find the parameter consistency and reliability for the measurements made in the repeated matches over positions. The ICC takes values between 0 and 1, where values over 0.9 indicate excellent reliability, values between 0.75 and 0.9 indicate good reliability, values between 0.5 and 0.75 indicate moderate reliability, and the values below 0.5 indicate poor reliability [27].

To investigate the effect of match-to-match variability for individual players' coefficient of variation (CV) for each performance parameter is calculated by dividing the standard deviation of the parameter by its mean for each player. The same analysis with the mixed ANOVA analysis is employed again for the CV values of each parameter with the Bonferroni post hoc test where applicable and possible differences for the performance metrics among positions are reported. $p$ values less than 0.05 are considered significant. All the statistical analysis is conducted in the R programming language.

## 3. Results

Table 1 gives the mean and standard deviation values for match performance metrics for both halves and total matches among each position. Possible differences among positions for the first half, second half, and total match are given with columns F and p. Bonferroni test result is reported in the source of difference column where applicable.

Midfielders' total distance per minute is significantly higher than the defenders in both halves and the total match. Walking distance per minute doesn't show any differences among positions. In contrast, jogging showed differences in the first half and the whole match, where midfielders were higher than the defenders and the forwards. Midfielders have higher running per min than both the forwards and defenders in the first halves of the matches, but the difference is only significant between the midfielders and defenders in the second half. There is a difference between forwards and defenders in the high-speed running in the first and second halves. Power (W/kg) per minute is significantly lower in defenders than midfielders and forwards in the first and second half.

Table 1 also gives another look at the data for the possible differences with the perspective of the halves. Both defenders and midfielders have a higher total distance per minute in the first half than in the second half, whereas there is no difference between the forwards among the halves. In the walking per minute, first-half averages for the midfielders and forwards are significantly higher than the second half, where there is no difference for the defenders. In the jogging per minute and running per minute, defenders and midfielders have higher averages in the first half compared to the second half. Forwards don't differ between halves in jogging per minute and running per minute. Only defenders showed significant differences at high-speed running per minute where averages at the first half are higher than the second half.

Table 2 gives the mixed ANOVA results for the coefficient of variation of the performance parameters per minute. After determining match-to-match variability for individual players with the coefficient of variation, there are only a few differences among positions. The first difference is in the high-speed running per minute, where defenders have lower averages than the midfielders and the forwards. Also, defenders have a significantly lower value than the midfielders in the second halves of the matches for the power.

Table 2 also gives the Mixed ANOVA results for the coefficient of variation values of the performance parameters. Only a few instances show statistically significant differences. The first difference is the high-speed running per minute for the forwards, where the second half value is higher than the first half.

## 4. Discussion

The main findings of the present study were that there are positional differences for the overall locomotor measures during both halves, except for walking. Relevant within-position differences are present between halves for DF and MF only for lower intensity speeds. The HSR showed greater variability than the overall locomotor measures. Also, significant between-position differences were mainly present for the HSR variability during the 1st half, while within-position differences were observed only for FW during the 2nd half.

Considering the between-position differences for the analyzed locomotor measures, our findings are in concordance with the study of Di Salvo *et al.* [13], where MF players presented significantly higher total distances than the defenders. Also, the above-mentioned study showed that the walking measure do not present any significant between-position differences during a football match, which is in line with our results [13]. Our study showed that FW presented the highest HSR per minute in both halves than DF and MF, although significant differences were present only between FW and DF. In contrast with these findings, Di Salvo *et al.* [13] the external midfielders presented the greatest HSR distances when compared with the other positional groups. Despite that, it must be noted that in the present study the players were categorized only in three different positional categories (DF, MD and FW), while the mentioned study stratified the groups into central

**Table 1. Between-position and within-position differences according to match periods.**

| Variables (per min) | Positions | 1st half | 2nd half | Match | % Change between Halves | According to halves | | | | According to positions | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | F | *p* | Source of difference | ICC | F | *p* | Source of difference |
| Total Distance (km/h) | DF | 104.43 ± 4.63 | 100.18 ± 5.23 | 102.3 ± 4.73 | –4% | 18.4 | 0.000 | 2nd half < Match < 1st half | 0.87 | 8.61 | 0.002 | DF < MF (1st half) |
| | MF | 115.84 ± 5.29 | 110.65 ± 4.94 | 113.24 ± 4.74 | –4% | 16.20 | 0.000 | 2nd half < Match < 1st half | 0.77 < ICC < 0.93 | 7.58 | 0.004 | DF < MF (2nd half) |
| | FW | 109.19 ± 8.32 | 108.21 ± 7.94 | 108.7 ± 7.78 | –1% | 0.17 | 0.846 | - | | 8.82 | 0.002 | DF < MF (Match) |
| Walking (km/h) | DF | 41.75 ± 1.62 | 42.08 ± 2.09 | 41.92 ± 1.77 | 1% | 0.58 | 0.575 | - | 0.85 | 2.28 | 0.131 | - |
| | MF | 42.1 ± 2.00 | 43.11 ± 1.72 | 42.61 ± 1.76 | 2% | 5.64 | 0.014 | 2nd half < 1st half | 0.75 < ICC < 0.92 | 0.6 | 0.562 | - |
| | FW | 44.1 ± 1.93 | 42.67 ± 2.12 | 43.39 ± 1.97 | –3% | 9.96 | 0.012 | 2nd half < 1st half | | 0.92 | 0.416 | - |
| Jogging (km/h) | DF | 42.12 ± 2.1 | 39.63 ± 1.64 | 40.88 ± 1.54 | –6% | 10.60 | 0.002 | 2nd half < Match < 1st half | 0.8 | 4.05 | 0.035 | DF < MF; FW < MF (1st half) |
| | MF | 46.57 ± 5.23 | 43.45 ± 5.64 | 45.01 ± 5.08 | –7% | 5.76 | 0.013 | 2nd half < 1st half | 0.67 < ICC < 0.89 | 2.07 | 0.155 | - |
| | FW | 40.4 ± 4.35 | 40.16 ± 2.95 | 40.28 ± 3.15 | –1% | 0.02 | 0.986 | - | | 3.48 | 0.049 | DF < MF; FW < MF (Match) |
| Running (km/h) | DF | 14.14 ± 2.36 | 12.42 ± 3.23 | 13.28 ± 2.77 | –12% | 17.70 | 0.000 | 2nd half < Match < 1st half | 0.87 | 11.80 | 0.000 | DF < MF; FW < MF (1st half) |
| | MF | 19.25 ± 2.45 | 16.81 ± 2.47 | 18.03 ± 2.36 | –13% | 27.70 | 0.000 | 2nd half < Match < 1st half | 0.72 < ICC < 0.94 | 6.03 | 0.010 | DF < MF (2nd half) |
| | FW | 15.37 ± 0.98 | 16.59 ± 2.37 | 15.98 ± 1.41 | 8% | 1.17 | 0.371 | - | | 8.27 | 0.003 | DF < MF (Match) |
| High Speed Running (km/h) | DF | 6.36 ± 2.15 | 6.01 ± 2.21 | 6.18 ± 2.18 | –6% | 15.50 | 0.000 | 2nd half < Match < 1st half | 0.97 | 4.30 | 0.042 | DF < FW (1st half) |
| | MF | 7.85 ± 2.23 | 7.24 ± 2.35 | 7.55 ± 2.26 | –8% | 7.23 | 0.006 | - | 0.95 < ICC < 0.99 | 4.08 | 0.045 | DF < FW (2nd half) |
| | FW | 9.27 ± 2.7 | 8.76 ± 1.98 | 9.02 ± 2.32 | –5% | 1.16 | 0.376 | - | | 4.22 | 0.043 | DF < FW (Match) |
| Power (W·kg$^{-1}$ ) | DF | 0.21 ± 0.02 | 0.18 ± 0.01 | 0.19 ± 0.01 | –12% | 37.00 | 0.000 | 2nd half < Match < 1st half | 0.65 | 3.72 | 0.044 | DF < MF; DF < FW (1st half) |
| | MF | 0.22 ± 0.01 | 0.23 ± 0.04 | 0.23 ± 0.02 | 5% | 0.81 | 0.462 | - | 0.46 < ICC < 0.80 | 4.55 | 0.025 | DF < MF; DF < FW (2nd half) |
| | FW | 0.23 ± 0.02 | 0.24 ± 0.08 | 0.23 ± 0.04 | 7% | 0.19 | 0.831 | - | | 5.76 | 0.012 | DF < MF; DF < FW (Match) |

Walking (from 0 to 7.2 km/h), jogging (from 7.2 to 14.4 km/h), running (from 14.4 to 20 km/h), high speed running (>20 km/h).

**Table 2. Coefficient of Variation of Match Activities according to Playing Positions, and Match Periods.**

| Variables (per min) | Positions | 1st half | 2nd half | Match | % Change between halves | According to Halves | | | | According to positions | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | F | *p* | Source of difference | ICC | F | *p* | Source of difference |
| Total Distance (km/h) | DF | 6.49 ± 1.23 | 5.51 ± 0.81 | 6.48 ± 0.46 | –15% | 1.76 | 0.221 | - | 0.30 | 0.86 | 0.448 | - |
| | MF | 5.75 ± 0.89 | 6.47 ± 2.23 | 6.74 ± 1.64 | 13% | 1.54 | 0.261 | - | 0 < ICC < 0.62 | 0.65 | 0.539 | - |
| | FW | 5.71 ± 1.37 | 5.42 ± 1.75 | 5.87 ± 0.91 | –5% | 0.07 | 0.931 | - | | 0.55 | 0.588 | - |
| Walking (km/h) | DF | 5.30 ± 1.31 | 5.62 ± 0.42 | 5.37 ± 0.56 | 6% | 0.36 | 0.577 | - | 0.10 | 1.58 | 0.244 | - |
| | MF | 4.75 ± 0.86 | 5.27 ± 1.08 | 5.18 ± 1.02 | 11% | 3.36 | 0.112 | - | –0.18 < ICC < 0.46 | 2.53 | 0.118 | - |
| | FW | 6.47 ± 2.52 | 3.83 ± 2.14 | 5.55 ± 0.86 | –41% | 1.03 | 0.436 | - | | 0.22 | 0.803 | - |
| Jogging (km/h) | DF | 11.17 ± 1.43 | 10.04 ± 2.2 | 11.28 ± 1.89 | –10% | 1.08 | 0.375 | - | 0.52 | 1.28 | 0.311 | - |
| | MF | 10.31 ± 2.08 | 10.35 ± 2.23 | 11.62 ± 2.91 | 0% | 2.83 | 0.098 | - | 0.23 < ICC < 0.77 | 1.24 | 0.321 | - |
| | FW | 8.25 ± 5.04 | 7.66 ± 3.89 | 10.09 ± 1.27 | –7% | 0.53 | 0.625 | - | | 0.45 | 0.648 | - |
| Running (km/h) | DF | 17.89 ± 3.36 | 17.72 ± 3.69 | 18.81 ± 4.55 | –1% | 0.37 | 0.703 | - | 0.66 | 2.66 | 0.107 | - |
| | MF | 17.55 ± 2.96 | 16.01 ± 6.21 | 18.27 ± 3.6 | –9% | 0.74 | 0.430 | - | 0.40 < ICC < 0.85 | 1.02 | 0.386 | - |
| | FW | 12.62 ± 4.8 | 11.59 ± 9.45 | 12.67 ± 5.94 | –8% | 0.13 | 0.883 | - | | 2.17 | 0.153 | - |
| High Speed Running (km/h) | DF | 33.79 ± 10.35 | 35.14 ± 7.25 | 33.6 ± 7.06 | 4% | 0.23 | 0.656 | - | 0.70 | 4.26 | 0.038 | DF > MF; DF > FW (1st half) |
| | MF | 21.72 ± 5.84 | 27.09 ± 6.48 | 24.32 ± 4.41 | 25% | 2.63 | 0.156 | - | 0.43 < ICC < 0.87 | 2.43 | 0.127 | - |
| | FW | 21.27 ± 7.56 | 30.77 ± 4.72 | 25.31 ± 6.41 | 45% | 23.20 | 0.006 | 1st half < 2nd half | | 4.41 | 0.035 | DF > MF (match) |
| Power (W·kg$^{-1}$) | DF | 13.65 ± 11.73 | 8.15 ± 2.6 | 13.62 ± 8.01 | –40% | 1.16 | 0.330 | - | 0.11 | 1.27 | 0.314 | - |
| | MF | 7.97 ± 1.54 | 15.53 ± 4.43 | 12.92 ± 2.72 | 95% | 14.20 | 0.007 | 1st half < Match; 1st half < 2nd half | –0.17 < ICC < 0.47 | 4.90 | 0.026 | DF < MF (2nd half) |
| | FW | 18.86 ± 18.53 | 12.2 ± 6.4 | 17.89 ± 9.68 | –35% | 0.25 | 0.792 | - | | 0.64 | 0.544 | - |

Walking (from 0 to 7.2 km/h), jogging (from 7.2 to 14.4 km/h), running (from 14.4 to 20 km/h), high speed running (>20 km/h).

defenders, external defenders, midfielders, external midfielders and FW [13]. That is, using different group categorizations regarding outfield football positions makes comparisons more biased. In terms of professional football match outcome, winning teams present higher TD volumes from which longer distances are covered at high-intensity speed thresholds [28]. Furthermore, it was previously showed that winning teams have higher mean values of total shots, shots on goal, effectiveness, pass efficacy, and ball possession than losing teams [29]. In order to present higher performance indicators, it is expected that players have to cope with greater high-intensity locomotor activities that assume a preponderant role in match final result [30].

Both DF and MF presented significant within-position differences from the 1st to the 2nd half, with the 1st half representing the highest values for TD and for locomotor measures based on different speed thresholds (i.e., walking, jogging and running), with the exception of HSR, which did not reveal significant within-position differences between halves. There is extensive literature that clearly shows a decline pattern of locomotor team performance from the 1st to the 2nd half of a football match, especially in lower-intensity speed thresholds [31–33]. However, such studies have considered only the team's average values when comparing the locomotor performance between halves. In fact, a recent study conducted on 23 professional football players, analyzed the differences between halves in players according to playing position [19]. The authors of the above-mentioned study showed that DF players presented large decreases in TD (ES = –1.43 ± 0.36) from the 1st to the 2nd half, while the other outfield positions had moderate decreases (ES = –0.62 to 1.10) during the second half [19]. Moreover, in the present study, the AMP measure showed only small decreases for MF (ES = 0.034) and DF (ES = 0.018) during the 2nd half, which is in concordance with the findings of Casamichana *et al*. [19], where it was found small differences (ES = –0.60 to –1.09) for the overall positions. From the overall team's observed declines in performance during a match, knowing the within-position differences may allow coaches to better individualize and adjust training according to specific outfield positions.

It was previously suggested that football players can perform high-intensity running without significant decreases throughout a match, with decrements in performance seen immediately after short bursts, as a result of temporary muscle fatigue [4,34]. Indeed, from our results, it was observed no significant within-position differences between halves for HSR measure for both MF and FW, with the exception of DF which showed significant differences. However, the significant differences observed for DF players must be interpreted with caution as the statistical significance found was only relative to the $p$ value and not to the $\eta^2$ value. That is, although significant within-DF differences between halves were found for HSR measure ($p$ = 0.000) its magnitude was non-significant ($\eta^2$ = 0.005, insignificant ES). In terms of football performance, moderate to very large ES in a measure such HSR, can potentially make a difference in the final outcome of a match [35,36] or even at an injury occurrence perspective, as HSR measure is related to both dimensions [10].

In respect to the third aim of the present study, between-position differences for locomotor variability during match were present only for HSR and AMP measures, with DF representing the lowest values. While, within-position differences showed that FW presented the greatest variability during the 2nd half for the HSR measure, and MF presented greater variability during the 2nd half for AMP measure. To the best of the authors knowledge, there is no study that analyzed the CV values of locomotor measures considering the between- and within-position differences according to match periods. For those reasons, comparisons with other studies are difficult. However, the positional roles that both MF and FW and their tactical linking during a football match, may explain the higher variability of high-intensity locomotor measures observed, as the two positions usually produce a greater volume of running at higher speed thresholds than DF [4]. Thus, coaches and practitioners can benefit from these findings, as it may help them to prescribe training doses of running at higher speed thresholds according to each player's needs.

The present study has its limitations. The main limitation is the sample size, as only 21 players participated in the present study. Future studies should increase the sample size to confirm such findings and allow generalizations. Another limitation is regarding playing position categorization. Although we can recognize that categorizing the sample only into the three main outfield positions (DF, MD and FW) may limit our understanding regarding the specificity of each position, it was out of the scope of the present study to conduct such analysis. However, future studies that may categorize the sample in all positions, must consider that different positions may arise when using different team formations.

## 5. Conclusions

Between- and within-position locomotor differences during different football match periods are present specially for DF and MF for the overall measures, with a greater relevance in high-intensity measures. Although some differences may appear to be statistically significant, their magnitude can be insignificant, and the same stands true for the opposite. For that reason, coaches and practitioners should be aware of this to improve the training process and decision-making. Moreover, some locomotor measures may present different levels of variability, depending on players position and tactical role. However, further research is needed to generalize such findings.

## Abbreviations

TD, total distance; AMP, average metabolic power; DF, defenders; MF, midfielders; FW, forwards; ICC, intraclass correlation; CV, coefficient of variation; GPS, global positioning systems; HSR, high speed running.

## Author Contributions

ZA, YY and EC conceived and designed the experiments; CP and RMS performed the experiments; AI and MY analyzed the data; AFS, GB and FMC contributed reagents and materials; ZA, YY, EC, CP, RMS, AI, MY, GB, AFS and FMC wrote the paper. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

## Ethics Approval and Consent to Participate

All procedures performed in studies involving human participants were in accordance with the ethical standards of institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study. Approval code: 2022/4/. Number of ethics commission: 2022/4.

## Acknowledgment

Thank numerous individuals participated in this study.

## Funding

This research received no external funding.

## Conflict of Interest

The authors declare no conflict of interest. FMC is serving as one of the Guest editors of this journal, GB is serving as one of the Editorial Board members and Guest editors of this journal. We declare that FMC and GB had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to DM.

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