Manuscript Title: Positional differences in GPS outputs and perceived exertion during soccer training games and competition

Brief Running Head: Positional demands of soccer training games

ABSTRACT

Soccer training games are popular training modalities, allowing technical, tactical, and physical aspects to be trained simultaneously. Small (SSGs), medium (MSGs) and large training games (LSGs) elicit differing physical demands. To date, no research has investigated physical and perceived demands of training games upon soccer playing positions relative to competitive demands. Additionally, previous research has referenced average competitive intensities, ignoring peak demands of competition. The current aim was to investigate the effect of training game formats upon average and peak physical outputs produced by soccer playing positions. Physical and perceptual data from twenty-two competitive matches and thirty-nine training game sessions was collected for forty-six U23 professional players using 10-Hz GPS and 100-Hz accelerometer devices (MinimaxX version 4.0; Catapult Innovations, Melbourne, Australia). Data analysed included GPS derived distance, speed, acceleration, deceleration, and RPE. Two-way between subjects ANOVAs were used to compare average and peak GPS metrics, and RPE, between training games and competition for playing positions. Despite eliciting significantly higher average total distances compared to competition ($p<0.01$), LSGs produced significantly lower peak total distances relative to competition ($p<0.01$). For very high-speed running and sprinting, LSGs elicited similar average intensities to competition, however peak intensities were significantly lower than competition ($p<0.01$). MSGs and LSGs produced significantly higher average and peak moderate-intensity explosive distances than competition ($p<0.01$). Results indicate the importance of analyzing relative to peak competitive demands, instead of focusing solely upon average demands. The study demonstrates specific game formats can overload the competitive demands of playing positions, and provide an individualized training stimulus.

Keywords: Global positioning systems, training load, playing position, peak demands

INTRODUCTION

The aim of soccer conditioning training is to replicate, or overload, competitive demands to develop performance during competition (17). To prescribe an appropriate overload stimulus, competitive demands need to be accurately identified and recorded. Global Positioning Systems (GPS) has been integral in determining the frequency, intensity, and duration of physical activity (5). GPS technology provides an indicator of external training load (e.g total distance, high-speed distances, and accelerations and decelerations), however it is important to consider the internal load elicited upon athletes (32). Rating of perceived exertion (RPE) is a valid indicator of internal training load, correlating with VO_2, heart rate, and blood lactate, and quantifying stress from tasks unable to be recorded using GPS (e.g jumping, heading, tackling and grappling with opponents) (11,24). Integration of GPS and RPE allows for physical and psychological demands of soccer competition to be comprehensively recorded, and overloaded during training. Past research has focused on a solitary marker of training load, failing to combine internal and external markers, and consequently overlooking the holistic training response (28,33).

The competitive demands of soccer differ between playing positions. Central defenders produce the lowest total and high-speed distances during competition, whilst central midfielders produce the highest total distances when compared to other positions (7,31). Wide attacking and wide defending positions are characterized by high-speed activities, producing the highest sprint distance, and number of high-intensity accelerations and decelerations (6,27). Considering the variation in competitive demands elicited upon playing positions, a 'one-size-fits-all approach' to training must be avoided, instead focusing upon the specific requirements of athletes to maximize training efficiency (18,32). When analysing competitive demands, it is vital to consider the peak demands. Preparing for the average demands of competition could leave athletes underprepared, and at a higher risk of injury, during the most demanding periods of play (20).

Training games are a popular training modality in soccer, allowing for technical, tactical, and physical aspects to be trained simultaneously (1,33). Training games can elicit intensities higher than competition, with Dellal et al (15) demonstrating sprint activities ranging from 1.8 - 2.6% of total distance during competition, compared to 13.6 – 16.3% of total distance during training games. Recent reviews suggest training game intensity can be manipulated to control the stimuli applied to athletes (3,22). Increasing player number whilst maintaining a constant pitch size decreases intensity (22). However, increasing the pitch size using a constant player number, increases intensity (12). Authors suggest investigating the effects of player number and pitch size in isolation limits the ecological validity of results. To maintain soccer specificity, and achieve tactical outcomes, it is important the relative playing area is consistent with competition, or those prescribed by technical coaches (35). Rationale exists for investigation of the effects of training game format (e.g small, medium, and large) upon physical outputs produced with a constant relative playing area. This would provide coaches the ability to manipulate physical outcomes of training games, whilst maintaining tactical validity for competition.

When maintaining relative playing area, research has shown small training games (SSGs – 3v3) elicit higher RPE and heart rate responses, and lower work:rest ratios in comparison to medium games (MSGs – 5v5), and large games (LSGs – 7v7) (10). The same has been demonstrated for agility demands, and changes in speed (13,21). SSGs are unable to replicate the sprint demands of competition however (9,34). LSGs demonstrate higher total distances, high-speed running, and number of accelerations when compared to their smaller equivalents (8,10). To date, no research has used GPS and RPE analyses to investigate how different training game formats overload playing positions relative to demands experienced during competition. Past research has referenced average competitive intensities, ignoring the peak demands of competition.

The aim of the present study was to investigate how training game format affects average and peak physical outputs produced by soccer playing positions. Results aim to provide coaches with vital information regarding the game formats most specific in stimulating competitive demands of playing positions. It was predicted that LSGs would elicit higher average and peak total and high-speed distances in comparison to MSG and SSG formats. It was predicted that SSGs would elicit higher moderate-intensity manuevors, and perceived exertions when compared to MSG and LSG formats. Due to limited previous research, it is unknown as to how these values will relate to average and peak demands of competition.

METHODS

Experimental Approach to the Problem

Competition and training data was collected for forty-six U23 professional players during the 2016/17 soccer season. Players were divided into five playing positions (central defenders, wide defenders, central midfielders, wide attackers, and strikers), with positional physical data from twenty-two competitive matches, and thirty-nine training game sessions (mean 12.3 ± 3.5 matches, 33.1 ± 2.2 training sessions) recorded using 10-Hz GPS and 100-Hz accelerometer devices (MinimaxX version 4.0; Catapult Innovations, Melbourne, Australia). GPS metrics analysed were distance, speed, acceleration, and deceleration. Individual RPE data was collected following each match and training game session. Average and peak GPS metrics, and RPE were compared between training games and competition for each playing position.

Subjects

Forty-six, male, full-time professional soccer players from an U23 Premier League academy participated in the study (age 19.1 ± 1.2 years, range 17-21 years, height 180.1 ± 7.9 cm, mass 79.8 ± 7.6 kg). Subjects had been involved in soccer for a mean of 7.8 (± 1.6) years, training 4-5 times a week for the past two years. Subjects were assigned one playing position by the head coach. Playing positions were; central defenders (CD, n=8) wide defenders (WD, n=9), central midfielders (CM, n=12), wide attackers (WA, n=9), and strikers (ST, n=8). Subjects were briefed with the aims, requirements, and potential risks of the study. Subjects provided written consent for their involvement, parental or guardian consent was provided for subjects under the age of eighteen. Subjects were free to withdraw at any time, without any repercussions. Full approval was received from the ethical review board at the institution the research was conducted. The study conformed to the requirements stipulated by the Declaration of Helsinki, and all health and safety procedures were complied with.

Procedures

Data collection spanned from August 2016 – May 2017, with competition and training games occurring once per week. Prior to commencement of the competitive season, subjects had undergone pre-season training and had appropriate conditioning levels. Fixtures used within the study were U23 Premier League 2 fixtures. Fixtures were in a competitive league format, with emphasis placed upon results, ensuring high motivation. Fixtures were played on a Monday evening, on natural grass. Prior to competition, subjects completed a 25-minute warm up consisting of physical drills, passing, possessions, and finishing. This ensured adequate preparation for competition, and was consistent throughout the data collection period. A 4-3-3 playing formation was utilized throughout the data collection period. During training game sessions, one game format was utilized (e.g large, medium or small), resulting in data collection for each format every three weeks. The head technical coach allocated teams prior to each training session, ensuring abilities were evenly distributed, and subjects played in their designated playing positions. Training sessions occurred on a Thursday morning, with Tuesday and Wednesday being designated rest days for the subjects, reducing the effects of fatigue. LSGs were characterized as 10v10, 9v9, 8v8, or 7v7 plus goalkeepers. MSGs were characterized as 6v6, 5v5, or 4v4 plus goalkeepers. SSGs were characterized as 3v3, 2v2, or 1v1 plus goalkeepers (36). Training games were played for four quarters of 4-minutes each, with three minutes rest between games (25). To maintain tactical validity, relative player area for all formats was 120m^2 per player, excluding goalkeepers (24,25). Prior to the commencement of training games, subjects completed a 25-minute warm up consisting of physical drills, passing, and possessions. As with competition, all training games were played on natural grass. Subjects used the same footwear throughout the study.

For training games and competition, subjects wore portable GPS devices (MinimaxX version 4.0; Catapult Innovations, Melbourne, Australia). Subjects wore the same GPS devices throughout the data collection period to avoid inter-device error. Individual RPE was recorded using the modified Borg CR10-scale. RPE values were recorded 30 minutes following the cessation of competition or training. Following training, subjects were asked to provide an RPE value solely representative of the intensity of training games. Subjects had previously been familiarized with the RPE scale prior to the data collection period.

Data Analysis

Following the collection of data, GPS devices were downloaded to a PC and analysed using Catapult Sprint software (Catapult Sprint 5.1.5, Catapult Innovations, Melbourne, Australia). Once downloaded, competition data was edited and split into two 45-minute halves. Only subjects completing the entire match or training session were included within the analysis process. Training data was edited to include only the active duration of training games. The mean number of satellites, and the horizontal dilution of position were recorded during data collection. If values ranged <12 for number of satellites, or >1 for horizontal dilution of position, data was excluded. A total of 156 data sets were collected from twenty-two fixtures. Totals of 156 data sets for SSGs (1v1, n=48, 2v2, n=48, 3v3, n=60), 199 for MSGs (4v4, n=64, 5v5, n=74, 6v6, n=61), and 224 for LSGs (7v7, n=42, 8v8, n=48, 9v9, n=54, 10v10, n=80) were collected during the study. GPS metrics were derived for each data set. To allow comparability between competition and training games of different durations, GPS metrics were presented as per minute values. Descriptions of GPS metrics are shown in Table 1.

TABLE 1

For competition and training game data, peak and average values were calculated for GPS metrics. Peak values were calculated by dividing each 90-minute match, or 16-minute training game, into 1-minute intervals, and recording the highest values achieved per minute for each GPS metric. Average values were calculated by dividing total values for the 90-minute match, or 16-minute training game, by the overall duration. For data presentation purposes, moderate-intensity acceleration and deceleration distances were added and presented as moderate-intensity explosive distance. High-intensity acceleration and deceleration distances were added and presented as high-intensity explosive distance. Very high-speed running and sprinting distances were added and analysed as a single value. These calculations are detailed in Table 1.

Statistical Analysis

Within the current study design, playing position and game format were independent variables, and GPS metrics produced were dependent variables. Descriptive analyses were conducted on all data sets. Normality values were assessed using Kolmogorov-Smirnov and Shapiro-Wilk tests. Significance values of $p > 0.05$ indicated even distribution of the data. Skewness and kurtosis values were assessed, with standard error within -2 and +2 indicating evenly distributed data.

To investigate the differences in eight GPS metrics and RPE produced by game formats for playing positions, two-way between subjects ANOVAs were used, with playing position (CD, WD, CM, WA, ST) and game format (SSGs, MSGs, LSGs, competition) being the between-subjects variables. Eta-squared values were calculated to estimate the effect size for the ANOVA. An eta-squared effect size of η^2=0.02 was considered a small effect size, an effect size of η^2=0.13 was considered a medium effect size, whilst η^2=0.26 was considered a large effect size. Bonferroni tests were used post-hoc to assess where differences occurred, with Cohen's *d* tests used to calculate effect sizes. A Cohen's *d* effect size of *d*=0.2 was considered a small effect size, *d*=0.5 a medium effect size, whilst *d*=0.8 was considered a large effect size. All statistical analyses were performed using the software IBM SPSS statistics (version 22; SPSS, Inc., Chicago, IL, USA). The alpha level of statistical significance was set at p <0.05.

RESULTS

Figure 1 presents average and peak total distances (m.min^{-1}) produced by game format and playing position. For average total distance, significant differences were identified between game formats ($F_{(3,715)}$ = 355.261, p < 0.01, η^2 = .60). Follow up analysis showed competition produced lowest average total distances, followed by SSGs, MSGs, and LSGs (see Figure 1, *ps* < 0.01). Significant differences were also identified for playing position ($F_{(4,715)}$ = 85.877, p < 0.01, η^2 = .33). CD produced significantly lower total distances than other playing positions, with CM producing significantly higher (*ps* < 0.01). There was a weak but significant interaction of playing position and game format ($F_{(12,715)}$ = 5.507, p < 0.01, η^2 = .09). Generally, the higher average total distances produced by CM compared to other positions were not evident in LSGs. For peak total distances, significant differences were identified between game formats ($F_{(3,715)}$ = 260.261, p < 0.01, η^2 = .52). Follow up analysis demonstrated SSGs produced the lowest peak total distance, followed by MSGs, LSGs, and competition (see Figure 1, *ps* < 0.01). Differences were also identified for playing position ($F_{(4,715)}$ = 66.992, p

< 0.01, $\eta^2 = .273$). Whilst CM produced highest peak total distances, distances did not differ significantly from WA, with CD producing the lowest peak distances. WD did not differ significantly from WA or ST (*ps* < 0.001). There was a weak but significant interaction of playing position and game format ($F_{(12,715)} = 4.278$, $p < 0.01$, $\eta^2 = .07$). Whilst all peak total distances increased with game format, differences between CD, WD and ST were not evident until LSGs and competition, with significant differences between CD and WD only evident during competition.

FIGURE 1

Figure 2 presents average and peak very high-speed running and sprinting distances ($m.min^{-1}$) produced by game format and playing position. For average very high-speed running and sprinting distance, significant differences were identified between game formats ($F_{(3,715)} = 1642.181$, $p < 0.01$, $\eta^2 = .87$). Follow up analysis demonstrated SSGs produced lowest very high-speed running and sprinting distances, followed by MSGs, competition, and LSGs (see Figure 2, *ps* < 0.01). Differences were also identified for playing position ($F_{(4,715)} = 224.717$, $p < 0.01$, $\eta^2 = .56$). There were significant differences between all playing positions for this measure. There was a medium effect and significant interaction of playing position and game format ($F_{(12,715)} = 61.863$, $p < 0.01$, $\eta^2 = .51$). For all positions excluding WD and WA, typical differences between positions during competition were not evident until game format increased to LSGs. Significant differences between WD and WA were only evident in competition. For peak very high-speed running and sprinting distance, significant differences were identified between game formats ($F_{(3,715)} = 1125.315$, $p < 0.01$, $\eta^2 = .83$). Follow up analysis demonstrated SSGs produced the lowest peak very high-speed running and sprinting distances, followed by MSGs, LSGs, and competition (*ps* < 0.01). Significant differences were also identified for playing position ($F_{(4,715)} = 1551.192$, $p < 0.01$, $\eta^2 = .35$). Highest peak very high-speed running and sprinting distances were observed in WD and WA, significantly different from all positions excluding each other, followed by ST, CM, and CD. There was a small effect and significant interaction of playing position and game format ($F_{(12,715)} = 16.415$, $p < 0.01$, $\eta^2 = .22$). Peak very high-speed running and sprinting distances increased with game format, however no significant differences were identified between playing positions in SSGs, and typical differences seen between positions in competition only emerged in LSGs.

FIGURE 2

Figure 3 presents average and peak moderate-intensity explosive distances ($m.min^{-1}$) produced by game format and playing position. For average moderate-intensity explosive distances, significant differences were identified between game formats ($F_{(3,715)} = 574.327$, $p < 0.01$, $\eta^2 = .71$). Follow up analysis demonstrated SSGs produced highest average moderate-intensity explosive distances, followed by MSGs, LSGs and competition (see Figure 3, *ps* < 0.01). Differences were also identified for playing position ($F_{(4,715)} = 30.082$, $p < 0.01$, $\eta^2 = .14$). CD produced significantly lower moderate-intensity explosive distances than all other positions, with CM producing significantly higher moderate-intensity explosive distances than all positions. No significant differences were identified between WD, WA and ST. There was a small effect and significant interaction of playing position and game format ($F_{(12,715)} = 2.248$, $p < 0.01$, $\eta^2 = .04$). Differences in average moderate-intensity explosive distances increased with game format. For peak moderate-intensity explosive distances, significant differences were identified between game formats ($F_{(3,715)} = 162.527$, $p < 0.01$, $\eta^2 = .41$). Follow up analysis demonstrated SSGs produced highest peak moderate-intensity explosive distances, followed by MSGs. There were no significant differences between LSGs and competition. Differences were also identified for playing position ($F_{(4,715)} = 33.198$, $p < 0.01$, $\eta^2 = .16$). CM produced highest peak moderate-intensity explosive distances, with CD producing the lowest. No significant differences were identified between WD, WA and ST. There was a small effect and significant interaction of playing position and game format ($F_{(12,715)} = 2.465$, $p < 0.01$, $\eta^2 = .04$). Whilst SSGs reflected the relative differences evident in competition, sizes of the differences were smaller in SSGs.

FIGURE 3

Figure 4 presents average and peak high-intensity explosive distances ($m.min^{-1}$) produced by game format and playing position. For average high-intensity explosive distances, significant differences were identified between game formats ($F_{(3,715)} = 252.092$, $p < 0.01$, $\eta^2 = .51$). Follow up analysis demonstrated SSGs produced lowest average high-intensity explosive distances, differing significantly from all other formats. LSGs produced the highest high-intensity explosive distances, significantly different from all formats. There were no significant differences between MSGs and competition (see Figure 4, *ps* > 0.05). Significant differences were also identified for playing position ($F_{(4,715)} = 73.145$, $p < 0.01$, $\eta^2 = .29$). CD and CM produced lowest high-intensity explosive distances, significantly different from all positions excluding each other. WD and WA produced the highest distances, significantly different from all positions excluding each other. There was a small effect and significant interaction of playing position and game format ($F_{(12,715)} = 8.617$, $p < 0.01$, $\eta^2 = .13$). MSGs most accurately reflected average competitive distances in WD, WA and ST, whereas relative differences between CD and CM during competition were only evident in LSGs, albeit at higher absolute distances. For peak high-intensity explosive distances, significant differences were identified between game formats ($F_{(3,715)} = 140.235$, $p < 0.01$, $\eta^2 = .37$). Follow up analysis demonstrated significant differences between all formats. SSGs produced lowest peak high-intensity explosive distances, followed by MSGs, competition, and LSGs. Significant differences were also identified for playing position ($F_{(4,715)} = 32.252$, $p < 0.01$, $\eta^2 = .15$). WD and WA produced highest peak high-intensity explosive distances, significantly different to all positions, excluding each other. CD and CM produced lowest peak high-intensity explosive distances, with no significant differences between each other, or between CM and ST. There was a small effect and significant interaction of playing position and game format ($F_{(12,715)} = 1.806$, $p < 0.05$, $\eta^2 = .03$). Generally, the relative differences between playing positions identified during competition were evident in game formats. However, ST peak high-intensity explosive distances were similar to CD and CM during SSGs and MSGs, but similar to WD and WA during LSGs and competition.

FIGURE 4

Figure 5 presents RPE (Borg CR10-scale) produced by game format and playing position. For average RPE, significant differences were identified between game formats ($F_{(3,750)} = 81.261$, $p < 0.01$, $\eta^2 = .25$). Follow up analysis demonstrated SSGs elicited the highest RPE followed by MSGs, competition, and LSGs (see Figure 5, *ps* < 0.01). No significant differences were identified for playing position ($F_{(4,750)} = .855$,

$p > 0.05$, $\eta^2 = .01$). There was a small effect and a non-significant interaction of playing position and game format ($F_{(12,715)} = 1.402$, $p < 0.01$, $\eta^2 = .02$).

FIGURE 5

DISCUSSION

The current study examined the effect of training game format upon physical outputs and perceived exertion within soccer playing positions. It was the first to combine GPS and RPE measures to identify positional demands elicited by game formats, relative to competition. Previous research had focused upon average demands, whilst the current study identified both average and peak positional demands for training games and competition. Current findings suggest no training game format develops overall soccer fitness, with each format eliciting a unique physical load. It is possible to attribute specific training game formats to playing positions, dependent upon the predominant activities performed during competition. However, care must be taken to analyze training game outputs relative to the peak demands of competition, as these differ to the average demands of competition.

Results demonstrated average total distance intensities were highest in LSGs, and lowest in SSGs. Previous results investigating the effects of game format upon total distance have been mixed. Aguiar et al (2) and Hill-Haas et al (23) suggested game format had no effect upon distances travelled, whilst Castellano et al (10) and Guadino et al (21) found distances travelled increased with game format. The current study found the latter, with a larger absolute playing area, and increased ‘off the ball’ running associated with LSGs providing rationale for findings. Alternative results produced by

Aguiar et al (2) and Hill-Haas et al (23) may result from only investigating SSGs and MSGs within their analysis. Despite MSGs and LSGs producing significantly higher average intensities than competition, peak total distance intensities results differed. For all positions excluding CD, competition produced significantly higher peak total distances than training game formats.

Very high-speed running and sprinting distances increased with game format, with LSGs producing the highest intensities. Similar findings have been cited in previous research (10,21). LSGs are characterized by larger absolute playing areas, and allow athletes to reach high-speeds unopposed (23). Comparing average very high-speed running and sprinting intensities to competition, only LSGs were able to replicate competitive demands, with SSGs and MSGs significantly below competitive values for all positions. For peak very high-speed running and sprinting distances, all training game formats were significantly below competitive demands. This suggests training games are an insufficient tool for replicating the peak demands of competition.

Average moderate-intensity explosive distances were highest in SSGs, and decreased as game format increased. Current results contrast those reported by Castellano et al (10), stating larger formats are associated with a higher frequency of accelerations. Castellano et al (10) did not differentiate between moderate and high-intensity forms of acceleration, making comparison in results difficult. Research by Davies et al (13) state the number of agility maneuvers produced during smaller formats were higher compared to larger formats, agreeing with the current study. Guadino et al (21) also produced comparable results, stating moderate acceleration and decelerations increase as game format decreases. Smaller formats are associated with increased ball involvement, and elicit more frequent changes of direction and speed to evade opposition (23). When comparing average moderate-intensity explosive distances between game formats and competition, all game formats were significantly higher, excluding LSGs for WD and ST positions. Peak demands followed a similar trend, with SSGs and MSGs demonstrating significantly higher peak moderate-intensity explosive distances compared to competition. No significant differences were identified between LSGs and competition for peak demands.

High-intensity explosive distances were highest in LSGs, and decreased with game format. Results compliment Guadino et al (21) and Owen et al (32), finding larger formats produce more high-intensity accelerations and decelerations compared to smaller formats. Rationale mirrors very high-speed running and sprinting distances, with lower absolute playing areas resulting in fewer opportunities to maximally accelerate unopposed. In smaller formats, distance between players is less, reducing the distance covered to pressurize opponents (32). When comparing average high-intensity explosive distances to competition, LSGs produced significantly higher intensities. MSGs produced average high-intensity explosive distances similar to competition, whilst SSGs produced significantly lower intensities. Differences were replicated for peak high-intensity explosive distances.

RPE was highest in SSGs, with lower ratings reported for MSGs, and the lowest for LSGs. Aguiar et al (2) reported similar, with higher RPE for 2v2 and 3v3 formats in comparison to 4v4 and 5v5. Abrantes et al (1) and Hill-Haas et al (23) also reported findings complimenting the current study. Rationale for higher RPE produced during smaller formats is an increased involvement with the football and opposition, and shorter recovery periods between physical actions (13,16). When comparing RPE between game formats and competition, SSGs demonstrated significantly higher RPE, whilst MSGs were similar to competition, for all positions. LSGs produced significantly lower RPE values for CM and WA compared to competition.

The current study demonstrates the importance of analyzing peak competitive demands. When comparing average total distance intensities of training games to competition, LSGs and MSGs were significantly higher than competition. However, when comparing the peak total distance intensities, all game formats were significantly lower than competition. This was also evident with very high-speed running and sprinting intensities. Comparison of average very high-speed running and sprinting intensities demonstrated no significant differences between LSGs and competition. However, when comparing peak very high-speed running and sprinting intensities, all game formats were significantly lower than competition. This concludes that despite certain game formats replicating average demands of competition, the peak demands of competition may not be replicated. From a performance optimization and injury prevention perspective, it is vital that coaches prepare the athletes for peak intensities of competition. Focusing on average demands of competition will leave athletes underprepared when faced with the most demanding periods of competition, resulting in poor performance, or injury occurrence (20).

Results demonstrate specific training game formats replicate, and at times exceed, average and peak demands of competition. Consequently, game formats can be prescribed to playing positions based upon their positional demands. CM are associated with large volumes of moderate-intensity maneuvors (7), highlighting SSGs as a training modality. During SSGs, CM produce significantly higher average and peak moderate-intensity explosive distances compared to competition. WD and WA are associated with high very high-speed running and sprinting, and high-intensity explosive distances during competition (27). Current results highlight LSGs as a specific training stimulus for these positions. During LSGs, WD and WA produce significantly higher average and peak high-intensity explosive distances compared to competition. Despite eliciting similar average very high-speed running and sprinting distances for WD and WA, LSGs do not replicate the peak demands of competition. For CD and ST, competitive demands are multifaceted, and therefore multiple game formats should be periodized throughout a training block. For example, utilizing SSGs to elicit a high frequency of moderate-intensity activities, and utilizing LSGs to elicit high total distance or very high-speed running and sprinting activities. An issue highlighted by the current study is the inability of training games to stimulate peak competitive very high-speed running and sprinting intensities. Considering the importance of high-speed activities for all positions within soccer (19), it is recommended supplementary sprinting training is prescribed alongside training games to prepare athletes for peak competitive intensities.

It is important to note the limitations of the current study. Despite recent improvements in GPS hardware and software, there is still error associated with devices. Delaney et al (14) state 10-Hz devices exhibit coefficient of variations of 1.2-6.5% when assessing acceleration and deceleration, and requires acknowledgment from practitioners when applying results. Secondly, the current study was conducted using U23 professional soccer players at a Premier League academy. Consequently, findings may not be directly applicable to other levels or age groups. Finally, the study classified training games into ‘small’, ‘medium, and ‘large’ formats. Small games were comprised of 1v1, 2v2, and 3v3 training games for example, of which the physical demands elicited by these variations may differ. As a result, caution must be exercised when applying current findings to training programmes.

PRACTICAL APPLICATIONS

The current study provides important information to coaches and scientists regarding the effect of training game formats upon physical outputs produced by soccer playing positions. Results highlight the necessity to analyze physical outputs of training games relative to peak demands of competition, and relative to individual playing position. Although certain game formats replicated average competition demands, they were unable to replicate the peak demands of competition. Prescribing training relative to average demands leads to under preparation for the most demanding periods of competition, potentially resulting in poor performance and an increased risk of injury. The current study demonstrates that specific game formats can overload competitive demands, but careful consideration of playing position and game format is required to provide an individualized training stimulus for athletes. Training games were unable to adequately stimulate peak competitive very high-speed running and sprinting intensities. Consequently, it is recommended that supplementary sprinting training is prescribed to prepare athletes for these demands.

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Figure Legends:

Figure 1. Average and peak total distance intensities produced by playing position during training games and competition.

Figure 2. Average and peak very high-speed running and sprinting intensities produced by playing position during training games and competition.

Figure 3. Average and peak moderate-intensity explosive distances produced by playing position during training games and competition.

Figure 4. Average and peak high-intensity explosive distances produced by playing position during training games and competition.

Figure 5. Ratings of perceived exertion produced by playing position during training games and competition.

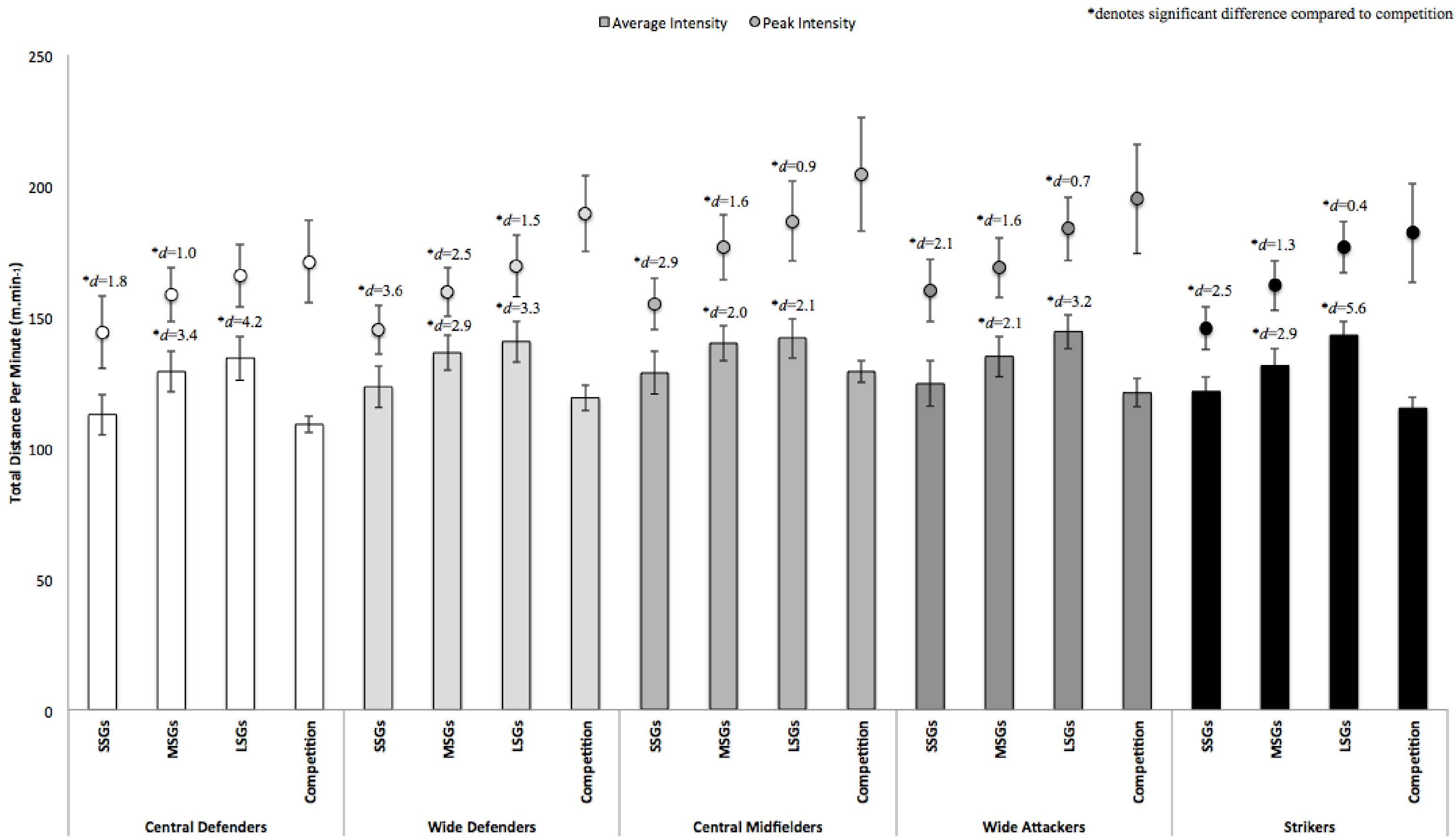

Figure 1. Average and peak total distance intensities produced by playing position during training games and competition.

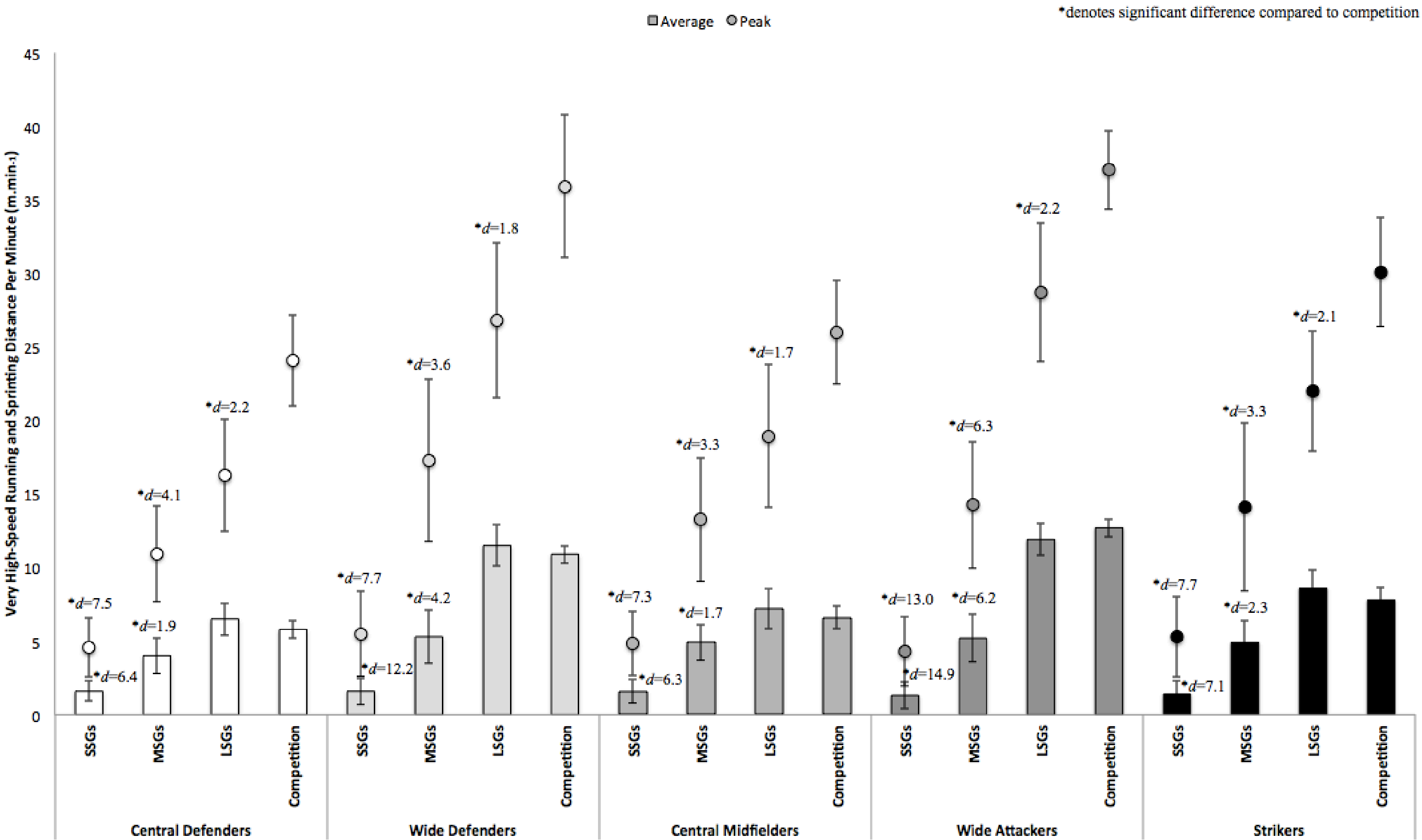

Figure 2. Average and peak very high-speed running and sprinting intensities produced by playing position during training games and competition.

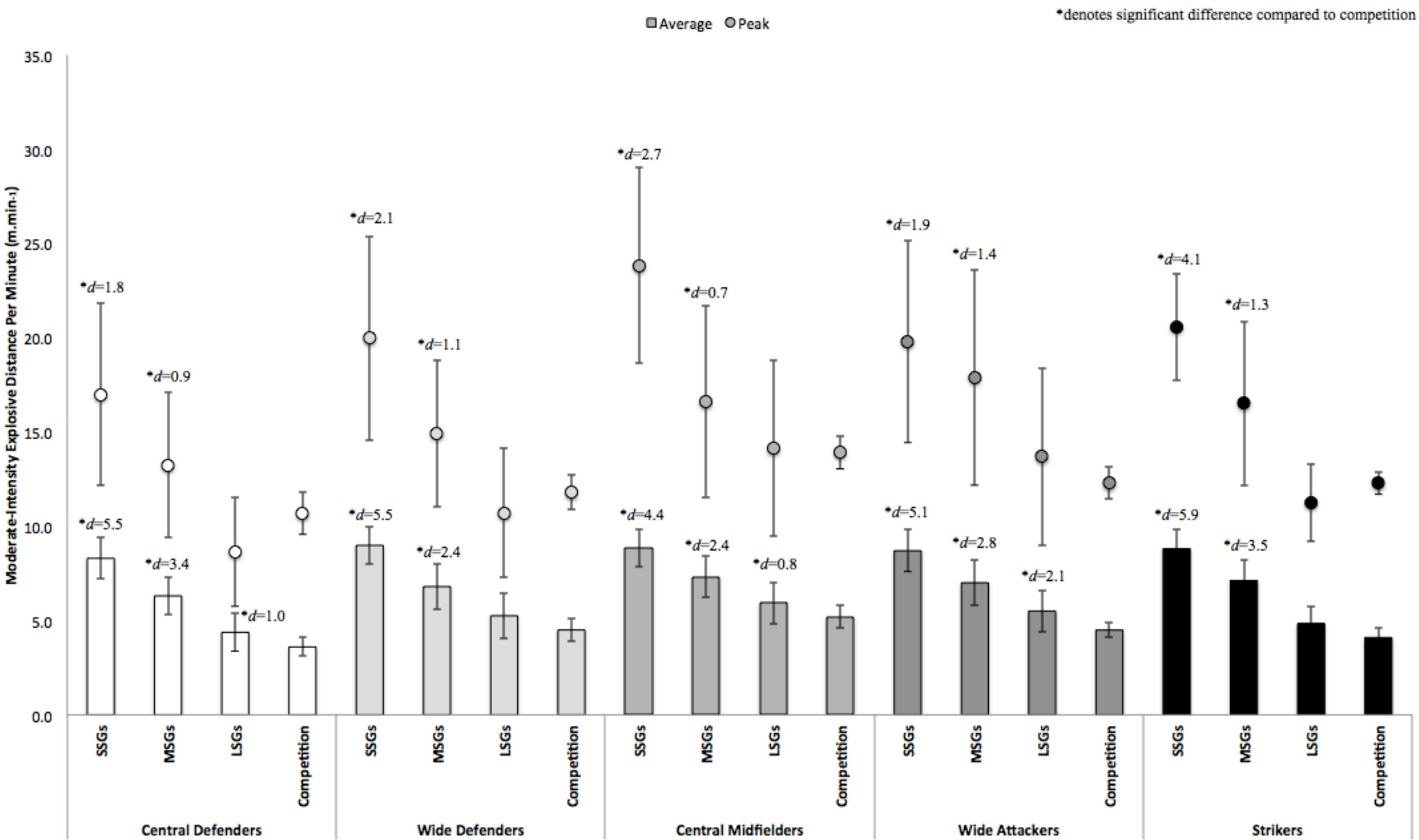

Figure 3. Average and peak moderate-intensity explosive distances produced by playing position during training games and competition.

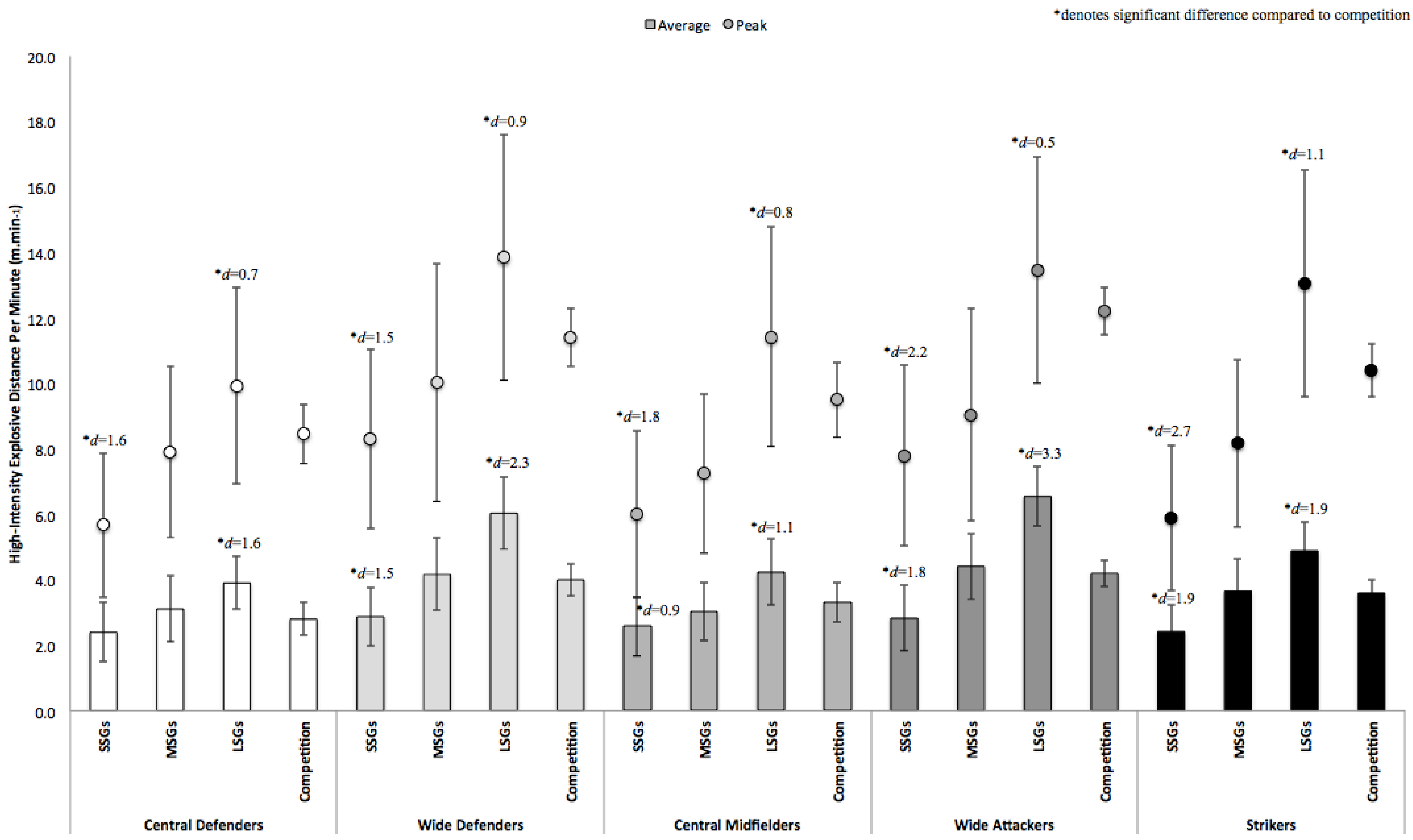

Figure 4. Average and peak high-intensity explosive distances produced by playing position during training games and competition.

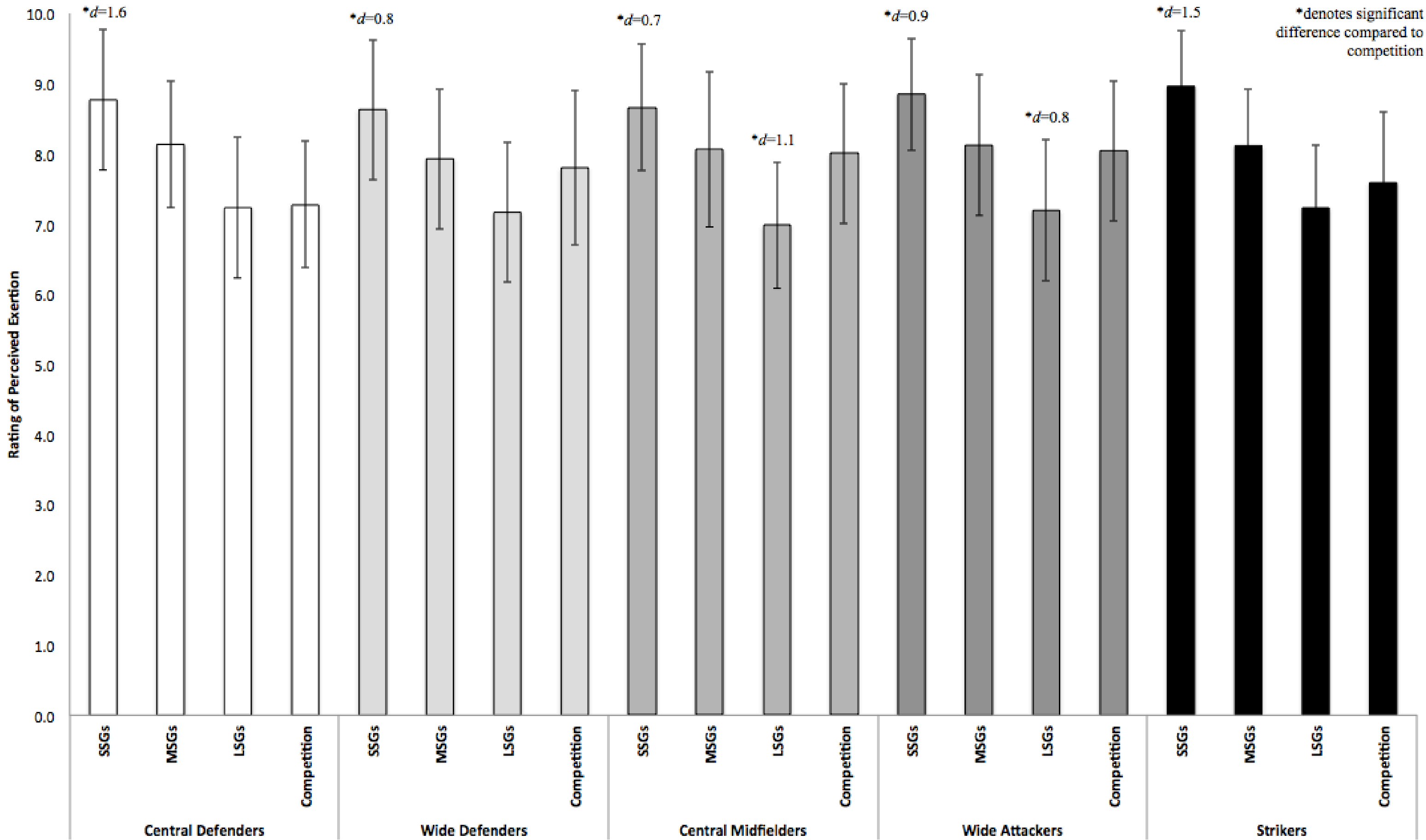

Figure 5. Ratings of perceived exertion produced by playing position during training games and competition.

Table 1. Descriptions of GPS metrics utilised.

GPS Metric	Description
Total distance ($m.min^{-1}$)	The total distance travelled.
Very high-speed running distance ($m.min^{-1}$)	The distance travelled between 100% maximum aerobic speed and 30% anaerobic speed reserve. Calculated using modified Montreal track test (29). Protocol previously utilized by Hunter et al (26) and Mendez-Villanueva, Buchheit, Simpson & Bourdon (30).
Sprinting distance ($m.min^{-1}$)	The distance travelled above 30% anaerobic speed reserve. Calculated using modified Montreal track test (29). Protocol previously utilized by Hunter et al (26) and Mendez-Villanueva, Buchheit, Simpson & Bourdon (30).
Very high-speed running and sprinting distance ($m.min^{-1}$)	Very high-speed running and sprinting distance added together.
Moderate-intensity acceleration distance ($m.min^{-1}$)	The distance travelled accelerating between 2 $m.s^{-2}$ and 3 $m.s^{-2}$ (4).
Moderate-intensity deceleration distance (m)	The distance travelled decelerating between -2 $m.s^{-2}$ and -3 $m.s^{-2}$ (4).
Moderate-intensity explosive distance ($m.min^{-1}$)	Moderate-intensity acceleration distance and moderate-intensity deceleration distance added together.
High-intensity acceleration distance (m)	The distance travelled accelerating above 3 $m.s^{-2}$ (4).
High-intensity deceleration distance (m)	The distance travelled decelerating below -3 $m.s^{-2}$ (4).
High-intensity explosive distance ($m.min^{-1}$)	High-intensity acceleration distance and moderate-intensity deceleration distance added together.
Rating of perceived exertion	Subjective rating of exertion using the 1-10 Borg scale