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Manipulation of Playing Field's Length/Width Ratio and Neutral Players' Positioning: Activity Profile and Motor Behavior Demands during Positional Possession Soccer Small Sided Games in Young Elite Soccer Players

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Abstract This study aimed to examine how changes in pitch length/width ratio and neutral players' positioning could modify the activity profile and motor behaviour demands during small-sided positional possession soccer games. 22 young male elite players divided in 2 teams (A and B) of 11 players participated in the study. All players participated in a positional possession game (4-a-side + 3 neutral players) on two different pitch formats with opposite length/width ratios (WIDE: 25 x 35 m; LONG: 35 x 25 m) and two different kinds of positioning for neutral players (VERTICAL: positioned high; HORIZONTAL: wide). The time motion variables of each player were recorded using a 15 Hz portable GPS. Average player displacement in width was significantly higher in WIDE format, while average player displacement in depth was significantly greater in LONG format ($p < .001$). Moreover, an increased activity profile was observed in regular team players with respect to neutral players ($p < .001$). These results highlight the physical and motor behaviour demands in small sided positional possession games. Furthermore, the different physical tasks required by various pitch formats and player positions were underlined. This information can help coaches to set up game-based training sessions.

Keywords Small Sided and Conditioning Games, Soccer, Activity profile, Young players, Field size

1. Introduction

Small sided conditioning games (SSCGs) have been increasingly generating interest among researchers because of their usefulness in the development of soccer skills in players of all ages and skill levels [1]. SSCGs are modified games played on reduced-sized field, often involving a smaller number of players and introducing adapted rules which are different from the normal eleven-a-side game [2]. As a game-based training method [3], SSCGs are considered more soccer-specific than traditional methods (characterised by extensive repetition of practice drills decontextualised from real game environment), since they allow training time to be optimised through the simultaneous development of technical skills, tactical awareness and physical performance [2].

However, only good training design can ensure advantages when this method is applied and the role of the coach becomes crucial in building the best learning environment through the manipulation of key task constraints (e.g. playing area, number of players, and rules). Numerous studies have been conducted in an attempt to understand how changes in particular constraints influence the physiological responses and the technical demands of the players. One of the most manipulated variables is the pitch size [2]. Focusing on physical task, it was demonstrated that the bigger the size of the field, the higher the physiological response [4] [5]. Furthermore, Hodgson et al. [6] confirmed what had previously been affirmed, underlining that acceleration and deceleration parameters were also greater on a larger field. As far as technical and tactical tasks are concerned, it has been shown how the pitch size can influence players' behaviour [4] [5] [7] [8]. Specifically, on a large field players were led to collaborate more than on a small one. Conversely, dribbles, shots on goal and individual play are the most common actions observed on a smaller pitch. Moreover, it was shown that field size should not to be estimated according to a personal feeling of what is "big" and what is "small". In fact, Fradua et al. [9] pointed out that the best way to reproduce a real tactical performance context in SSCGs is related to the individual playing area available for

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each player, which might be included in a range of 65-110 m^2, with a length/width ratio comprising this area of 1-1.3. However, no studies have investigated field length/width ratio manipulation and, consequently, its effects on physiological and technical-tactical demands. Contrariwise, the manipulation of the number of players involved in the game should cause the opposite effects on physiological response with respect to those provoked by changing pitch size [4] [10] [11]. Physiological response and physical activity demands increase when the number of players on the field is low. Analysing technical requirements, it was shown that lower the number of players involved in the exercise, the higher the number of dribbles, shots on goal, tackles and time spent playing the ball. On the other hand, with many players on pitch, collaborative behaviour, passes and controlling the ball are the most popular actions. [11] However, the efficiency of SSCGs training on technical tasks should not be influenced by the changing of the number of players on field [12].

In most of the literature analysed, SSCGs were played with both teams containing equal numbers of players (3-a-side, 4-a-side etc.,). Nevertheless, to carry out some specific technical-tactical exercises or to replicate some particular game situations, coaches might propose SSCGs with teams containing unequal numbers of players (one or two men less like 3vs2, 4vs2, etc.). Otherwise, some "floating" [13] or "supporting" [10] neutral players can be introduced, always playing with the team in possession of the ball in order to create temporary numerical superiority/inferiority. Unfortunately, there are few studies on this aspect.

The search for training contexts that increasingly represent the match environment has led coaches to create SSCGs in which players are forced to move across the pitch according to their position and function in the game. In this regard, Dellal et al. [14] have shown the importance for coaches to understand the physiological demands imposed upon players in various positional roles during SSCGs. Thanks to the insight of some coaches, new game-based training methods were created called "positional possession games" or, more simply, "positional games". These forms of practice are small-sided possession games based on tactical roles and there is a correlation between the system of play used (e.g. 4-3-3) and the specific positional role of each individual player. In positional games, it is usual to include some neutral supporting players to create numerical superiority in attack and to promote the maintenance of ball possession. The positioning in the exercises should be related to the player's position in the team's formation. In practice, the manipulation of the shape of the field (length/width ratio) and the line-up of the players' allows coaches to create different spatial/positional references that define a particular orientation of the playing space (e.g. space oriented according to depth by placing the neutral players high up a long pitch). It was demonstrated that at the level of the performer-environment relationship [15], the specific interaction between players and these constraints of practice context promotes the emergence of opportunities for action (i.e. affordances) that regulate adaptive behaviours and task achievement [16]. Several studies [17-21] have shown that the modification of the orientation of space, defined by the presence or absence of spatial references in a game situation (e.g. additional goals with or without a goalkeeper, scoring areas, reference players, etc.), should be considered a key constraint in the design of SSCGs. However, there is a lack of understanding on whether varying spatial and positional task constraints can have a diverse impact on activity profiles and technical-tactical demands in different SSCG formats.

In this research we first hypothesised that manipulating the length/width ratio of the pitch would influence physical response and movement patterns during positional possession SSGs. We expected to find a difference in physical activities on a wide field compared to a long field. Secondly, our next hypothesis is that changing the supporting players' positioning might have a significant effect on players' orientation and space perception, perhaps modifying physical load and motor profile. As a third hypothesis, significant differences were expected in the studied variables among regular and neutral players.

2. Methods

2.1. Participants and Experimental Design

Twenty-two young male elite players belonging to a club from Italian Serie A participated in the study (age = 14 ± 1 years, height = 168 ± 8 cm, body mass = 56 ± 8 kg, soccer experience = 5 years). The players were divided by the team coaches into two balanced groups of eleven players called group A and group B. All participants gave prior informed consent and all experimental procedures were approved by parents, the youth academy director and the Ethics Committee of the Motor Sciences Research Centre, Training and Performance Unit.

The experiment involved the analysis of a positional possession game (4-a-side + 3 neutral supporting players) on a 35 x 25 m pitch (dimensions already used by Rampinini et al. [4]. In these circumstances, every player held ~80 m^2 of playing area, in line with the guidelines provided by the study of Frauda et al. [9]. To perform this kind of SSCGs, both group A and group B were additionally divided in two teams composed of 4 regular players each. They competed for the ball during the exercises, while the 3 remaining participants became the neutral players and always played with the team in possession of the ball. In both groups, the teams and roles (regular or neutral player) were the same for the entire experiment. The pitch was manipulated by changing length/width ratio, considering as LONG the initial dimensions of 35 m length x 25 m width and WIDE the altered format of 25 m length x 35 m width. Then, the positioning of neutral players was manipulated by creating two different variants: VERTICAL, if they had to attack high, and HORIZONTAL, if they had to attack wide. Mixing these two variables, 4 different SSCGs formats were created: 1)

WIDE-VERTICAL (W-V), 2) WIDE-HORIZONTAL (W-H), 3) LONG-VERTICAL (L-V) and 4) LONG-HORIZONTAL (L-H) (see **Figure 1**). Each group performed four experimental sessions in two consecutive weeks using a counterbalanced design, as shown in **Table 1**. In every session each group performed four games in an intermittent regime, two sessions in VERTICAL positioning and two sessions in HORIZONTAL positioning. In the first week group A played WIDE formats in session 1 and LONG formats in session 2, while group B did the opposite. In the second week, the procedures were inverted in order to avoid a possible sequence effect. Every session was 3 minutes long interspersed by 3 minutes of passive recovery (work: rest ratio = 1:1), in which technical advice was given by the coach. Each trial was performed under the supervision and encouragement of the team's coach in order to maintain a high game intensity [4], with the collaboration of the investigators for the rapid replacement of the ball during the game [10]. Each experimental session was preceded by a standardised 15-minute warm up. All matches were played on the same synthetic football ground and at the same time of the day, in order to limit the influence of circadian variability on measurements [22].

Table 1. Scheme of experimental counterbalanced design. LA-V = large-vertical positional game format; LA-H = large-horizontal positional game format; LO-V = long-vertical positional game format; LO-H = long-horizontal positional game format

Week	Session	Group A	Group B
I	1	2 x LA-V + 2 x LA-H	2 x LO-V + 2 x LO-H
	2	2 x LO-V + 2 x LO-H	2 x LA-V + 2 x LA-H
II	3	2 x LA-V + 2 x LA-H	2 x LO-V + 2 x LO-H
	4	2 x LO-V + 2 x LO-H	2 x LA-V + 2 x LA-H

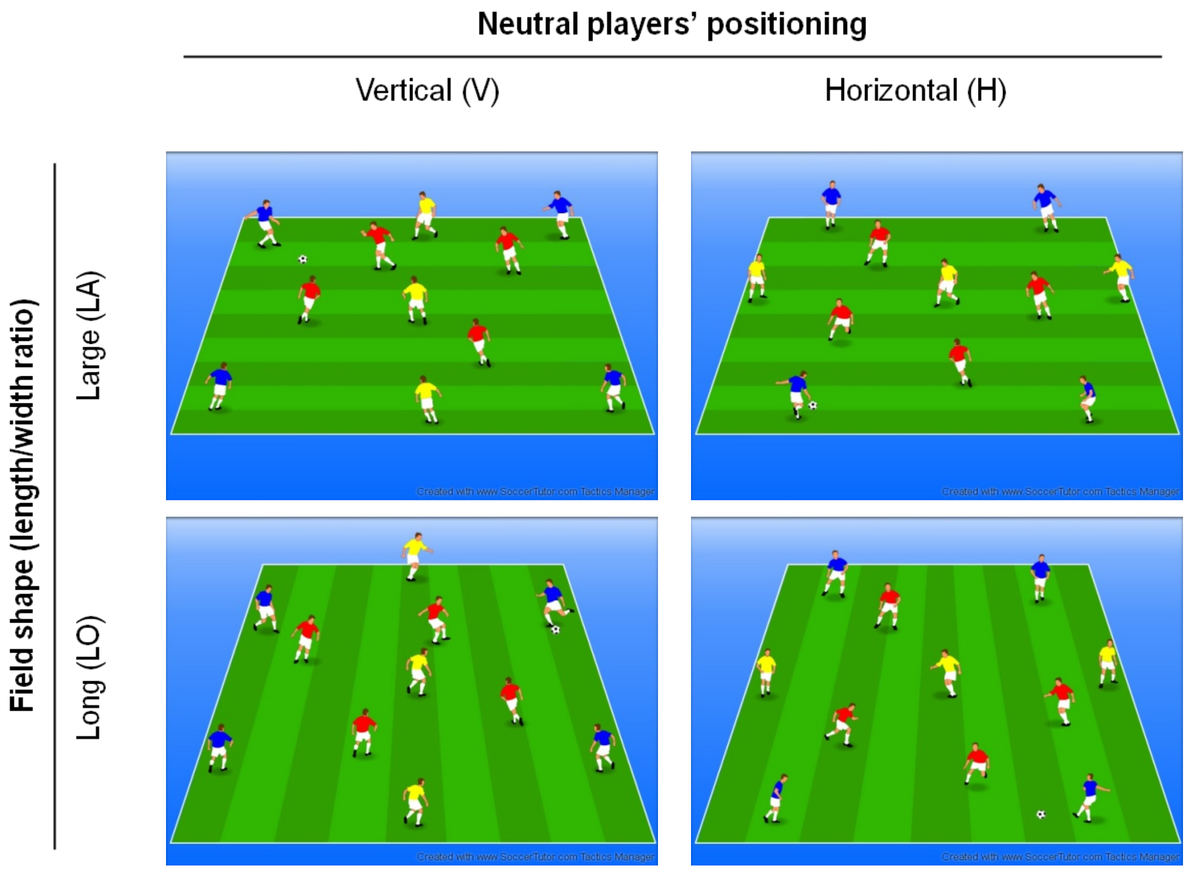

Figure 1. Representation of the four variants of positional possession game (4 vs 4 + 3 neutral players) included in this study. Reds and blues are the regular players, while the yellows are neutral players. Pitch dimensions = 35 x 25 m for long formats; 25 x 35 m for large formats

2.2. Data Collection and Analysed Parameters

During each experimental session the players' time motion variables were monitored with 11 portable GPS units (GPSports, SPI HPU, Canberra, Australia). This version (16g tri-axial accelerometer sampling at 100Hz integrated; size = 74 x 42 x 16 mm; mass = 66 g) provides raw position, velocity and distance data at 15 Hz (15 samples per second). Smoothing was carried out on the series of collected data by calculating the average of every three raw data points and obtaining a sampling frequency of 5 Hz [23] [24] in order to attenuate the noise generated by interference phenomena linked to very small scale factors (e.g. movements of the centre of mass). Each player wore a special vest that allows the receiver to be placed between the scapulae. All devices were activated 15 minutes before data collection to allow acquisition of satellite signals [25]. In addition, in order to avoid measurement errors arising from inter-unit variability [26] the players used the same GPS device during the various trials. While the validity and reliability of GPS technology for the estimation of instantaneous velocity during movements in acceleration, deceleration and constant speed have been studied previously [27], to our knowledge, no research exists regarding validity and reliability tests of this version of SPI HPU. However, evidence from other studies concerning the accuracy and reliability of an earlier version produced by the same company [28], the interchange-ability of GPS technology with other more sophisticated tracking systems [29] and the high validity and reliability of inter-unit 10 Hz and 15 Hz devices with respect to 1 Hz and 5 [30] Hz systems, all justify the use of such instrumentation.

Through the use of this system, the distance covered per minute and the time spent in different speed categories were calculated using a custom Microsoft Excel 2007 (Microsoft Office 2007, Microsoft Corporation, Washington, USA) spreadsheet, from instantaneous raw data of time, speed and distance available from the producer Team AMS software (GP Sports, Canberra, Australia). In the same program, the instantaneous acceleration value was calculated as the instantaneous speed variation in time. Finally, the mathematical model proposed by Di Prampero et al. [31] was integrated into a custom spreadsheet in order to calculate estimated total energy expenditure, average metabolic power and time spent in different metabolic power categories as displayed in previous studies [23] [24] [32].

In each drill the following physical parameters were detected: distance covered per minute (D/min), and %age of time at high speed running (%THS), taking as reference the speed values > 14,4 km h^{-1} (the threshold used in previous research by [23] [24] [32] [33]. Moreover, in accordance with the categories of acceleration and deceleration previously used in other studies [6] [34], and based on breakthroughs by Minetti et al. [35], which demonstrate the essential non-effect on metabolic cost of speed variations up to ~1 m s^{-2}, in this work only acceleration values > 2 m s^{-2} have been taken into account. Consequently the %age of time was calculated at high acceleration (%THA - > 2 m s^{-2}) and deceleration (%THD - < –2 m s^{-2}). With regard to the estimation of metabolic demands, the parameters of total energy expenditure (EE), average metabolic power (P_{met}) and %age of time at high power (%THP) were calculated, referring to values > 20 W kg^{-1}, which previous studies have already shown to be a valid threshold value for a high intensity index [23] [24].

Finally, the average displacement was investigated in width, on x axis (Disp *x*), and in depth, on y axis (Disp *y*) of each player on the field to assess how the manipulated variables influenced individual movement patterns.

2.3. Statistical Analysis

Descriptive statistics were presented as mean ± standard deviation. The differences between the four versions of the positional game due to the manipulation of the length/width ratio of the field and the neutral players' positioning were evaluated, for all the variables measured, through a two-way ANOVA for repeated measures and Bonferroni post hoc. The differences between regular players and neutral players were analysed, for all the variables measured, through a t test for independent groups. Statistical significance was set at $p < .05$. All statistical analysis was carried out using GraphPad Prism 5 software (GraphPad Software, Inc., USA).

3. Results

3.1. Distance and High Intensity Parameters

Table 2 shows the distance and high intensity parameters relative to different formats of the positional game and to various categories of player (regular and neutral). For all the variables, no significant difference was found between the SSCG variants. In the comparison between the types of role, significantly higher values are detected, in all parameters, for regular players compared to neutral ones ($p < .001$). Finally, a significant difference between THS and THP should be noted, with an average %age change of 283% in positional game formats and regular player analysis, and even a %age change of 1400% in neutral player analysis.

3.2. Estimated Metabolic Parameters

The total energy expenditure (EE) and the average metabolic power (P_{met}) are presented in Table 3. Estimated metabolic data showed the same trend in the comparison between the 4 variants of SSCG while, in the comparison between the types of role, they were significantly higher for regular players compared to neutral ones ($p < .001$).

3.3. Acceleration and Deceleration Parameters

The key parameters related to changes in velocity are reported In **Table 4**. Time at high acceleration (THA) and time at high deceleration (THD) were significantly greater in wide field format (W) drills compared to long (L) ones ($p < .05$), whilst they were generally similar between vertical players' positioning SSCGs (V) and horizontal players' positioning SSCGs (H).

In the comparison between classes of position, acceleration and deceleration data showed a significant difference, being higher in regular players compared to neutral players ($p < .001$).

3.4. Motor Behaviour Parameters

Table 5 shows the key data relative to players' motor behaviour during the experiment. Average displacement in width (Disp *x*) was more elevated in wide field format (W) positional games with respect to the longer (L) variants ($p < .05$), while average displacement in depth (Disp *y*) was significantly higher in L formats compared to W ones ($p < .05$).

Table 2. Distance and high intensity parameters related to the different formats of positional game and the various categories of role expressed as mean ± SD

	LARGE VERTICAL (n = 88)	LARGE HORIZONTAL (n = 87)	LONG VERTICAL (n = 88)	LONG HORIZONTAL (n = 87)	NEUTRAL players (n = 95)	REGULAR players (n = 255)	Post hoc
D/min (m)	98 ± 19	94 ± 21	95 ± 22	95 ± 19	75 ± 21	103 ± 14	LA-V = LA-H = LO-V = LO-H Regular > Neutral***
THS (%)	2 ± 2	2 ± 2	2 ± 2	2 ± 2	0 ± 0	3 ± 2	LA-V = LA-H = LO-V = LO-H REGULAR > NEUTRAL***
THP (%)	8 ± 4***	8 ± 4***	7 ± 4***	8 ± 4***	3 ± 2***	10 ± 3***	LA-V = LA-H = LO-V = LO-H Regular > Neutral***
% Change	283	282	288	279	1400	233	

*D/min = distance covered per minute; THS = time at high speed (> 14,4 km h^{-1}); THP = time at high power (> 20 W kg^{-1}). *** Signficant difference ($p < .001$).*

Table 3. Estimated metabolic parameters related to the different formats of positional game and the various categories of role expressed as mean ± SD

	LARGE VERTICAL (n = 88)	LARGE HORIZONTAL (n = 87)	LONG VERTICAL (n = 88)	LONG HORIZONTAL (n = 87)	NEUTRAL players (n = 95)	REGULAR players (n = 255)	Post hoc
EE (kJ kg^{-1})	1,6 ± 0,3	1,6 ± 0,4	1,6 ± 0,4	1,6 ± 0,4	1,2 ± 0,3	1,7 ± 0,2	LA-V = LA-H = LO-V = LO-H Regular > Neutral***
P_{met} (W kg^{-1})	9,1 ± 1,9	8,8 ± 2,2	8,7 ± 2,1	8,8 ± 2,0	6,6 ± 1,9	9,7 ± 1,3	LA-V = LA-H = LO-V = LO-H Regular > Neutral***

*EE = total energy expenditure; P_{met} = average metabolic power. *** Signficant difference ($p < .001$).*

Table 4. Acceleration and deceleration parameters related to the different formats of positional game and the various categories of role expressed as mean ± SD

	LARGE VERTICAL (n = 88)	LARGE HORIZONTAL (n = 87)	LONG VERTICAL (n = 88)	LONG HORIZONTAL (n = 87)	NEUTRAL players (n = 95)	REGULAR players (n = 255)	Post hoc
THA (%)	13 ± 3	13 ± 3	12 ± 3	12 ± 4	11 ± 2	13 ± 4	LA > LO* V = H Regular > Neutral***
THD (%)	12 ± 4	12 ± 5	11 ± 4	11 ± 5	8 ± 4	13 ± 4	LA > LO* V = H Regular > Neutral***

*THA = time at high acceleration (> 2 m s^{-2}); THD = time at high deceleration (> –2 m s^{-2}). * Signficant difference ($p < .05$). *** Signficant difference ($p < .001$).*

Table 5. Motor behavior parameters (players' displacement in width and depth) related to the different formats of positional game and the various categories of role expressed as mean ± SD

	LARGE VERTICAL (n = 88)	LARGE HORIZONTAL (n = 87)	LONG VERTICAL (n = 88)	LONG HORIZONTAL (n = 87)	NEUTRAL players (n = 95)	REGULAR players (n = 255)	Post hoc
Disp *x* (m)	4,2 ± 0,9	3,8 ± 1,4	3,0 ± 0,9	2,6 ± 0,9	2,4 ± 1,1	3,8 ± 1,0	LA > LO* V > H* Regular > Neutral***

With regard to the comparison between players' role categories, all the motor behaviour parameters (Disp *x* and Disp *y*) were greater in regular players than in neutral ones ($p < .001$).

4. Discussion

This study aimed to verify the effects of changes in pitch length/width ratio and neutral supporting players' positioning on activity profiles and motor behaviour demands during positional possession SSCGs in young elite soccer players. The first result highlighted by the data analysis shows that changing field shape does not influence physical effort (**Figure 2**, **Figure 3**). Only %THA was significantly influenced (**Figure 3**). Unfortunately, there is no previous research considering this kind of manipulation, so it is impossible to compare data. In addition, only a few studies have evaluated acceleration and deceleration parameters, so it is hard to discuss our information in relation to other literature [6] [32] [36]. Focusing on the players' movement patterns on the field a trend of "moving wide" was identified when the game was played on a WIDE SSCG format, while on the LONG format the tendency was of "moving up and down" the pitch (**Figure 4**). This information should suggest that through the manipulation of field shape it is possible to influence the space exploration behaviour of the players involved in the game. More precisely, the variation of this constraint would seem to be able to change the perception of the players in relation to their area of intervention (more width and less depth in a "wide" pitch shape and more depth and less width in a "long" pitch shape). Consequently, the manipulation of this variable seems to create different affordances according to field shape, enhancing the players' ability to self-regulate their behaviour during game dynamics [1]. This can partially confirm our first hypothesis, showing that it is possible to manipulate players' motor behaviour by changing the length/width ratio. However, this manipulation does not significantly modify players' physical effort during games.

Similarly, the orientation of positional reference variation performed by different neutral players' positioning did not provoke changes in physical parameters (**Figure 2**, **Figure 3**). Contrariwise, a higher trend of "moving wide" was recorded when neutral players were vertically positioned, while no variations were identified for "up and down" (**Figure 4**). Also, as before, our second hypothesis can be only partially confirmed, considering that just one positioning variable was effectively influenced by this manipulation.

With regard to the third hypothesis, we can affirm that regular players obtained greater values than neutral players in all the variables analysed (**Figure 2**, **Figure 3**, **and Figure 4**). The results of this research are in contrast with those described by Hill-Haas et al. [13], in which an increased activity profile was detected (total distance covered and distance travelled at > 18 km h^{-1}) for the regular players with respect to the others. However, in this previous study, the SSCG format featured oriented space through the presence of certain scoring targets (regular goals defended by goalkeepers), with the aim of scoring a goal, and the single neutral player that offered numerical superiority had complete freedom of movement. Conversely, in our study, the SSCG type was possession based (without the aim of scoring a goal), the numerical imbalance was more marked (temporarily 7 vs 4 for the team in possession of the ball) and neutral players had positional reference tasks, and were therefore more comparable to supporting players. This game situation, therefore, would seem to create fewer movement opportunities for neutral players, also taking into account that they were constantly in an attacking phase without having to regain possession of the ball (defending phase), which would entail greater movement demands. These considerations may explain the differences in the two categories of role and fully confirm the third hypothesis.

Finally, in accordance with previous studies by Gaudino et al. [23] Gaudino et al. [24] and Gaudino et al. [32], a higher percentage of high metabolic power was observed (> 20 W kg^{-1}) in comparison with high speed activity (> 14,4 km h^{-1}), showing how the evaluation of high intensity demands through the use of the metabolic power parameter may be a more valid index compared to using running speed, especially in smaller playing fields.

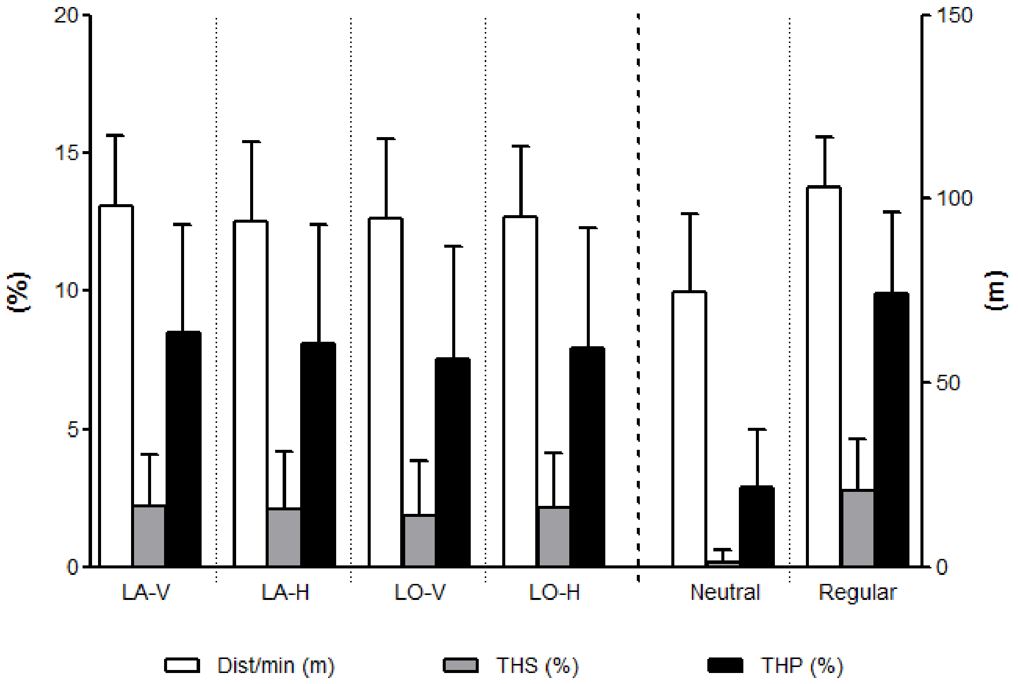

Figure 2. Dist/min (distance covered per minute; in meters), % THS (% time at high speed running; i.e., > 14,4 km h^{-1}) and % THP (% time at high power; i.e., > 20 W kg^{-1}) relative to the four variants of SSCG and to the two categories of role players (mean ± SD)

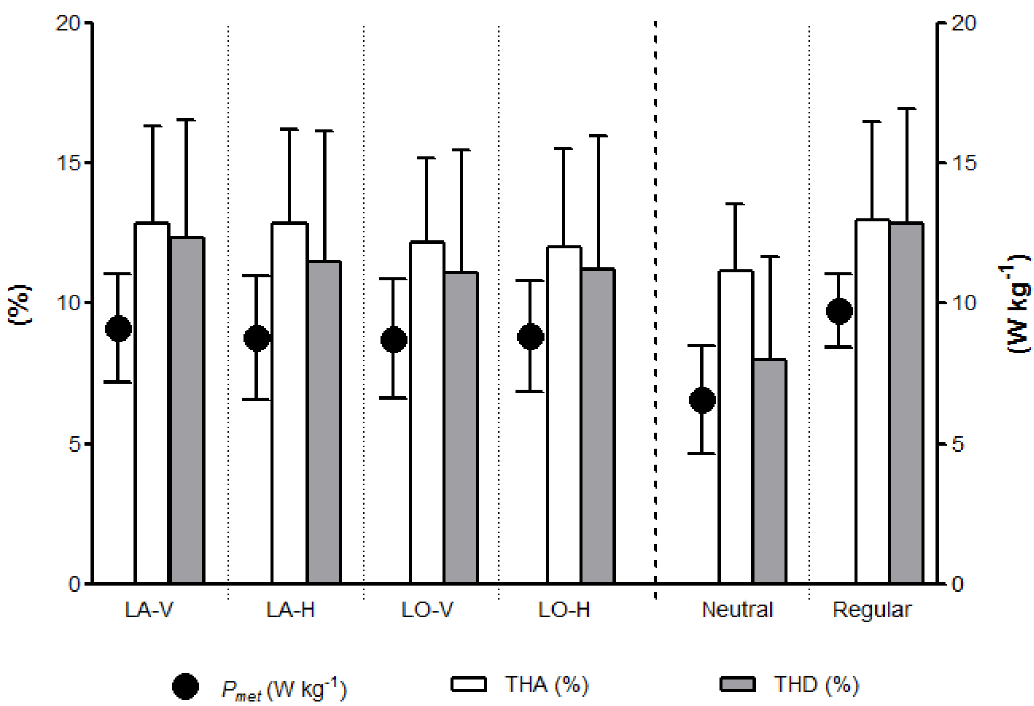

Figure 3. P_{met} (average metabolic power; in W kg^{-1}), % THA (% time at high acceleration; i.e., > 2 m s^{-2}) and % THD (% time at high deceleration; i.e., > –2 m s^{-2}) relative to the four variants of SSCG and to the two categories of role players (mean ± SD)

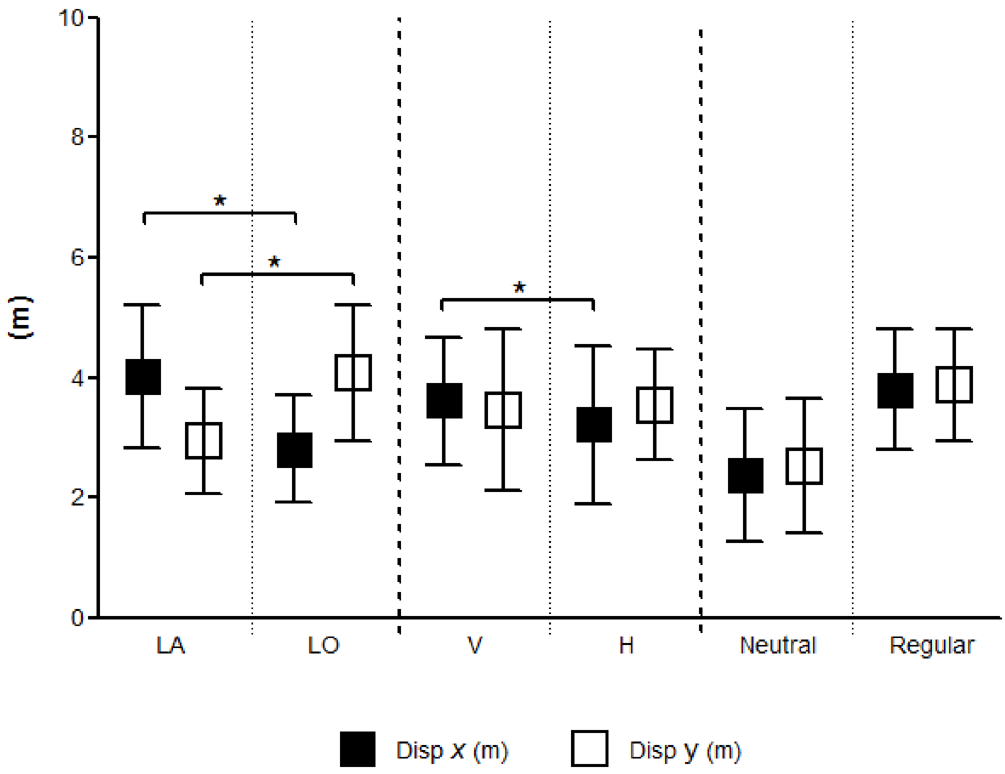

Figure 4. Disp *x* (average displacement in width; in meters) and Disp *y* (average displacement in depth; in meters) relative to the manipulated variables and to the two categories of role players (mean ± SD)

5. Conclusions

To sum up, this study provides data about activity profiles and motor behaviour patterns in positional possession SSCGs, and how the manipulation of length/width ratio and neutral players' positioning influence these parameters. Most of the analysed parameters (metabolic and mechanical) did not significantly change through the manipulation of the examined variables, whilst motor behaviour data showed differences between the various SSCG formats. Considering this, we can affirm that changing the pitch format does not modify the physical effort. However it can be a good strategy to train players in different tactical situations without altering metabolic tasks. Various formats create several tactical aspects that can be useful to help players to gain experience in facing different game circumstances. On the other hand, the activity profile of neutral players is significantly different from that of regular players. In particular, neutral players showed a lower physical work compared to "regulars". Post-injured or over-trained players can take advantages from this situation, because they can reduce the training intensity without leaving a specific context. Such information may be useful to coaches for a more accurate employment of soccer-specific exercises during the training process. In addition, to better understand this topic, future studies should investigate the game dynamics in SSCGs when players are forced to play in given roles with specific tasks. Finally, further investigations are essential to better understand the influence of the manipulation of spatial variables in SSCGs (shape and orientation of the playing field through spatial/positional references) on technical, tactical and physical, individual and collective performance, and to examine more accurately the activity profile and the impact of neutral players in various game-based training contexts.

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