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Original Article

Heart rate response comparison of young soccer plyers in "cage" small-sided and 8vs8 games

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Abstract:
Aim: Small-sided games are widely used training methods because they permit the trainer to focus on technical/tactical and physical aspects at the same time. The study also aims to investigate and compare the cardiac responses assessed during 3 vs. 3 games played in a "cage" compared with 8 vs. 8 games played with goal keepers and to understand the correlation between the values of aerobic power and heart rate measured during small-sided games.
Methods: 16 young soccer players.
Results: The assessment of aerobic power, measured by means of the Leger test, revealed a mean VO2max value equal to 54.23 ± 3.89 ml/kg/min.
The results showed statistically significant differences between 3vs3 cage and 8vs8 for % mean heart rate (88±2,7 vs 77±3,8, $p<0.0005$) and % max heart rate (94,6±1,5 vs 88,6±2,9, $p<0.0005$). A significant negative correlation emerged between the VO2max and % mean heart rate during the first period ($r=-0.873$, $p<0.01$), the second period ($r=-0.678$, $p<0.05$) and the third period ($r=-0.615$, $p<0.05$).
Conclusion: This study is the first to describe and quantify the internal load imposed by a specific playing modality (i.e. a cage-enclosed pitch) on a small-sided games format (i.e. 3 vs. 3) that demands that play is continuous and without any interruption (for example, due to balls going out of play) using young football players. The results also show that physiological responses in young players are greater in small-sided games involving a smaller number of players (i.e. 3 vs. 3 compared with 8 vs. 8).
Key words*:* Small-sided games, heart rate, young soccer player, soccer.

Introduction

The data obtained from *match analysis* research confirm the intermittent nature of the football, with phases of high-intensity exercise interspaced by phases of recovery (1,2,3,4,5,6,7,8,9,10) that require heart rate (HR) to adapt continually (11,12,13,14,15,16,17,18,19,20,21,22,23,24).

Small-sided games (SSG) are technical training exercises performed in the form of matches played on reduced sized pitches, with a reduced numbers of players and specific rules; they are often inserted into weekly microcycles and used at different points of a training programme depending on the technical-tactical and physical objectives that the trainer, in agreement with the athletic trainer, has fixed for the session; this is because in addition to leading to improvements in technical abilities, SSG also activate aerobic metabolism (25,26).

From the practical point of view, SSG played using higher numbers of players become ideal training exercises for improving technical-tactical aspects, while those played with relatively few players are more suitable for physical conditioning (26). SSG are widely used in football training programmes, including youth football training, even in players as young as 6-7 years. Due to the reduced dimensions of the playing area and the reduced number of players involved, the frequency at which each player is in possession of the ball is higher, thus providing more opportunity for each player to improve passing, dribbling and their capacity to strike the ball, and to deal with common tactical situations during play, such as collaborating with team members, running without the ball and escaping a marker in order to receive the ball (27).

Consequently, studies exist in the literature that have specifically addressed the use of SSG in young players as well as more experienced athletes and that compare the various playing formats (e.g. 1 *vs*. 1, 2 *vs*. 2, 3 *vs*. 3, 4 *vs*. 4 and 5 *vs*. 5) and monitor lactate concentration, heart rate, the percentage of maximal heart rate and the perceived exertion (15,17,19,24,28,29,30). Other studies have analysed SSG organised such that one of the two sides is formed of a greater number of players (12,18). Finally, some Authors have observed and compared the cardiac response and the technical actions performed during different SSG formats and the traditional 11-a-side game (31).

However, a specific problem remains unanswered in the literature: what physiological responses occur during SSG played on a pitch in which the perimeter lines are delimited by barriers (the so-called "cage") and what are the relationships between the values measured during maximal incremental aerobic tests and HR

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assessed during 3 vs. 3 games played in "cage" modality. Considering that aerobic performance does not solely constitute a biological foundation of strength capacity, but also favours to a significant level the speed of the recovery processes following intensive interval training, the relationships between the values of aerobic power and cardiac response in young football players undergoing SSG training also remain to be understood (32,33,34).

The aims of this study are the following:

1. to evaluate and compare the values of heart rate recorded during two different SSG formats: 8 *vs*. 8 with a goal keeper and 3 *vs*. 3 in a pitch delimited and enclosed along all perimeter lines and above (i.e. the so-called "cage" format);
2. to assess the correlation between the values of aerobic power and heart rate recorded during the alternating play and recovery phases (four periods of play each lasting of 3 minutes spaced by 2 minutes of passive recovery) of a 3 *vs*. 3 SSG in "cage" modality.

Methods

Participants

The sample is composed of young football players participating in the novice training category (N = 16). The mean age, weight and height of the players was 13 ± 0.1 years, 45.4 ± 10.1 Kg and 155.5 ± 8.6 cm, respectively.

Of the N = 16 subjects enrolled into the study, only N = 12 completely the evaluation procedure as the inclusion criteria required participation in both the exercise sessions in the absence of injury and that the 72 hour recovery period between the two sessions was fully respected. Thus data pertaining to N = 4 subjects were excluded from the final results.

Materials

HR was assessed using wireless heart rate monitors equipped with a telemetry system (*Polar Electro Oy, Kempele, Finland*). The 3 *vs*. 3 SSG was played on a 16 x 8 metre pitch enclosed by a cage, which delimited the playing area along all perimeter lines as well as above. The playing surface was composed of the latest generation of artificial turf. The dimensions of the two goals were 1 x 0.8 meters. The 8 *vs*. 8 with goal keeper SSG format was played on a 62 x 44 meter pitch with standard sized goals (7.32 x 2.44 metres). Both SSG formats used a size 5 football.

Procedures

Seventy-two hours before the first SSG was played, anthropometric variables for all participating subjects were assessed, followed by a maximal incremental aerobic test (specifically, the Leger test; 35). After 72 hours of recovery, the 8 *vs*. 8 with goal keepers SSG was played, composed of two 25 minutes playing sessions with a passive recovery phase of 5 minutes at half time. Throughout the duration of the two playing sessions, heart rate was constantly monitored using wireless Polar heart rate monitors. Along the sidelines of the pitch, extra footballs were located such that the game could be immediately restarted without a pause should a ball go out of play. Following the completion of this first SSG, the players were subjected to a 72 hour recovery period, before the 3 *vs*. 3 "cage" format SSG was then played. This second SSG consisted of a series of four periods of play, each lasting of 3 minutes, spaced by 2 minutes passive recovery between each play period. As in the case of the 8 *vs.* 8 SSG, throughout the duration of the playing and recovery times, all players were constantly monitored using wireless Polar heart rate monitors.

Statistical Analysis

Descriptive statistics (M ± SD) were calculated for all assessed variables; Student's t tests for paired data were used to investigate the existence of statistically significant differences between the HR values measured during the execution of the two different SSG typologies. Pearson's correlations were performed to test the strength of the linear relationships between the values of VO_2max obtained from the Leger test and the percentage of mean HR, the percentage of maximal HR, the percentage of HR during recovery, maximal HR (BPM) and the time spent in the different intensity zones identified in the 3 *vs*. 3 SSG. Statistical significance was set at $p \leq 0.05$.

Results

The assessment of aerobic power, measured by means of the Leger test, revealed a mean VO_2max value equal to 54.23 ± 3.89 ml/kg/min. The mean results for the cardiac responses that emerged during the two SSG typologies considered are summarised in table 1.

Table 1. Comparison of % meanHR and % HRmax recorded during the 3 *vs*. 3 and 8 *vs*. 8 + goal keeper SSG

	3 *vs*. 3	**8 *vs*. 8 + goal keeper**
% meanHR	88 ± 2.7	77 ± 3.8 ****
% maxHR	94.6 ± 1.5	88.6 ± 2.9 ****

**** $p<0.0005$

Pearson's correlation coefficients for the assessed variables are summarised in **tables 2, 3 and 4**.

Table 2. Pearson's correlation coefficients for the values of aerobic power obtained in the maximal increment aerobic fitness tests and values of % meanHR measured during the four periods of play that made up the 3 *vs*. 3 "cage" SSG

	VO_2max	% meanHR	% meanHR	% meanHR	% meanHR
VO_2max	-	-0.873(**)	-0.678(*)	-0.615(*)	-0.302

* p<0.05; ** p<0.01

Table 3. Pearson's correlation coefficients for the values of aerobic power obtained in the maximal increment tests and % maxHR recorded during each of the 4 periods of play and % meanHR measured during the first and second minute of recovery time between the play periods in the 3 *vs*. 3 "cage" SSG

	Period 1			**Period 2**		
	% maxHR	**% meanHR** 1st min rec.	**% meanHR** 2nd min rec.	**% maxHR**	**% meanHR** 1st min rec.	**% meanHR** 2nd min rec.
VO_2max	-0.801(**)	-0.843(**)	-0.579(*)	-0.547	-0.843(**)	-0.579(*)
	Period 3			**Period 4**		
	% maxHR	**% meanHR** 1st min rec.	**% meanHR** 2nd min rec.	**% maxHR**	**% meanHR** 1st min rec.	**% meanHR** 2nd min rec.
VO_2max	-0.524	0.094	-0.158	-0.184	-0.027	-0.303

* p<0.05; ** p<0.01

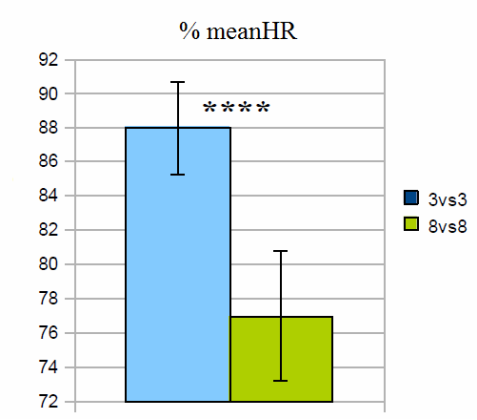
Table 4. Pearson's correlation coefficients for the values of aerobic power obtained in the maximal increment aerobic fitness tests and the length of time spent in the different intensity zones identified in the 3 *vs*. 3 "cage" SSG

	VO_2max	s at 50-60%	s at 61-70%	s at 71-80%	s at 81-90%	s at 91-100%
VO_2max	-	0.318	0.874(**)	0.549	0.828(**)	-0.818(**)

** p<0.01

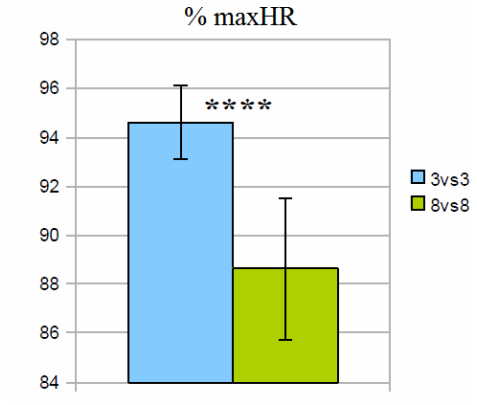
Discussion

The first hypothesis of the study was to analyse and compare the values of % meanHR and % maxHR between the 3 *vs*. 3 "cage" SSG and the 8 *vs*. 8 with goal keeper SSG (figures 1 and 2).



**** p<0.0005

Fig. 1. % meanHR recorded in the 3 *vs*. 3 and 8 *vs*. 8 + goalkeeper SSG formats



**** p<0.0005

Fig. 2. % maxHR recorded in the 3 *vs*. 3 and 8 *vs*. 8 + goalkeeper SSG formats

This study is the first to analyse the responses in players participating in 3 *vs*. 3 SSG employing a pitch delimited and enclosed along the perimeter lines and above by a cage; of consequence, the values identified in this type of SSG can only be compared with those from other similar studies involving 6 players in a 3 *vs*. 3 game. The % meanHR measured in this study during the 3 *vs*. 3 "cage" SSG was 88 ± 2.7%, a level that is coherent with other studies assessing the 3 *vs*. 3 format, (performed without the presence of goalkeepers) that have reported percentages of maxHR ranging between 87% and 89% (24,30,36,37,38).

Other studies exist in the literature, however, reporting values higher that those reported in the present study, with a % maxHR that exceeds 90% (18,19,20,28). One study carried out on the 3 *vs*. 3 SSG performed in three different playing modalities (normal playing rules in the presence of goal keepers; possession football; and possession football in the presence of 2 factotum players) obtained the same values as reported here for the first SSG playing modality, but reported a % maxHR of 91% for the second and third playing modalities, highlighting how the simple variation of certain elements of the game is sufficient to cause a significant change in the cardiac response (39).

Other studies that have analysed the 3 *vs*. 3 have reported more modest values of %maxHR, ranging between 80-84% (12,40,41).

The "organisational" advantage of the caged pitch helps to eliminate the frequent interruptions caused by balls going out of play and, therefore, ensures a more intense cardiac response compared with that occurring in classic 3 *vs*. 3.

The studies that obtained values of %HR greater than those observed here involved pitch dimensions that were greater than those of the present study (18,20,28) or used longer playing times (19).

The importance of varying the number of players, according to the technical-tactical or physical objectives of the training sessions, is also confirmed by the statistically significant difference that emerged from the comparison of the cardiac responses from the 3 *vs*. 3 and the 8 *vs*. 8 SSG, which validate the hypothesis that SSG played with a larger number of players are better for improving the technical-tactical aspects of play, whilst those involving a reduced number of players are more appropriate for achieving physical conditioning objectives (26).

The significant correlations obtained between the value of VO_2max and the mean HR values during the series of play and recovery periods, and the correlations between VO_2max and maxHR lead us to hypothesise that the young football players with higher levels of VO_2max are able to recover better following periods of intense interval exercise training (32,33,42,43,44), such that it seems they are able to tolerate high intensity exercise by controlling their HR better (44).

The same inverse correlations found between the value of VO_2max and the time spent in the 81-90% maxHR intensity zone ($r = -0.828$, $p < 0.01$) and VO_2max and the time spent in the 91-100% maxHR intensity zone ($r = -0.818$, $p < 0.01$) seem to confirm this tendency.

In the literature, these functional relationships have been widely described and explained in studies investigating the relationship between HR recorded immediately after high intensity exercise and levels of aerobic power (45, 46).

Conclusions and practical applications

This study is the first to describe and quantify the internal load imposed by a specific playing modality (i.e. a cage-enclosed pitch) on a SSG format (i.e. 3 vs. 3) that demands that play is continuous and without any interruption (for example, due to balls going out of play) using young football players. The results also show that physiological responses in young players are greater in SSG involving a smaller number of players (i.e. 3 *vs*. 3 compared with 8 *vs*. 8). Furthermore, the results suggest that the SSG formats involving fewer players may be more appropriate for training programmes that specifically aim to improve the fitness levels of young players because they lead to a cardiac response of around 90% of maximal HR.

This study also confirms previous data in the literature: that formats involving smaller pitches are more appropriate for increasing internal load, while those played on larger pitches are more indicated for training specific actions required in match play. Football trainers can thus choose the SSG format that best corresponds with the objective of each specific training session.

Conflicts of interest

The authors of the following article have not received any funding and have no contractual relationship with the companies that produce the products mentioned in the text.

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