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Research article

The effects of man-marking on work intensity in small-sided soccer games

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Abstract
The aim of this study was to examine the effect of manipulating defensive rules: with and without man-marking (MM and NMM) on exercise intensity in 3 vs. 3 small-sided games (SSGs). Twelve adolescent soccer players (age: 16.2 ± 0.7 years; body mass: 55.7 ± 6.4 kg; body height: 1.70 ± 0.07 m) participated in this repeated measures study. Each participant performed in four different SSGs formats: 3 vs. 3 MM with and without goals and 3 vs. 3 NMM with and without goals. Each SSG lasted 3 x 4 minutes interspersed with 4 minutes passive recovery. The percentage heart rate reserve (%$HR_{reserve}$) was recorded continuously during SSG and session-rating of perceived exertion (session-RPE) after the SSG. MANOVA showed that defensive rule had significant effects on intensity ($F = 5.37$, $p < 0.01$). Specifically, MM during SSG induced significantly higher %$HR_{reserve}$ compared to NMM (Goal: 80.5 vs. 75.7%; No goal: 80.5 vs. 76.1%; $p < 0.05$, effect size = 0.91-1.06), irrespective of the presence or absence of goals. However, only MM with the presence of goals induced significant higher session-RPE compared to NMM (7.1 vs. 6.0; $p < 0.05$, effect size = 1.36), whereas no difference in session-RPE was observed between MM and NMM (7.4 vs. 6.9; $p > 0.05$, effect size = 0.63) when no goals were used. Higher intra-class reliability and lower coefficient of variation values were also reported in MM as compared to NMM. This study in youth soccer players shows there is ~4.5% increase in heart rate response by using the man-marking in 3 vs. 3 SSG thus the intensity of SSG can be significantly increased when using man-marking tactics.

Key words: Training, football, goal, fitness, aerobic.

Introduction

Soccer performance is highly dependent upon a combination of technical, physical and tactical skills (Bangsbo, 1994; Dellal et al., 2010; Iaia et al., 2009). In training, small-sided games (SSGs) are widely used as a means to simultaneously enhance technical skills, tactical awareness, and physical fitness. In SSGs, the reduced pitch size and smaller number of participants are used to simulate the competitive demands of real match-play situations as players are frequently required to make decisions under pressure and fatigue conditions (Jones and Drust, 2007; Rampinini et al., 2007). Moreover, it has been suggested that SSGs can be a valid substitute for traditional interval running training drills to improve aerobic fitness as well as providing a platform for practicing technical skills (Hill-Haas et al., 2008; Dellal et al., 2011d).

Research has frequently shown that the exercise intensities achieved during SSGs are similar or even higher than generic fitness training drills of similar duration (Dellal et al., 2008; Hill-Haas et al., 2009a; Impellizzeri et al., 2006). For example, Impellizzeri et al. (2006) reported no significant differences between values for physiological variables such as maximum heart rate and %VO_{2max} during specific SSGs compared to generic interval running training in junior players. Recent studies by Dellal et al. (2008) and Hill-Haas et al. (2009a) also demonstrated matching heart rate values in the two forms of training although a higher perceived intensity was reported in generic training in the latter study. In addition, in a comparison with generic fitness training methods, Reilly and White (2004) found that small-sided games are effective in maintaining fitness levels during the competitive season.

A comprehensive body of research has shown that the exercise intensity achieved in SSGs can be manipulated by changing the rules (Sampaio et al., 2007), number of players (Hill-Haas et al., 2009b; Jones and Drust, 2007; Koklu et al., 2011), pitch dimension (Kelly and Drust, 2009), coach encouragement (Rampinini et al., 2007) and bout duration (Fanchini et al., 2011). Yet, up to now, no previous studies have investigated the potential effects of modifications in defensive tactics (e.g., man-making or zonal marking) on exercise intensity during SSGs. However, small-sided games are reported to show a higher variability in exercise intensity across participants when compared with generic training, which may be caused by unstructured movement in SSGs (Hill-Haas et al., 2011). In addition, additional variables such as individual playing area and coach encouragement can alter the variability in intensity of SSGs. Hill-Haas et al. (2008) examined different game formats (2 vs. 2, 4 vs. 4 and 6 vs. 6 players) and regimes (continuous vs. interval) in 16 male youth soccer players. Results showed that an increased format size affected the variability of blood lactate concentration, which may ascribe to the stochastic nature of SSGs.

Work load and physical performance in small-sided games are usually assessed by measuring the rating of perceived exertion (RPE), heart rate (HR), blood lactate concentration, and time motion movement analyses (Casamichana and Castellano, 2010; Dellal et al., 2011a; 2011b; 2011c; 2011e; Hill-Haas et al., 2011). HR is the most commonly used measure and has been accepted as a reliable indicator of physiological responses in previous studies on SSG (Dellal et al., 2008; Hill-Haas et al., 2010; Rampinini et al., 2007). In addition, Coutts et al. (2009) reported that RPE is also a good indicator of global exercise intensity as it was highly correlated with other physiological markers such as blood lactate concentration

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in soccer SSGs training. Aroso et al. (2004) investigated 3 vs. 3 SSGs using man marking (MM) and small goals in a 30 m x 20 m pitch, a significantly higher RPE was found when the field of play was enlarged and the number of players decreased. Besides, time spent in standing still and both lateral and backward running were decreased significantly. However, session-RPE, an internal training load indicator for SSG, was not examined in their study.

Rule modifications have long been used to vary the physiological stimulus and tactical aims in SSG. For example, Sampaio et al. (2007) has examined the effect on heart rate and RPE of three modifications (coach encouragement, two ball touches per player and man-to-man defense) in two small-sided games (2 vs. 2 and 3 vs. 3). The results suggested that there were no significant differences on physiological loading but the players' perceptual view of exercise intensity was affected. Despite the wealth of research conducted on exercise intensity in small-sided games, to our knowledge, no studies have analyzed defensive man-marking tactics in SSGs thus the potential physiological effects of such a change in defensive rule are unknown. To our knowledge, the only related research has reported higher blood lactate concentrations in match-play when players performed man-marking compared to zonal marking (Gerisch et al., 1988).

Therefore, the aim of this study was to examine the effect of manipulating defensive rules (with and without man-marking, [MM and NMM]) in 3 vs. 3 SSGs using both session-RPE and HR. It was hypothesized that MM during SSGs induce higher exercise intensity and lower variance compared with NMM. It is hoped that this study will help coaches to determine the intensity levels when adopting specific defensive rules in SSG.

Methods

Study design

To test the hypothesis, two specific defensive rules were investigated: MM and NMM. We compared the corresponding session-RPE and HR reserve of players in these game formats both in the presence and absence of goal formats. The variability of these four different forms of SSGs was also measured across multiple sessions. In this repeated measures study, each participant attended eight 3 vs. 3 SSG sessions within 6 weeks. Specifically, each participant attended each of the 4 SSG formats twice, and each session consisted of 3 x 4 min interval of SSG play interspersed with 4 min of passive recovery. Inter-session and inter-interval reliabilities were calculated from these data. During MM, each defensive player was required to mark an assigned player when their team did not possess the ball. On the other hand, when there was NMM regulation, defensive players were free to perform any form of defense. The total playing area was 18 m x 25 m for all SSGs performed on an outdoor artificial turf. Two 3-meter-wide goals were placed on the two wider sides of the area in 'with goal' games. Data on HR of each player was recorded during the small-sided games, whereas the session-RPE was collected 10 minutes after each small-sided game.

Participants

Twelve adolescents (age: 16.2 ± 0.7 years; body mass: 55.7 ± 6.4 kg; body height: 1.70 ± 0.07 m; maximal HR: 205 ± 6 bpm; and resting HR: 66 ± 4 bpm) from a secondary school soccer team participated in the study. All players were physically active, taking part in an average of two hours of soccer training twice a week in school. All participants were notified of the research procedures, requirements, benefits and risks before giving informed consent. Letters of consent were collected, and parent approvals were given. Goalkeepers were excluded in this study as they do not participate in SSGs ball possession training. The study was conducted according to the Declaration of Helsinki, and the study was approved by the Human Research Ethics Committee of The Hong Kong Institute of Education.

Small-sided games

Two weeks before the data collection, participants were participated in 6 SSG sessions to familiarize them with the data collection procedure. During data collection, players were randomly assigned to one of two groups (Group A and B). The duration of each SSG session was 24 minutes, and performed as intervals consisting of 3 bouts of 4 minutes separated by 4 minutes of passive recovery between each bout (Figure 1). When group A players were being tested, group B players were asked to sit and passively rest on a bench outside the playing area and vice versa. All testing sessions were conducted at the same time of day to limit the potential effects of circadian variation on physiological variables (Drust et al., 2005). To encourage players to maintain a high work-rate, consistent coach verbal support was given throughout the SSGs (Rampinini et al., 2007). All games were preceded by a standardized warm-up for a period of 10 minutes. This included jogging at 9 $km \cdot h^{-1}$, dynamic stretching (including butt kick, high-knee, hip adduction and abduction, lateral step, truck rotation, ankling) and two 20 m sprints from a standing start.

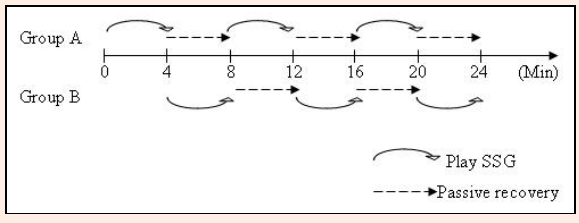

Figure 1. Experimental procedure.

Over the course of data collection, research assistants stood along the boundary line of the playing area to supply balls when the ball was kicked out of play.

Heart rate

Heart rate was measured by individual HR monitors (Polar, Finland) at 5 s intervals. HR data were expressed as $\%HR_{reserve}$. To obtain the maximal HR of each player, all participants completed the Yo-Yo intermittent recovery test-level 1 (Krustrup et al., 2003). The test consisted of 20-m shuttle runs performed with increasing speed in each level, with 5 s of active recovery between run until

Table 1. Effects of man-marking (MM) on exercise intensity. Data are means (±SD).

	Goal			No goal		
	MM	NMM	Effect Size	MM	NMM	Effect Size
%HRreserve	80.5 (5.8) *	75.7 (4.7)	.91/large	80.5 (4.1) *	76.1 (4.2)	1.06/large
Session-RPE	7.1 (.7) *	6.0 (.9)	1.36/large	7.4 (.8)	6.9 (.8)	.63/medium

* $p < 0.05$: Significantly higher compared to NMM. MM = man-marking; and NMM = no man-marking.

exhaustion. The test was terminated when the participants were unable to continue running at the required pace and did not attain the line on two occasions (Krustrup et al., 2003). The highest HR value consistently recorded three times during the Yo-Yo intermittent recovery test was considered their maximum HR (HR_{max}). Moreover, the resting HR (HR_{rest}) was collected for six times, four of which were collected when the participants woke up in the morning, and two were recorded 10 minutes after the briefing sessions before the SSGs. The $\%HR_{reserve}$ was calculated by the following Karvonen formula: $\%HR_{reserve}$ = (exercise mean HR – HR_{rest}) / (HR_{max} – HR_{rest}) x 100 (Karvonen et al., 1957).

Session-rating of perceived exertion (session-RPE)

All players were asked to state their mean session-rating of perceived exertion (session-RPE) 10 minutes after the 3 x 4 minutes SSGs to represent the whole game, i.e., all three bouts of games, using Borg's CR10 scale (Borg, 1998). The 10-point session-RPE was employed to determine the global internal load of the players in SSGs (Impellizzeri et al., 2004). Two weeks before the training, all participants were asked the same standardized question on their session-RPE to ensure they were familiar with this measure.

Statistical analysis

Data are expressed as mean ± standard deviation. MANOVA was used to examine the differences of the $\%HR_{reserve}$ and RPE between defensive (MM and NMM) and goal (presence and absence) rules. Intra-class correlation (ICC) coefficients were calculated to measure the inter-session and inter-interval reliabilities. The magnitude of the correlations was determined using the modified scale by Hopkins (2000): trivial: $r < 0.10$; low: 0.1-0.3; moderate: 0.3-0.5; high: 0.5-0.7; very high: 0.7-0.9; nearly perfect > 0.9; and perfect: >0.9-1.0 Effect size (Cohen's *d*) was calculated to determine the practical difference between MM and NMM. Effect size values of 0-0.19, 0.20-0.49, 0.50-0.79 and 0.80 and above were considered to represent trivial, small, medium and large differences, respectively (Cohen, 1988). The level of statistical significance was set at $p < 0.05$.

Results

MANOVA results showed significant difference between MM and NMM ($F = 5.37$, $p < 0.01$) in HR response and session-RPE, whereas there was no significant difference between the goal rules in HR and session-RPE ($p > 0.05$). No significant interaction effect was observed between defensive and goal rules ($p > 0.05$). In comparison to NMM, the implementation of MM in SSGs induced significant higher HR response with and without the goal ($p < 0.05$, large effect, Table 1). However, only MM with the presence of goal induced significant higher session-RPE compared with NMM ($p < 0.05$, large effect), whereas no significant difference in session-RPE was found between MM and NMM ($p > 0.05$, medium effect) when no goal was used.

The inter-session reliability of heart rate measure in small-sided games was moderate to very high, and that of session-RPE was high to very high (Table 2). In addition, the inter-interval reliability of HR measure was very high to perfect. As compared with NMM, SSGs performed with MM showed lower variation and higher reproducibility in terms of HR and session-RPE measures (Table 2). The same trend was found with and without the presence of goals with an exception for session-RPE during no goal SSGs in which MM showed higher variation compared to NMM.

Discussion

In this study, we found that man-marking defensive rule induced higher HR responses in youth players during SSG compared to NMM irrespective of the presence or absence of goals. Furthermore, less variation and higher reproducibility in MM were observed in comparison to NMM. This finding could be linked to the necessity for more motor skill behaviour performed both by the offensive and defensive sides (i.e., passing, dribbling actions) in MM thereby increasing exercise intensity in SSGs as previously reported in other time motion analysis studies (Casamichana and Castellano, 2010; Hill-Haas et al., 2010; Owen et al., 2011). Dellal et al. (2011d) also reported a higher exercise intensity ($\%HR_{reserve}$) when the

Table 2. Reliability and variance of heart rate (%HRreserve) and session-RPE measures.

		Goal		No goal	
		MM	NMM	MM	NMM
Inter-session	Heart rate - ICC	.84	.58	.79	.45
	Heart rate - CV (%)	3.26	4.62	4.05	4.47
	RPE – ICC	.65	.60	.77	.69
	RPE – CV (%)	9.17	10.92	6.31	5.38
Inter-interval	Heart rate - ICC	.96	.95	.92	.86
	Heart rate - CV (%)	1.94	1.99	2.00	3.16

CV = coefficient of variation; MM = man-marking; NMM = no man-marking; ICC = intra-class correlation.

number of ball touches authorized was reduced (one touch, 83.6 ± 3.3; two touches, 80.8 ± 4.1) in 4 vs. 4 SSGs. In the present study, although the number of ball touches was not measured, we subjectively observed that during MM games the defenders frequently closed down the opponents resulting in fewer ball touches. As a result, attackers probably performed quicker movements and more running to receive passes potentially leading to a higher physiological load and eventual greater exercise intensity. Also, the frequent changes between offensive and defensive phases in SSGs induce a higher game tempo and thus the intensity would be higher (Dellal et al., 2011a). In the present study, players might have encountered a greater number of changes in possession requiring additional efforts throughout a game such as repeated directional changes, accelerations and decelerations although technical elements of play were not measured here. This would lead to extra movement in SSGs and thus the physical load of adopting marking would be increased in players in both teams in MM. Furthermore, the results were comparable with those reported by Aroso et al. (2004) regarding MM and small goals (~80.5%$HR_{reserve}$ vs. 81%$HR_{reserve}$). Thus, a higher exercise intensity observed in SSG may be caused by a defensive rule change.

Sampaio et al. (2007) reported no significant differences in heart rate responses but higher session-RPE values (16.5 ± 0.5 vs. 14.4 ± 0.5, Borg 6-20 scales) in 3 vs. 3 SSG when comparing MM with regular SSGs. In comparison to the present results, the difference may be caused by the variation in the total duration (2 bouts x 1.5 min vs. 3 bouts x 4 min) and substantial difference in rest time (1.5 min vs. 4 min). Also, MM with the absence of goals significantly increased HR responses in comparison to NMM SSG with the absence of goals but no significant difference was observed in session-RPE. Furthermore, previous studies have confirmed that distractions during exercise can lower RPE even when the intensity (e.g. heart rate, and percentage of peak oxygen consumption) was the same (Nethery, 2002; Potteiger et al., 2000). Here, a higher session-RPE was reported in SSGs with NMM and no goal and the reason may be due to the distractive effect of goals. When the visual distractor (goal) was used in SSGs, the attention of players may have been distracted during the games and their perceptual feeling would be alleviated. This might explain the higher session-RPE observed in no goal SSGs even though intensity was similar to when goals were included (76.1% vs. 75.7%). Hill-Haas et al. (2010) reported no significant changes in RPE between SSGs using 4 different rule modifications in 3 vs. 4 and 3 vs. 3 + floater games. The authors concluded that in SSGs there are changes in physiological and time-motion responses but not in perceptual responses (i.e., RPE) when rule changes are employed. This situation can be explained by the increased intensity caused by MM but marking the assigned opposition player may distract players, therefore the session-RPE was lower compared with NMM.

Our results revealed higher ICC and lower CV in MM compared to in NMM except during MM with the absence of goals. Hill-Haas et al. (2011) analysed exercise intensity (%HR_{max}) in various soccer training activities. Compared to tactical training, SSGs and other generic interval training modalities have a lower standard deviation and higher mean values in terms of %HR_{max}. SSGs have been associated with higher variability in intensity as compared to interval running training (Dellal et al., 2008). However, it is postulated that the inclusion of MM increased the overall movements in all players and made the SSGs intensity less variable. Little et al. (2007) measured intensity in different soccer training drills (from 2 vs. 2 to 8 vs. 8) and results showed that when the number of players decreased, a higher %HR_{max} was attained, although 2 vs. 2 SSG induced significantly lower responses than 3 vs. 3 and 4 vs. 4. However, lower variability was reported in drills with fewer players. Also, similar results in HR responses with the presence and absence of goals implied that the former might not induce higher exercise intensity in SSGs. On the other hand, previous research has stated that the inclusion of goals would impose greater loads on soccer players as it increases motivation with the aim of scoring and preventing goals (Dellal et al., 2008; Spalding et al., 2004; Stolen et al., 2005). The reason might be that players stay in a set defensive format and pay attention to defending their goal. In MM however, all the players were forced to mark an assigned player and this prevented them from staying in a set defensive format. This may partly explain why the presence of goals did not result in a higher intensity in 3 vs. 3 game design with MM in this study.

Limitation

In this study, only HR and RPE were used during the data collecting process. This simplified the experiment but restricted the quantity of information collected to study the effects of MM and NMM in SSGs. For example, time motion measures from Global Positioning Systems could be included in a future study to provide additional performance-related data. Moreover, participants were secondary school students, not elite junior nor senior professional soccer players and the SSG format examined was 3 vs. 3 perhaps limiting the applicability of the present study findings to other populations.

Conclusion

This study has demonstrated that exercise intensity in soccer small-sided games can be influenced by changing the defensive rules. In this regard, man-marking significant increased HR during SSGs. Approximately, there was ~4.5% increase in heart rate response by using the man-marking in 3 vs. 3 SSG. Therefore, MM could be an effective defensive rule to increase intensity level in SSGs. Also, it has been clearly demonstrated that goal rule (inclusion or not) did not have any significant effects on exercise intensity during 3 vs. 3 SSGs. The present study will aid coaches in determining and manipulating the exercise intensity during SSG.

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Key points

- Intensity level of exercise during games can be raised if man-marking rule is adopted.
- No significant differences in perceived exertion were found in no goal SSG with and without man-marking.
- Adding goals in 3 vs. 3 SSG can lower perceived exertion without leading to large variations in intensity level.

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