

Physiological and affective responses of 30s–30s intermittent small-sided game in elite handball players: A new alternative to intermittent running

GILLES RAVIER^{1,2} ✉, CLAIRE HASSENFRAZ¹, ROMAIN BOUZIGON¹, ALAIN GROSLAMBERT^{1,2}

¹Unit of Formation and Research in Sports, Laboratory C3S (EA 4660), Department of Sport and Performance, University of Franche-Comte, Besançon, France

²Exercise Performance Health Innovation platform, University of Franche Comté, Besançon, France

ABSTRACT

Objectives: To compare physiological and affective demands of a novel small-sided game designed in intermittent (30s–30s) regimen opposing 3-a-side field players with 30s–30s shuttle running and handball match play. **Methods:** Fourteen elite male handball players (age 23.8 ± 4.4 y; body mass 84.0 ± 7.4 kg; height 188 ± 0.06 m) performed 2 periods of 10-min of each experimental exercise in separate occasions. Physiological demand was assessed using mean heart rate, time spent in heart rate intensity zones and post-exercise blood lactate concentration. The difference between ‘perceived exertion’ and ‘pleasure’ determined the affective balance. **Results:** Small-sided game and shuttle running drills showed similar mean heart rate (88.8 ± 2.4 and 90.4 ± 2.8 % of peak heart rate, respectively) and time spent in heart rate zones. The match play elicited lower mean heart rate (86.9 ± 3.4 % of peak heart rate, $P \leq 0.05$, large ES) than small-sided game and shuttle running. Peak lactate for small-sided game (6.6 ± 2.6 mmol/L) was lower than shuttle running (10 ± 2.2 mmol/L, $P \leq 0.05$, large ES) whereas no significant difference was observed with match play. The small-sided game showed lower affective balance than shuttle running ($P \leq 0.01$, large ES). **Conclusions:** Coaches can be confident in prescribing the small-sided game as a suitable alternative to shuttle running to provide consistent aerobic stimulus with lower affective balance. The small-sided game may be considered as a specific training method in achieving relevant physiological adaptations for handball match play. **Keywords:** Handball; Ball-drill; Intermittent high-intensity exercise; Enjoyment; Fitness training.

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✉ **Corresponding author.** Laboratory C3S - Department of Sport and Performance, University of Franche-Comté, 31 chemin de l'Épitaphe, 25000 Besançon, France. <https://orcid.org/0000-0001-5169-5808>

E-mail: gilles.ravier@univ-fcomte.fr

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INTRODUCTION

Modern handball has been defined as an intermittent team sport with locomotion activities and technical skills of short duration and high intensity interspersed by walking and standing still (Chelly et al., 2011; Michalsik, Aagaard, & Madsen, 2013; Póvoas et al., 2012). Analysis of the physiological demands during handball match play revealed high contribution of both aerobic and anaerobic metabolisms (Chelly et al., 2011; Póvoas et al., 2012; Michalsik, Madsen, & Aagaard, 2015). The average game heart rate (HR) was reported to be 82% of players' maximal HR (Chelly et al., 2011; Póvoas et al., 2012), and post-match blood lactate reached concentrations ranging between 4.8 and 8.3 mmol/L (Chelly et al., 2011; Michalsik et al., 2015). High-intensity interval running are traditionally prescribed to improve handball match-specific fitness because intensity can be individualised and controlled using the maximal running velocity determined from maximal aerobic field test (Buchheit et al., 2009; Dello Iacono, Eliakim, & Meckel, 2015). As an alternative to traditional interval running, small-sided game (SSG) is widely used in team sports to improve match-specific aerobic and anaerobic fitness while involving technical skills and increasing players' involvement and motivation (Buchheit et al., 2009; Dello Iacono et al., 2015; Delextrat & Martinez, 2014; Dellal et al., 2008; Hill-Haas, Coutts, Rowsell, & Dawson, 2009; Impellizzeri et al., 2006; Los Arcos et al., 2015). Concerning the conditioning effectiveness with highly-trained team players, it has been shown that intermittent running and SSG should elicit intensity higher than 90% of maximal HR during a total duration of at least 10 min per training session to provide an appropriate stimulus for large changes in aerobic fitness and match play performance (Impellizzeri et al., 2006; Bogdanis, Ziagos, Anastasiadis, & Maridaki, 2007). Having respected the target intensity, both SSG and high intensity intermittent runs appeared to be equally effective at improving the physiological capacities of team sport players (Dellal, Varliette, Owen, Chirico, & Pialoux, 2012). This previous result was confirmed in team handball by the few studies having analysed the SSGs formats for long-term physiological adaptations (Buchheit et al., 2009; Dello Iacono et al., 2015).

Handball game-based training drill does not allow controlling exercise characteristics such as intensity, time duration and recovery comparable with traditional interval runs. Due to tactical and technical requested during the course of the game, time characteristics of high-intensity actions cannot be planned during SSGs. While physiological response might be modified by manipulating the exercise characteristics (technical restrictions and / or rule modifications, field dimension, and number of players) (Castagna, Impellizzeri, Chaouachi, Ben Abdelkrim, & Manzi, 2011; Conte, Favero, Niederhausen, Capranica, & Tessitore, 2016; Dello Iacono et al., 2018), the only possibility to control exercise-to-rest ratio seems to design an intermittent regimen. However, intermittent format of SSG comprising short bouts of exercise similar to those prescribed with high intensity intermittent running has never been studied in handball. The duration of the bouts is a key aspect of designing a training regimen. Previous studies on team handball players have reported that traditional conditioning drills are mostly short intermittent runs (ranging from 15 s to 1 min with an exercise-to-rest ratio of 1:1) while the most frequently investigated regimen in handball game-based drills consists of 2–5 bouts lasting at least 2 min (Buchheit et al., 2009; Dello Iacono et al., 2015; Dello Iacono et al., 2018). Traditional SSGs do not use durations shorter than prescribed for high intensity intermittent running. Because of the nature of the handball game, coaches fear that motion latency at the onset of each playing bout should minimise physiological demands.

For this reason, the present study aimed to compare the physiological demands and affective balance of a novel SSG opposing 3-a-side field players (3v3) performed with intermittent regimen (30s–30s) with an intermittent shuttle running with similar time characteristics (ISR) and a handball match play (6v6). Our hypotheses were that the 3v3 based on short bouts of match play provides i) aerobic demands comparable

to traditional interval running with lower affective balance ii) and anaerobic stimulus more suitable than the ISR to handball match play demands (6v6).

MATERIAL AND METHODS

Participants

Fourteen male handball players (means \pm SD: age 23.8 ± 4.4 y, range 19–34 y; body mass 84.0 ± 7.4 kg; height 1.88 ± 0.06 m) consisting of 2 goalkeepers, 2 pivots, 6 backcourt and 4 wing players from the same team involved in the professional French National Handball League, volunteered to participate in this study. All players received the same training volume, and they were trained by the same physical conditioner. Their training background was 12.4 ± 4.2 y in handball. Each participant was medically screened and had no medical or orthopaedic problems. The testing period was conducted during the second half of the competitive season. During the five months preceding the beginning of the study, each participant had trained, on average, seven times a week, including two conditioning training sessions, and they had competed on weekends. All participants were informed of the research procedures, requirements, benefits and risks of the investigation as well as the right to terminate participation at will. Each participant provided voluntary written consent to participate in the experiment. All procedures of this study were in accordance with ethical standards of the institutional Research Committee of local University and the Declaration of Helsinki.

Measures

Capillary blood samples were drawn at rest, 2 min and 4 minutes after the end of each experimental exercise. An ear lobe blood sample of 3 μ l was collected on a test strip, and blood lactate concentration ([La]) was determined (Lactate Pro2, Arkray, Inc., Tokyo, Japan). The peak [La] ([La]_{peak}) of each experimental session was defined as the highest [La] obtained during the recovery period.

The field players' HR was continuously recorded at 2 s intervals using a HR chest memory belt (Suunto, Vantaa, Finland) throughout the experimental exercises. The highest HR recorded during the Intermittent Fitness Test (IFT) (Buchheit, 2008) was defined as the maximal HR (HR_{peak}). During the experimental exercises, the HR time course was analysed from the beginning to the end of each of two 10-min exercise periods, while the 2 min recovery inter-period was excluded. Mean HR (HR_{mean}, absolute and relatively to HR_{peak}) and time spent in the HR zone (expressed as % of the total time) for three intensity zones (<80%, 80–90%, and 90–100% of HR_{peak}) were determined individually for ISR, 3v3 and 6v6. Measures of reliability for the three experimental exercises were previously provided (Ravier, Hassenfratz, & Bouzigon, 2017). Based on test-retest analyses, the 3v3, ISR, and 6v6 demonstrated a high level of reproducibility for HR_{mean} (correlation coefficient = 0.9, typical error of measurement = 2.2-2.6 bpm and coefficient of variation = 1.2-1.5%).

The field players were required to provide their RPE within 30 min after the end of each experimental drill. RPE was measured using Borg's category-ratio scale (Borg, Ljunggren, & Ceci, 1985), which consists of 11 statements ranging from 0 to 10 (from "nothing" to "maximum"). Recently, Baron, Guilloux, Begue, & Uriac, (2015) proposed quantifying the level of motivation during fatiguing exercise by determining pleasure and affective balance. These psychological factors provides important information about the level of physical and psychological engagement of players during exercise. The category-ratio scale was used to quantify the pleasure perceived during the exercise, as previously proposed and the affective balance was calculated as the difference between RPE and pleasure.

Design and procedures

This study is the first to try to compare intermittent SSG regimen comprising short bouts of match play with an equivalent interval-running in terms of their capability to provide aerobic and anaerobic stimulus suitable to handball match play demands. The study used an observational within-subject repeated-measures design to compare the physiological and perceptual demands of three conditioning exercises. Participants took part in 4 testing sessions involving a maximal field test as well as 3 sessions of training drills (3v3, ISR, 6v6). The experimental sessions were undertaken on separate occasions 7 days apart at the same time of the day ($16:00 \pm 1$ hour), and they were implemented during the team's regular weekly training schedule (Table 1). All participants were accustomed to experimental exercises insofar as they were performed as part of their normal season training. Each exercise session was performed on a regular indoor handball court (20x40-m), and consisted of two 10-min periods interspersed with 2 min of passive recovery during which the players were allowed hydration ad libitum. The players were verbally encouraged by the coach to maximally perform throughout the protocol. Before each experimental session, the players completed a standardised 20 min warm-up, after which a period of 5 min was provided so they could wear the HR device. The players recovered 30 min after the training intervention.

The participants took part in the IFT to assess their maximal aerobic performance and peak HR (Buchheit, 2008). The IFT is a maximal intermittent incremental shuttle-run test that consists of 30 s shuttle runs interspersed with 15 s periods of passive recovery. The participants ran over 40-m shuttles and they were instructed to complete as many stages as possible. The running velocity that was reached at the last fully completed stage was retained as the maximal velocity (V_{IFT}) for individualising the intensity prescription of the intermittent shuttle running exercise.

The ISR session consisted of 30 s of effort interspersed with 30 s of passive recovery. Running was completed over 40-m shuttles, which required three to four 180° directional changes within 30 s of runs (depending on the V_{IFT}). Exercise intensity was set at 95% of V_{IFT} .

Both ball drills were completed on a regular handball court, consisting of an intermittent SSG opposing 3-a-side field players plus goalkeepers (3v3), and a handball match play with 6-a-side field players plus goalkeepers (6v6). Each ball-drill session consisted of two match play periods of 10 min interspersed with 2 min of passive recovery. The referee was an official referee affiliated with the French Handball Federation. The official rules of the International Handball Federation were applied with the following exceptions: 1) a throw-in after a goal was immediately made by the goalkeeper from his 6-m area, 2) investigators were available to replace the ball when it was thrown out of the playing court and 3) any infringement of the rules of the game was sanctioned. However, 2 min exclusions were not used. When the referee awarded a penalty, it was performed at the end of the two 10-min periods of playing time and the fault was immediately sanctioned with a free-throw. These adaptations of the rules minimised interruption of the game. Ball dribble and tackles were avoided during the 3v3 to increase physiological demand. This ball drill was completed as interval training consisting of 30 s of match play interspersed with 30 s of passive recovery. Each team consisted of 6 field players; 3 played the match while 3 others stood off the handball court. The status was reversed every 30 s periods. Thus, immediately after the timekeeper's whistle was blown, the 3 engaged players left the court and the 3 waiting players entered the game. Before leaving, the ball carrier passed the ball to one of his teammates entering the court to continue the match. This player rotation minimised interruption of the game. The 6v6 case consisted of a continuous handball game.

Table 1. Setup of experimental sessions

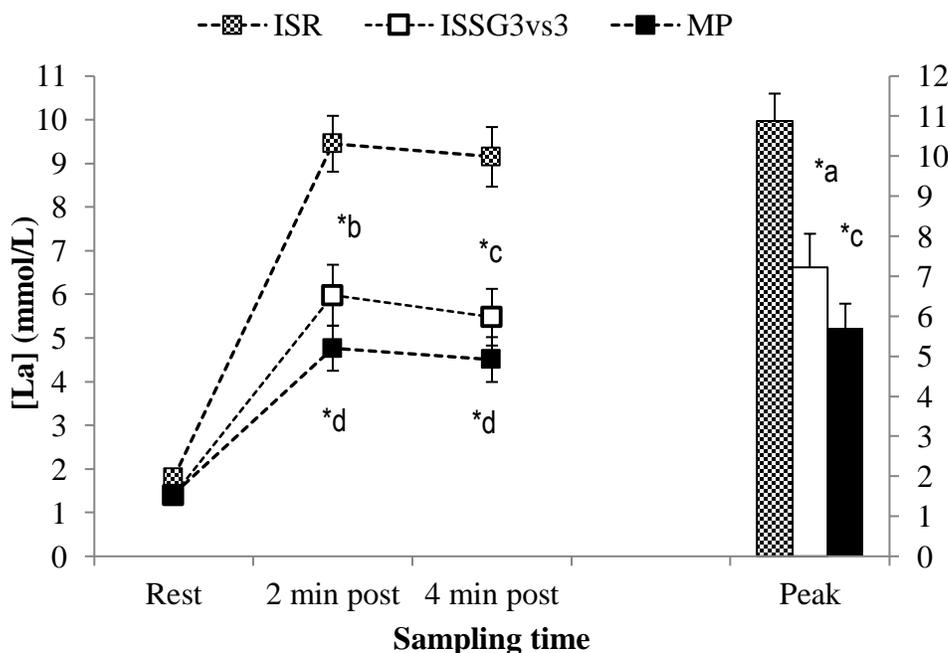
	Monday	Tuesday	Wednesday	Thursday	Friday
Week 1	Morning	Strength	Handball		
	Afternoon	Handball	Strength	Handball	Handball
Weeks 2/3/4	Morning	Strength	Handball		Intermittent Fitness Test
	Afternoon	Handball	*ISR/ 3v3 / 6v6	Handball	Handball

*ISR, 3v3 and 6v6 were performed during the 2nd, 3rd and 4th week, respectively

Statistical analysis

Data were reported as mean ± SD. The assumption of normality for data distribution was checked using the Shapiro-Wilk test, and the equality of variance between the exercise conditions was tested using the Bartlett test for experimental variables. Differences between experimental conditions for [La]_{peak}, HR_{mean}, time spent in the HR zones and perceptual variables, were assessed using analysis of variance for repeated measurements. A two-way analysis of variance for repeated measurements was used to determine the significant mean effects of the [La] changes over time (rest, 2, and 4 min post-exercise) and the interaction effects between the conditions (ISR, 3v3, and 6v6). Pairwise comparisons were tested using the post-hoc Tukey test. Cohen’s *d* effect size (ES) analysis was performed to determine the magnitude of the effects of the exercise on HR_{mean}, [La]_{peak} and perception responses. Effect sizes of <0.20 were classified as trivial, 0.20–0.49 were small, 0.50–0.79 were moderate, and >0.80 were large effects. A *P* ≤ 0.05 criterion was used to establish statistical significance.

RESULTS

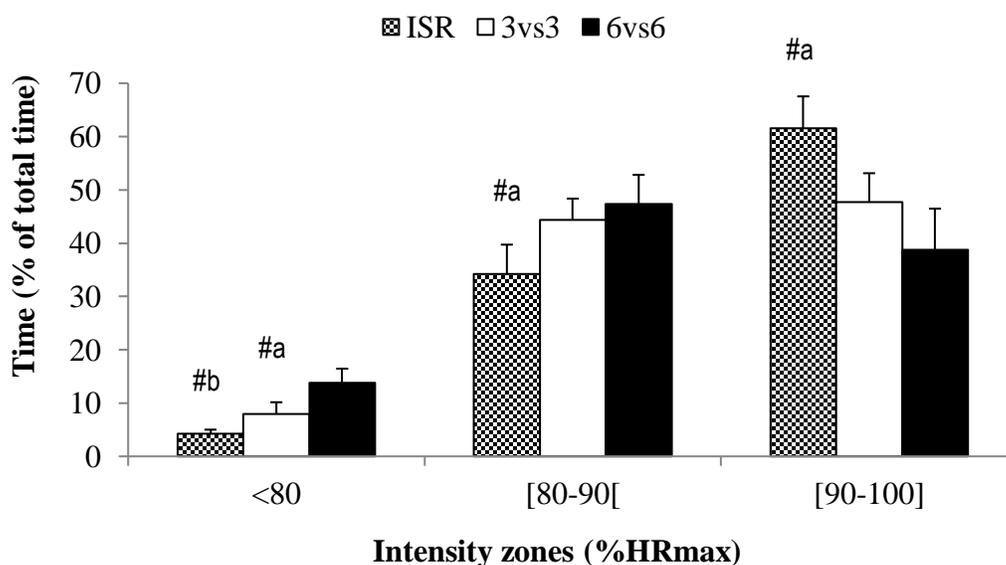


Mean (± Standard Error) value in intermittent small-sided game (3v3), intermittent shuttle running (ISR) and match play (6v6). * specify significant differences compared with ISR (a = *P* < 0.05; b = *P* < 0.01; c = *P* < 0.001; d = *P* < 0.0001).

Figure 1. Blood lactate concentration

Maximal aerobic performance: the V_{IFT} was 20 ± 0.95 km/h and the HR_{peak} was 197 ± 5.46 beats/min. The $[La]$ significantly changed over time ($P < 0.0001$) and they were affected by the experimental drill ($P < 0.001$). The interaction between the experimental drills and time was significant ($P < 0.0001$). The pairwise comparisons are presented in Figure 1. The inter-subject coefficient of variation (CV) for $[La]$ was 23.5%, 40.4% and 37.5% at 2 min; 25.9%, 41.1% and 39.5% at 4 min; 21.7%, 39.9% and 37.7% at peak value for ISR, 3vs3 and 6v6, respectively. The $[La]_{peak}$ showed inter-individual differences with values ranging between 5.9–12.2 mmol/L in ISR, 2.4–11.7 mmol/L in 3v3 and 2.5–8.5 mmol/L in 6v6.

HR_{mean} and time spent in the HR zones are presented in Table 2. The time spent in the HR zones significantly changed over time ($P < 0.0001$). The interaction between the experimental drills and the HR zones was significant ($P < 0.05$). The pairwise comparisons are presented in Figure 2. The inter-subject CV for time spent in HR zones was 64.9%, 96.7% and 65.2% for the $<80\%$ HR_{peak} zone, 55.6%, 31.5% and 39.9% for the 80–90% HR_{peak} zone and 33.6%, 39.0% and 68.6% for the 90–100% HR_{peak} zone for ISR, 3v3 and 6v6, respectively.



Mean (\pm Standard Error) value in intermittent small-sided game (3v3), intermittent shuttle running (ISR) and match play (6v6). # specify significant differences compared with 6v6 (a = $P < 0.05$; b = $P < 0.01$).

Figure 2. Time spent in heart rate intensity zones

The differences between the experimental conditions for perceptual variables (RPE, pleasure and affective balance) are presented in Table 2.

Table 2. Heart rate, lactate and perception responses

Variables	3v3	ISR	6v6	d (descriptor)		
				3v3 vs ISR	3v3 vs 6v6	ISR vs 6v6
HR _{mean} (beats/min)	174.89 ^{#a} ±5.58 (3)	178.03 ^{#a} ±7.32 (4)	171.08 ±6.28 (4)	0.48 (small)	0.64 (moderate)	1.02 (large)
HR _{mean} (% of HR _{peak})	88.80 ^{#a} ±2.36 (3)	90.37 ^{#a} ±2.81 (3)	86.88 ±3.41 (4)	0.60 (moderate)	0.65 (moderate)	1.12 (large)
[La] _{peak} (mmol/L)	6.63 ^{*a} ±2.65 (40)	9.98 ±2.16 (22)	5.23 ^{*c} ±1.95 (37)	1.39 (large)	0.60 (moderate)	2.31 (large)
RPE (AU)	4.50 ^{*b} ±1.17 (26)	7.58 ±0.90 (12)	3.79 ^{*c} ±1.41 (38)	2.95 (large)	0.55 (moderate)	3.20 (large)
Pleasure (AU)	6.08 ^{*b} ±2.19 (36)	2.13 ±2.23 (105)	6.42 ^{*c} ±1.62 (25)	1.79 (large)	0.18 (trivial)	2.20 (large)
Affective balance (AU)	-1.58 ^{*b} ±2.29 (145)	5.46 ±2.40 (44)	-2.63 ^{*c} ±1.90 (72)	3.00 (large)	0.50 (moderate)	3.74 (large)

Mean ± SD, (inter-subject coefficient of variation in %) and Cohen's d effect size (descriptor) values for mean heart rate (HR_{mean}), peak lactate ([La]_{peak}), rating of perceived exertion (RPE), pleasure and affective balance. Comparisons between the intermittent small-sided game (3v3), intermittent shuttle running (ISR) and the match play (6v6).

specify significant differences compared with 6v6 ($P \leq 0.05$); * specify significant differences compared with ISR ($a = P \leq 0.05$; $b = P \leq 0.01$; $c = P < 0.001$).

DISCUSSION

This study aimed to analyse physiological demands and affective balance of an intermittent SSG with time characteristics similar to that of traditional interval training and to compare with an equivalent intermittent-running, and match play in elite handball players. This is the first study that demonstrates that 3v3 elicited an HR response comparable to ISR, [La] similar to 6v6 and lower affective balance than ISR.

Firstly, the HR_{mean} response during 3v3 was similar to that of ISR (Table 2). The HR_{mean} response elicited by the 3v3 was comparable to previous results observed during 5 bouts of 3-min SSGs opposing 3-a-side field players plus goalkeepers (88.6–89.2% of HR_{peak}) with elite junior handball players (Dello Iacono et al., 2018). Moreover, the HR_{mean} observed in the present ISR was within the range previously reported (90–92% of HR_{peak}) in response to traditional high intensity intermittent running with basketball and elite handball players (Dello Iacono et al., 2015; Delestrat & Martinez, 2014). From a conditioning point of view, the present study's HR_{mean} results for both the 3v3 and the ISR were comparable to those previously recorded during intermittent runs and SSGs, which substantially improved aerobic fitness in response to an intervention period (Dello Iacono et al., 2015; Delestrat & Martinez, 2014). For SSG and interval running to be effective for large changes in aerobic fitness and match play performance, an exercise intensity close to or above 90% of HR_{peak} is required with highly-trained team players. The experimental results for HR_{mean} response showed that both 3v3 and ISR reached the expected target HR intensity. In addition, the inter-subject CVs were small in comparison to previous results for soccer SSGs (Dellal et al., 2008; Little & Williams, 2006). The present study's data suggests that both training drills enabled all players to receive similar aerobic training stimulus.

Moreover, analysis of the exercise HR distributions showed that the time spent in the HR intensity zones was similar for 3v3 and ISR (Figure 1). Previous studies analysing the effectiveness of interval running and game-based training programs in improving aerobic fitness focused on the amount of time spent above 90% of HR_{peak} throughout the training drill. Assessing the amount of time spent in HR zones during 25 min of soccer

SSG bouts, Impellizzeri et al. (2006) reported that a duration close to 9 min twice a week within the target intensity (90–100% of HR_{peak}) was effective in substantially enhancing aerobic fitness and soccer match performance. However, a lower time spent above 90% of HR_{peak} was shown to be insufficient to improve aerobic power in response to interval training or SSG program (Hill-Haas et al., 2009; Bogdanis et al., 2007). Basing on these data, both 3v3 and ISR showed a sufficient amount of time (Figure 2) spent above 90% of HR_{peak} . Consequently, it is reasonable to expect an aerobic fitness improvement in response to 3v3 and ISR training period. Although the 3v3 design implied frequent turnover of teammates and short bouts of playing the game, both of the two 10-min periods elicited a high HR_{mean} response and a relatively long time above 90% of HR_{peak} in professional players. Coaches can be confident in prescribing the 3v3 as a suitable alternative to ISR to provide consistent aerobic stimulus.

The HR response for 3v3 showed a higher HR_{mean} and a lower time spent in the <80% of HR_{peak} zone than 6v6. These results suggest that two 10-min periods of the 30s–30s SSG provided higher aerobic stimulus than the training match play of the same duration. Interestingly, the HR_{mean} recorded during the 6v6 case was higher than the values previously reported (82% of HR_{peak}) during an official match play (Chelly et al., 2011). The only research to report time spent in HR intensity zones during official adult competition in handball showed that elite players spent 7% of the total time in the 90–100% of HR_{peak} zone, 42% in the 80–90% of HR_{peak} zone and 51% in the <80% of HR_{peak} zone (Póvoas et al., 2012). The present study showed that the participants spent 5-fold more time at the maximum HR zone in the 6v6 case. This result is probably due to the fact that the playing rules were adapted to avoid game breaks and/or the duration of the game was shorter than official match play (2x30 min), allowing players to maintain high exercise intensity.

The blood lactate analysis showed similar $[La]$ and $[La]_{peak}$ for 3v3 and 6v6, but these values were lower than that of ISR (Figure 2). Results were expected for the 6v6 regarding the handball game characteristics which involves high-intensity short-duration activities and explosive technical skills (Chelly et al., 2011, Michalsik et al., 2013, Póvoas et al., 2012). It is reasonable to assume that phosphocreatine and adenosine triphosphate make an important contribution to the anaerobic energetic pathways. The ISR lactate values were close to those previously reported with similar 30–30s shuttle runs (Dellal et al., 2010). The present study's $[La]$ values for ISR reflect high physiological demand involving an important solicitation of anaerobic glycolytic pathways.

Interestingly, the 3v3 and the 6v6 showed similar $[La]$ values. This result was not expected because the decrease in the number of players is known to increase blood lactate concentrations in SSGs (Castagna et al., 2011; Conte et al., 2016). The lack of difference in $[La]$ between 3v3 and 6v6 might be related to the exercise regimen. Indeed, 3v3 included rest periods every 30 s whereas work/rest combination cannot be planned in 6v6 because they depend on the tactical and technical requests, which are modulated according to the course of game. Relatively low values of lactate accumulation in 3v3 was likely due to 30 s rest periods allowing a sufficient reloading of oxygen to partially remove part of the lactate produced, and to resynthesize the phosphocreatine. The present study's results for $[La]$ might suggest that 3v3 enables players to receive an anaerobic training stimulus similar to what they would experience in the 6v6.

The $[La]_{peak}$ values reached in 3v3 and 6v6 were lower than those reported after the first and second half of handball match play (8.3–9.7 mmol/L) with elite adolescent players (Chelly et al., 2011) and they were slightly higher than the values (3.7–4.8 mmol/L) reported for male Danish premier league players (Michalsik et al., 2015). Our results suggest that the anaerobic glycolytic pathways involved during both ball-drills potentially reflect those of an official match play with adults. Although blood lactate concentration is usually considered to be a reflection of anaerobic metabolism contribution during continuous exercise, the relationships during intermittent exercise should be considered with caution.

The perceptual variables were similar for 3v3 and 6v6, but the RPE and affective balance were lower and the pleasure was higher in both than they were in the ISR case. The result for RPE was in agreement with the findings reported in previous studies with soccer players (Hill-Haas et al., 2009; Los Arcos et al., 2015). Indeed, despite similar HR demand, traditional interval-training was perceived to be more strenuous than ball-drills. For the present results, one of the main explanations is the greater enjoyment resulting from manipulation of the ball in comparison to interval running. However, during match play, pleasure is influenced by many other factors, such as individual performance (scoring a goal, defensive and offensive action success) and, mainly, the match victory. During a training session, the achievement of fatigue is important: it is well known that physical fatigue provides a feeling of well-being due to the satisfaction 'getting a job done'. Thus, the strenuous of conditioning training is generally associated with duty accomplishment because of the expected benefits for individual competitive performance. Moreover, the exercise intensities during 3v3 and 6v6 are close to the intensities previously reported to provide more pleasure (Ekkekakis, Parfitt, & Petruzzello, 2011).

CONCLUSIONS

This is the first study that demonstrates similar HR demands during intermittent SSG and ISR with similar time characteristics. Moreover, the 3v3 was found to accumulate lower [La] than ISR, and similar concentrations to those observed for the 6v6. In addition, the present results confirm that in comparison to the running drill, the 3v3 showed lower RPE and higher pleasure, resulting in lower affective balance. Coaches can be confident in prescribing the 3v3 to provide consistent aerobic stimulus with low participation of anaerobic glycolysis and low affective balance.

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DISCLOSURE OF INTEREST STATEMENT

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