Rev Bras Cineantropom Hum

original article

DOI: http://dx.doi.org/10.5007/1980-0037.2017v19n5p515

Reproducibility of heart rate and perceptual demands of game-based training drills in handball players

Reprodutibilidade da frequência cardíaca e percepção de demandas do treinamento baseado em jogos em atletas de handebol

Gilles Ravier[1]
Claire Hassenfratz[1]
Romain Bouzigon[1]

Abstract – Game-based training are popular in team-sports; however there is a lack of research specific to team handball. The aim of this study was to assess i) the test-retest reliability of heart rate (HR), time spent in HR zone intensities and rating of perceived exertion of a novel small-sided game, ii) and whether it is comparable to that of generic intermittent shuttle running and match play with team handball players. Fourteen elite male handball players completed each exercise comprising two periods of 10min interspersed with 2min recovery in separate occasions and repeated them one week apart. Exercises consisted of intermittent 30s-30s shuttle running (ISR), intermittent 30s-30s small-sided game (with 3-a-side field players, 3vs3) and match play (with 6-a-side field players, 6vs6). Mean HR demonstrated high level of reproducibility for the three drills (r = 0.86-0.89, TEM = 2.21-2.63 bpm, CV = 1.23-1.55%). For time spent in heart rate zones TEMs reached up 1.12, 1.40 and 2.48 min for ISR, 6vs6 and 3vs3, respectively. Specifically for HR zone higher than 90% of HRmax, CVs showed wide extent of scores with 9.73 (ISR), 27.39 (6vs6) and 108.29% (3vs3). Mean HR results suggest that physiological response was consistent between sessions. Because of the poor reproducibility for time spent in the target zone higher than 90% of HRmax, the efficiency of both 3vs3 and 6vs6 in improving aerobic power should be analysed with caution. The present results suggest that reproducibility of physiological demand of ball-drills should be considered before prescribing them as conditioning training.

Key words: Heart rate; Intensity; Perception; Reliability.

Resumo – *O treino através do jogo é popular quando se trata de esportes coletivos. Contudo, constata-se uma falta de estudos específicos sobre a prática do handball. Objetivou-se testar a reprodutibilidade de um jogo com equipe reduzida através da análise da frequência cardíaca (HR), do tempo decorrido nas diversas faixas de intensidade de HR e da percepção do esforço. A reprodutibilidade do jogo com equipe reduzida foi comparada àquelas de um exercício padrão de corrida e de um jogo de handball. Quatorze jogadores de handball masculino nível elite realizaram um mesmo exercício em duas ocasiões com uma semana de intervalo entre elas. Cada exercício foi realizado em dois períodos de 10 minutos com dois minutos de intervalo entre cada um. Os diferentes exercícios consistiram numa corrida intermitente de 30s-30s, realizadas em ida e volta (ISR); um jogo com equipe reduzida intermitente de 30s-30s (com três jogadores em cada equipe, 3vs3); e um jogo de handball (com 6 jogadores em cada equipe, 6vs6). A HR média demonstrou um nível avançado de reprodutibilidade dos três exercícios (r = 0,86-0,89; TEM = 2,21-2,63 bpm; CV = 1,23-1,55%). No que se refere ao tempo decorrido nas diferentes faixas de frequência cardíaca, os TEM (erros típicos de medição) foram 1,12, 1,40 e 2,48 minutos respectivamente para ISR 6vs6 e 3vs3. Especificamente para a faixa de HR superior a 90% da frequência cardíaca máxima, os coeficientes de variação mostraram uma larga amplitude de valores, com 9,73 (ISR), 27,39 (6vs6) e 108,29% (3vs3). Os resultados da média da frequência cardíaca sugerem que a resposta fisiológica global é coerente nas duas sessões do mesmo exercício. A reprodutibilidade reduzida no tempo decorrido na faixa superior a 90% da HRmax indica necessidade de cautela quando se trata do 3vs3 e 6vs6 para melhoria do potencial aeróbico. Os resultados do estudo sugerem que a reprodutibilidade da demanda fisiológica dos exercícios com bola deve ser considerada antes de sua utilização como treinamento físico.*

Palavras-chave: *Frequência cardíaca; Intensidade; Percepção; Validade.*

1 Unit of formation and research in Sports. Laboratory Culture Sport Health Society. Department of Sport and Health. University of Franche-Comté. Besançon, France.

Received: 13 June 2017
Accepted: 09 October 2017

INTRODUCTION

Handball is characterized as an intermittent team-sport with high intensity technical skills and short sprints interspersed by low intensity activities including walking and standing still which represent approximately 70-80% of the total playing time[1,2]. Studies analysing the physiological demands of handball match play from heart rate (HR) response reported average values of 82% of the individual maximal HR (HR_{max}) in elite adult[2] and adolescent[1] players.

Regarding the intermittent nature of handball game, conditioning training comprised commonly traditional interval-training exercises targeting the ability to perform high-intensity actions and to rapidly recover during the less intense periods. As an alternative, small-sided games (SSG) are widely prescribed in team-sports to improve both match-specific aerobic and anaerobic fitness while involving technical and tactical skills of team players[3-8]. Most of studies comparing the effect of ball drills with generic high intensity intermittent runs showed that both training methods appeared equally effective at improving physiological capacities in team-sport players[3,4,6,7,9,10].

Because of the success of game-based training methods in team-sports, several researchers[11-14] have focused on physiological and physical activities of specific ball-drills. Thus, physiological demand of SSGs can be altered by manipulating the exercise regime, duration of playing time, field dimension, coach encouragement, technical restrictions and/or rule modifications, goalkeeper presence, and number of players involved. For instance, number of players affects intensity of basketball SSGs[11] with greater mean HR in 2*vs*2 than 3*vs*3 and 5*vs*5 (92.0%, 88.0% and 84.0% of HR_{max}, respectively).

Concerning the conditioning training effectiveness, an exercise intensity higher than 90% of HRmax is recommended throughout the training period to improve physical fitness and match play performance[7,9] with team-sport players. Game-based drills may provide an aerobic stimulus comparable with intermittent runs. However, they does not allow planning and control of exercise characteristics such as motion activities, time duration of exercise and recovery, and intensity involved, comparable with traditional interval runs. Because these features depending on the tactical and technical requests which are modulated according to the course of game, the between-session reproducibility of the physiological responses and physical performance has been analysed in previous studies with soccer[5,13,15,16] and cricket games[17]. For instance, comparing soccer ball-drills performed in continuous and intermittent regimes, Hill-Haas et al.[5] showed higher between-session typical error of measurement scores for mean HR in continuous than in intermittent regimen. It has been shown that intensity is another factor affecting test-retest variability of physiological response in soccer SSGs[13]. Indeed, reproducibility of HR was positively related to the exercise intensity.

When coaches prescribe game-based drill as conditioning exercise, they expect that each training session elicit a similar physiological demand throughout the training period. However, there is a lack of research related

to the test-retest intra-exercise comparison specific to team handball. In this context, the present study aimed to assess whether the between-session reliability of HR, time spent in HR zone intensities and rating of perceived exertion of an intermittent (30s-30s) game-based drill with 3-a-side field players is comparable to that of traditional intermittent running (30s-30s). In addition, the assessment of reproducibility of handball match play (6vs6) was important to consider reproducibility of game demands.

METHODOLOGICAL PROCEDURES

Participants

Fourteen male handball players (means ± SD: age 23.9 ± 4.3 years, range 19-34 years; body mass 85.1 ± 7.9 kg; height 188.8 ± 5.9 cm) 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. Their training background was 12.5 ± 4.1 years in handball. Each participant was medically screened and had no medical or orthopaedic problem. The testing period was carried out between the first and the second half of the competitive season. During the four months preceding the beginning of the study, each participant had trained, on average, seven times a week. The protocol and procedures were conducted according to the recommendations of the Declaration of Helsinki. All participants were informed of the research procedures, requirements, and risks of the investigation as well as the right to terminate participation at will. Each subject gave a voluntary written consent to participate in this experiment, which was approved by the institutional research ethics committee and handball club review board.

Experimental design

This study employed a within subjects repeated measures experimental design to analyse test-retest reliability of physiological and perceptual demands of three specific conditioning exercises: intermittent shuttle running (ISR), intermittent SSG opposing 3*vs*3 field players (3vs3), and handball match play opposing 6*vs*6 field players (6vs6). Each session of exercise comprised 2 periods of 10min interspersed with 2min of passive recovery during which players were allowed hydration ad libitum. Players were verbally encouraged by the coach to maximally perform during the overall protocol. All testing sessions were performed at the same time of day (5 to 7 PM) on regular indoor handball court (20x40m). Before each experimental session, players completed a standardized 20 min warm-up, after which a period of 5 min was planned to worn the heart rate device.

Participants were first tested with the Intermittent Fitness Test (IFT)[18]. The IFT is a maximal intermittent incremental shuttle-run test that consists of 30s shuttle runs interspersed with 15s periods of passive recovery. The initial running velocity was set at 8km.h^{-1} and increased by 0.5km.h^{-1} for every subsequent stage. The running velocity reached at the last fully

completed stage was retained as the maximal velocity (V_{IFT}). The peak heart rate recorded was considered as player's .

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

During the two handball games the referee was an official referee of the French Handball Federation. The official rules were applied with the exceptions of 1) throw-in after a goal was immediately made by goalkeeper from his 6m area 2) investigators were available to replace the ball when it was thrown out of the playing court 3) any infringement of the rules of the game were sanctioned. However, the 2min exclusions were not present. When the referee awarded a penalty, it was performed at the end of the two 10min periods of the playing time and the fault was immediately sanctioned with free-throw.

The 3vs3 was completed as interval-training consisting of 30s of match play interspersed with 30s of passive recovery. The 3vs3 comprised goalkeepers and three-a-side field players. Each team comprised six field players with 3 of them playing the match while 3 others standing out of the handball court. The status was reversed every 30s periods. So immediately after the whistle of the timekeeper players leave the court to be substituted simultaneously. Before leaving, the ball carrier makes pass to one of his teammate getting into the court. The rotary organization allowed minimizing interruption of the game. Concerning technical task constraint, ball dribble was avoided during match play.

The 6vs6 consisted in continuous handball game opposing six-a-side field players plus goalkeepers.

All participants were accustomed to the experimental exercises insofar they performed as part of their in-season training regime. During the experimental period, the study-related sessions were implemented in the team's regular weekly training schedule (Box 1).

Box 1. Experimental setup of training sessions.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Week 1 *Morning*	HB	HB				
Afternoon	HB	HB	HB	HB	IFT	
Week 2 *Morning*					HB	HB
Afternoon	HB	ISR	6vs6	3vs3	HB	
Week 3 *Morning*					HB	HB
Afternoon	HB	ISR	6vs6	3vs3	HB	

HB: technical and tactical handball training.

Measures

The field players' HR was continuously recorded at 2s intervals using HR chest memory belt (Suunto, Vantaa, Finland) throughout experimental exercises. The HR time course was analysed from the beginning to the end of each 2 periods of 10min exercise while 2min inter-period recovery was excluded. Mean HR (absolute and relatively to HRmax) and time spent in HR zone (Tzone) for three intensity zones[12,19] (<80%, [80-90[%, and ≥90% of HRmax) were determined for ISR, 3vs3 and 6vs6. Between 5 to 10min following the conclusion of each exercise, field players were required to provide a rating of perceived exertion (RPE) of the overall difficulty of the exercise using Borg's category-ratio scale (CR10)[21], which consists of 11 statements ranging from 0 to 10 (from "nothing" to "maximum"). Players were requested to make certain that their RPE score referred to the intensity of the whole session rather than the most recent sequence intensity to avoid the instant perception of the last effort.

Statistical analysis

The normality of the data distribution was checked with the Shapiro-Wilk test. Test-retest reproducibility of HRmax, Time spent in HR zones and CR10 was assessed using the change in mean between measurements, the typical error of measurement and retest correlation of Pearson as described by Hopkins[21] and Hopkins et al.[22]. To assess the magnitude of the correlation coefficient, the threshold values were 0.1, 0.3, 0.5, 0.7, and 0.9 for low, moderate, high, very high and nearly perfect, respectively[22]. The change in mean was tested with paired Student's t-test. The typical error of measurement (TEM) for each variable was calculated with raw values as the SD of the within subject absolute change measure between test and retest divided by √2. The coefficient of variation (CV) was determined from the typical error of the log-transformed data (TEMln) and thereafter calculated as specified in the following equation: CV(%) = 100.[exp(TEMln) -1] where exp is the natural exponential function. The $P \leq 0.05$ criterion was used for establishing statistical significance.

RESULTS

Values are mean ±SD. Test-retest differences are presented in Table 1.

The between-session reliability and the variability for ISR, 3vs3 and 6vs6 are shown in tables 2, 3, and 4, respectively. The magnitude of the correlation coefficient between sessions for HR and Tzones ranged between high to nearly perfect for ISR, high to very high for 3vs3 and high to nearly perfect for 6vs6. Concerning mean HR during ISR, 3vs3 and 6vs6, low CVs were shown with 1.23, 1.55 and 1.48%, respectively, whereas high values were observed for Tzones in all experimental exercises. The main result was CVs for the Tzone≥ 90% of HRmax reaching 9.73, 27.39, and 108.29% for ISR, 6vs6, and 3vs3, respectively.

Table 1. Heart rate (HR, bpm), percentage of maximal HR (%HRmax), time spent in heart rate zones (Tzone, min) and category-ratio scale (CR10, AU). * P ≤ 0.05

Variables		Test	Retest
ISR	HR	176.2±6.6	174.7±5.7
	%HRmax	89.6±2.9	88.8±2.1
	Tzone≥90%	11.3±4.4	9.9±3.6*
	Tzone[80-90[%	7.6±3.8	8.8±3.2*
	Tzone<80%	1.1±0.9	1.3±0.7
	CR10	7.5±1.3	7.5±0.9
3vs3	HR	171.4±6.8	170.5±6.3
	%HRmax	87.2±3.4	86.7±3.1
	Tzone≥90%	7.5±5.3	6.8±4.1
	Tzone[80-90[%	10.6±4.1	10.9±3.0
	Tzone<80%	1.9±2.3	2.2±2.2
	CR10	4.6±1.3	5.0±1.8
6vs6	HR	171.1±6.2	171.3±6.6
	%HRmax	86.5±3.7	86.6±3.6
	Tzone≥90%	7.0±5.8	6.6±5.5
	Tzone[80-90[%	9.8±4.2	10.5±3.9
	Tzone<80%	3.2±2.0	2.9±1.9
	CR10	3.7±1.2	5.1±1.3*

Table 2. The ISR test-retest reliability for heart rate (HR, bpm), percentage of maximal HR (%HRmax), time spent in heart rate zones (Tzone, min) and category-ratio scale (CR10, AU).

Variables	r (CI 95%)	TEM (CI 95%)	CV (CI 95%)
HR	0.89* (0.65-0.97)	2.21 (1.57-3.76)	1.23 (0.87-2.11)
%HRmax	0.87* (0.58-0.96)	1.12 (0.79-1.90)	1.23 (0.87-2.11)
Tzone≥90%	0.94* (0.81-0.98)	1.12 (0.79-1.89)	9.73 (6.80-17.07)
Tzone[80-90[%	0.94* (0.78-0.98)	1.01 (0.72-1.72)	24.44 (16.75-44.95)
Tzone<80%	0.60* (0.04-0.87)	0.54 (0.38-0.91)	59.29 (39.07-120.43)
CR10	0.74* (0.28-0.92)	0.65 (0.46-1.10)	9.79 (6.90-17.21)

CI: confidence interval; r: Pearson's correlation; TEM: typical error of measurement; CV: coefficient of variation; * P ≤ 0.05.

Table 3. The 3vs3 test-retest reliability for heart rate (HR, bpm), percentage of maximal HR (%HRmax), time spent in heart rate zones (Tzone, min) and category-ratio scale (CR10, AU).

Variables	r (CI 95%)	TEM (CI 95%)	CV (CI 95%)
HR	0.86* (0.56-0.96)	2.63 (1.86-4.46)	1.55 (1.10-2.65)
%HRmax	0.85* (0.55-0.96)	1.33 (0.95-2.27)	1.55 (1.10-2.65)
Tzone≥90%	0.78$ (0.37-0.93)	2.42 (1.71-4.10)	108.29 (68.17-247.57)
Tzone[80-90[%	0.58* (0.01-0.87)	2.48 (1.76-4.22)	31.89 (21.66-60.00)
Tzone<80%	0.79* (0.40-0.94)	1.06 (0.75-1.80)	52.21 (34.66-104.06)
CR10	0.44 (-0.18-0.81)	1.23 (0.87-2.08)	55.09 (36.51-110.61)

CI: confidence interval; r: Pearson's correlation; TEM: typical error of measurement; CV: coefficient of variation; * P ≤ 0.05; $ P = 0.06.

Table 4. The 6vs6 test-retest reliability for heart rate (HR, bpm), percentage of maximal HR (%HRmax), time spent in heart rate zones (Tzone, min) and category-ratio scale (CR10, AU).

Variables	r (95% CI)	TEM (95% CI)	CV (95% CI)
HR	0.87* (0.54-0.97)	2.46 (1.69-4.50)	1.48 (1.02-2.72)
%HRmax	0.90* (0.62-0.98)	1.24 (0.85-2.27)	1.48 (1.02-2.72)
Tzone≥90%	0.95* (0.81-0.98)	1.31 (0.90-2.40)	27.39 (18.12-55.57)
Tzone[80-90[%	0.90* (0.61-0.98)	1.40 (0.96-2.55)	22.46 (14.95-44.76)
Tzone<80%	0.59$ (-0.02-0.90)	1.26 (0.87-2.31)	45.15 (29.21-97.42)
CR10	-0.09 (-0.68-0.57)	1.31 (0.90-2.40)	36.38 (23.77-76.28)

CI: confidence interval; r: Pearson's correlation; TEM: typical error of measurement; CV: coefficient of variation; * $P \leq 0.05$; $ $P = 0.07$.

DISCUSSION

This study aimed to assess the reproducibility of physiological and perceptual responses to ISR, 3vs3 and 6vs6, from a test-retest design in two identical test sessions performed one week apart with the same professional handball players.

The main finding was that mean HR showed high level of reproducibility for the three experimental exercises, with a lack of significant difference between test-retest sessions, a very high reliability and a low variability (with CVs ranged between 1.23 and 1.55%). TEMs ranged between 2.21 and 2.63 bpm were similar to that reported by previous researches in laboratory conditions[23,24]. Analysing test-retest reliability of mean HR during 4min bouts on treadmill with three submaximal intensities (14, 16 and 18km.h^{-1}), Saunders et al.[24] reported small TEM (ranged from 2.9 to 3.7bpm) and coefficient of variation (1.7 to 2.4%) with elite male distance runners. Similar results were reported by Peserico et al.[23] during submaximal intensity stages in three continuous incremental tests protocols on treadmill for running velocity at 14km.h^{-1} while TEM reached up 7bpm with lower velocities (8-12km.h^{-1}). Furthermore, the present TEM scores for ISR, 3vs3 and 6vs6 are in agreement with previous research reporting values of 2.6 bpm for mean HR during 30min team-sport simulation on a non-motorised treadmill in laboratory[25].

Moreover, the small CVs results reported in the present study are comparable with those of previous field-based research[15]. Indeed, Ade et al.[15] revealed CVs for mean HR ranged between 1.3-1.9% and 0.9-1.9% for soccer intermittent SSGs (1*vs*1 and 2*vs*2) and high intensity running, respectively. In the present study, mean HR results suggests that the differences between experimental exercises concerning the possibility to control and plan time characteristics and work intensity not influence the high level of test-retest reliability. High scores of reproducibility reported in the present study may be related to intensity of experimental drills that displayed mean HR response higher than 86.5% of HRmax. Indeed, previous authors reported that SSG intensity improved test-retest reliability of HR response during ball-drills[13].

The time spent in HR zones is a variable widely used in team-sports in order to estimate the physiological demand of match play[1,2], to assess the internal training load[9,12] and to control the training stimulus during running exercises and ball-drills with basketball[9], soccer[7] and handball players[14]. Among the present experimental exercises, the time spent in HR zones not differed between sessions for ball-drills while values revealed test-retest differences for ISR. Time spent in HR zone decreases for intensity ≥90% HRmax and increases for [80-90[% HRmax during ISR. This result might be due to training adaptation and/or variation in motivation between sessions. Indeed, with a RPE score reaching 7.5 the ISR load was perceived as very heavy and involved high degree of motivation with team-sport players. Indeed, traditional running training has been perceived to be more strenuous compared with specific ball-drills in soccer players despite similar HR demand[19,26]. Consequently, SSG training is thought to increase player compliance and motivation.

Regarding overall HR zone results, TEM reached up 1.12, 1.40 and 2.48min for ISR, 6vs6 and 3vs3, respectively. The lack of previous data not allows an appropriate comparison with these reproducibility scores. Anyway, when TEM was expressed in CVs, variability showed wide extent of scores particularly for Tzone≥90% HRmax, from 9.73% during ISR to 108.29% during 3vs3. These results suggest a lower variability for ISR than 6vs6 and 3vs3. The marked CV scores observed for ball-drills concerning time spent in HR zones might be due to differences in temporal characteristics of high-intensity actions between test and retest. Due to tactical and technical requested during the course of the game, time characteristics of high-intensity actions cannot be planned during SSGs. For instance, Ade et al.[15] reported high variability in time-motion with CVs of 141% for total sprint distance and 62% in total very-high-speed running distance during intermittent soccer SSGs with elite players. Such inter-sessions difference should affect substantially the HR response. Indeed, it has been shown that modifications either in sprint distance or in exercise/rest ratio during repeated sprint drills affected significantly HR response[27]. The low TEM score for 3vs3 may be explained by the strategy of player's rotation mode (short intervals, 30s-30s). Even if the match play was not stopped every 30s period (*i.e.* offensive players can score a goal without the defenders to be ready), the latency occurred during the substitution for players could not be avoided. Frequent exchanges of players (every 30s) may be considered as a limitation for test-retest reliability (Table 3). The 3vs3 intermittent format needed further analyze to control reproducibility with various pause and effort durations, before to be prescribed by coaches.

The time spent in HR zone is widely used to control the aerobic stimulus during conditioning drill. The present results may be analysed in the light of previous studies analysing the effectiveness of conditioning training on physical fitness with team-sport players. It has been shown that intermittent running and SSG should elicit intensity higher than 90% of HRmax to provide an appropriate stimulus for large changes in physical fitness and match play performance[7,9]. Assessing time spent in HR zones during 25min

of intermittent soccer SSG, Impellizzeri et al.[7] reported a total duration of 9min spent within the target intensity (≥90% of HRmax) shown to be effective in enhancing aerobic fitness and soccer performance. Conversely, a ball-drill based-training involving 4min above 90% of HRmax over each training session was not adequate for substantial improvement of aerobic power with basketball players[9]. For practical aspects, present TEMs might be considered in the light of these previous results. With a TEM of 1.1min for total time spent above 90% of HRmax of 11.3min and 9.9min in test and retest, respectively, the ISR is considered to be the most efficient in improving aerobic power among our experimental drills. Conversely, due to concomitant higher TEM and shorter duration spent within the target intensity, both 3vs3 and 6vs6 needed further analyse to be considered as conditioning drills specifically designed to improve aerobic power.

The reproducibility of RPE was higher in ISR than in both ball-drills. The RPE score presented low variability between sessions for ISR with TEM of 0.65 and CV of 9.79%. These results are in line with previous research conducted in laboratory conditions[23] and analysing reproducibility of RPE in three continuous incremental exercises performed on treadmill (TEM between 0.5 and 1.3 and CV between 5.2 to 15.3%). Nevertheless, CV assessed for ISR was lower than that reported in field condition in response to 8min bouts of submaximal intermittent running (10, 11.5 and 13 km.h-1, CV ≈ 31.9%) with team sport athletes[28]. In the present study, CVs were four and six fold greater in 6vs6 and 3vs3, respectively when compared with ISR, which showing high test-retest variability. Few studies analysed reproducibility of RPE in SSG. Compared with our results, Ade et al.[15] reported smaller CVs (2.9-5.7%) for both running drills and soccer SSG with elite players. However, these authors not specified if CV was determined from raw or log transformed values which did not allow an appropriate comparison[21]. Finally, ISR and 6vs6 presented similar CVs to that reported by Rampinini et al.[13] with soccer SSGs (CV ranged between 5.5 and 31.0%). Because RPE evaluate psychophysiological strain of players, involving interaction of perceptual, cognitive and metabolic processes a poor between sessions reproducibility was expected. Nevertheless, ISR's level of reproducibility was similar with that observed in laboratory condition.

CONCLUSIONS

Mean HR response elicited by ISR, 3vs3 and 6vs6 demonstrated high level of test-retest reproducibility with similar scores to that reported during treadmill running in laboratory condition. Therefore, when coaches prescribed one of these drills in separate occasions they can be confident in expecting the same overall training demand. However, time spent in HR zone higher than 90% of HRmax shown poor reproducibility for both ball-drills while exercise design is kept consistent. Therefore, the effectiveness of ball-drills used in this study to provide a sufficient stimulus for improving aerobic power remains uncertain and should be analysed with caution.

REFERENCES

1. Chelly MS, Hermassi S, Aouadi R, Khalifa R, Van Den Tillaar R, Chamari K, et al. Match analysis of elite adolescent team handball players. J Strength Cond Res 2011;25(9):2410-7.
2. Póvoas S, Seabra A, Ascensão A, Magalhães J, Soares J, Rebelo A. Physical and physiological demands of elite team handball. J Strength Cond Res 2012;26(12):3366-76.
3. Buchheit M, Laursen PB, Kuhnle J, Ruch D, Renaud C, Ahmaidi S. Game-based training in young elite handball players. Int J Sports Med 2009;30:251-8.
4. Dellal A, Chamari K, Pintus A, Girard O, Cotte T, Keller D. Heart rate responses during small-sided games and short intermittent running training in elite soccer players: a comparative study. J Strength Cond Res 2008;22(5):1449-57.
5. Hill-Haas S, Rowsell G, Coutts A, Dawson B. The reproducibility of physiological responses and performance profiles of youth soccer players in small-sided games. Int J Sports Physiol Perform 2008;8(3):393-6.
6. Iacono A, Eliakim A, Meckel Y. Improving fitness of elite handball players: small-sided games vs high-intensity intermittent training. J Strength Cond Res 2015;29(3):835-43.
7. Impellizzeri FM, Marcora SM, Castagna C, Reilly T, Sassi A, Iaia FM, et al. Physiological and performance effects of generic versus specific aerobic training in soccer players. Int J Sports Med 2006;27(6):483-92.
8. Owen A, Wong D, Paul D, Dellal A. Effects of periodized small-sided game training intervention on physical performance in elite professional soccer. J Strength Cond Res 2012;26(10):2748-54.
9. Bogdanis GC, Ziagos V, Anastasiadis M, Maridaki M. Effects of two different short-term training programs on the physical and technical abilities of adolescent basketball players. J Sci Med Sport 2007;10:79-88.
10. Dellal A, Varliette C, Owen A, Chirico E, Pialoux V. Small-sided games versus interval training in amateur soccer players: effects on the aerobic capacity and the ability to perform intermittent exercises with changes of direction. J Strength Cond Res 2012;26(10):2712-20.
11. Castagna C, Impellizzeri FM, Chaouachi A, Ben Abdelkrim N, Manzi V. Physiological responses to ball-drills in regional level male basketball players. J Sports Sci 2011;29(12):1329–36.
12. Conte D, Favero T, Niederhausen M, Capranica L, Tessitore A. Effect of different number of players and training regimes on physiological and technical demands of ball-drills in basketball. J Sports Sci 2016;34(8):780-6.
13. Rampinini E, Impellizzeri F, Castagna C, Abt G, Chamari K, Sassi A, et al. Factors influencing physiological responses to small-sided soccer games. J Sports Sci 2007;25(6):659-66.
14. Corvino M, Tessitore A, Minganti C, Sibila M. Effect of court dimensions on player's external and internal load during small-sided handball games. J Sports Sci Med 2014;13(2):297-303.
15. Ade JD, Harley, JA, Bradley PS. Physiological response, time-motion characteristics, and reproducibility of various speed-endurance drills in elite youth soccer players: small-sided games versus generic running. Int J Sports Physiol Perform 2014;9:471-9.
16. Dellal A, Chamari K, Payet F, Djaoui L, Wong DP. Reproducibility of physical performance during small- and large-sided games in elite soccer in short period: practical applications and limits. J Nov Physiother 2016;6(6):1-7.
17. Vickery W, Dascombe B, Duffield R, Kellett A, Portus M. Battlezone: an examination of the physiological responses, movement demands and reproducibility of small-sided cricket games. J Sports Sci 2013;31(1):77-86.
18. Buchheit M. The 30-15 intermittent fitness test: accuracy for individualizing

interval training of young intermittent sport players. J Strength Cond Res 2008;22(22):365-74.
19. Los Arcos A, Vázquez JS, Martín J, Lerga J, Sánchez F, Villagra F, et al. Effects of small-sided games vs. interval training in aerobic fitness and physical enjoyment in young elite soccer players. Plos One 2015;10(9), e0137224.
20. Borg G, Ljunggren G, Ceci R. The increase of perceived exertion, aches and pain in the legs, heart rate and blood lactate during exercise on a bicycle ergometer. Eur J Appl Physiol Occup Physiol 1985;54(4):343-9.
21. Hopkins WG. Measures of reliability in sports medicine and science. Sports Med.2000;30(1): 1-15.
22. Hopkins WG, Marshall SW, Batterham AM, Hanin J. Progressive statistics for studies in sports medicine and exercise science. Med Sci Sports Exerc 2009;41(1):3-12.
23. Peserico CS, Zagatto AM, Machado FA. Reproducibility of heart rate and rating of perceived exertion values obtained from different incremental treadmill tests. Sci Sports 2015;30(2):82-8.
24. Saunders PU, Pyne DB, Telford RD, Hawley JA. Reliability and variability of running economy in elite distance runners. Med Sci Sports Exerc 2004;36(11):1972-6.
25. Sirotic AC, Coutts AJ. The reliability of physiological and performance measures during simulated team-sport running on a non-motorised treadmill. J Sci Med Sport 2008;11(5):500-9.
26. Hill-Haas S, Coutts A, Rowsell G, Dawson B. Generic versus small-sided game training in soccer. Int J Sports Med 2009;30:636-42.
27. Little T, Williams AG. Effects of sprint duration and exercise/rest ratio on repeated sprint performance and physiological responses in professional soccer players. J Strength Cond Res 2007;21(2):646-8.
28. Scott TJ, Black CR, Quinn J, Coutts AJ. Validity and reliability of the session-RPE method for quantifying training in Australian football: a comparison of the CR10 and CR100 scales. J Strength Cond Res 2013;27(1):270-6.

CORRESPONDING AUTHOR

Gilles Ravier
Laboratory C3S (EA4660) - 31
Chemin de l'Epitaphe, 25000
Besançon, FRANCE
Email: gilles.ravier@univ-fcomte.fr