Original Paper DOI: https://doi.org/10.5114/biolsport.2021.99327

Effects of small-sided games and high-intensity interval training on physical performance in young female handball players

AUTHORS: Mila Vukadinović Jurišić[1], Damjan Jakšić[1], Nebojša Trajković[1], Dušan Rakonjac[1], Jovica Peulić[1], Jelena Obradović[1]

[1] Faculty of Sport and Physical Education, University of Novi Sad, Serbia

ABSTRACT: This study was designed to compare the effectiveness of small-sided handball games in combination with handball training (SSG group) versus high-intensity interval training in combination with handball training (HIIT group) on physical performance of young female handball players during pre-competitive period. Twenty-four young female handball players, who have a 6.17 ± 1.54 years training experience and competition in the national league participated in this study. SSG group (n = 12; age 16.06 ± 0.80 years, body mass 61.27 ± 3.68 kg, body height 1.64 ± 4.7 m, body mass index 22.7 kg/m^2) while HIIT group (n = 12; 16.20 ± 1.28 years, body mass 62.46 ± 7.86 kg, body height 1.68 ± 6.8 m, body mass index 22 kg/m^2). Both groups applied training programs twice-a-week for 8 weeks. Before and after the training programs physical performances were assessed: Countermovement jump (CMJ), Squat jump (SJ), Sprint on 0–10 m; Sprint on 0–20 m; Sprint on 0–30 m, Throwing medicine ball and total distance covered during the Yo-YoIRT1. After 8 weeks SSG and HIIT groups significantly improved CMJ, SJ, 0–20 m sprint, 0–30 m sprint, throwing medicine ball and Yo-YoIRT1 ($p \leq 0.05$). However, significantly greater improvement was achieved in Yo-YoIRT1 (m) in HIIT group (28.40%) than SSG group (17.63%). These results indicate that SSG group and HIIT group equally improve of physical performances (jump, sprint and upper explosive strength) among young female handball players in pre-competitive period.

CITATION: Jurišić MV, Jakšić D, Trajković N et al. Effects of small-sided games and high-intensity interval training on physical performance in young female handball players. Biol Sport. 2021;38(3):359–366.

Received: 2020-06-01; Reviewed: 2020-07-09; Re-submitted: 2020-08-02; Accepted: 2020-09-02; Published: 2020-10-24.

Corresponding author:
Mila Vukadinović Jurišić
Faculty of Sport and Physical Education, University of Novi Sad
E-mail: mila.vukadinovic88@gmail.com

Key words:
interval training
sport-specific training
aerobic performance
women
jumping
strength

INTRODUCTION

Handball is a strenuous contact team sport that involves highly demanding intermittent actions, such as sprinting, jumping, short accelerations and decelerations, blocking, pushing, and throwing, interrupted by a short period of low-intensity activities [1, 2]. It is a high-intensity intermittent sport that requires successful female handball athletes to have well-developed agility, explosive power of the upper and lower extremities, speed, aerobic capacity, hand coordination and repetitive torso strength [3]. Many training methods have been used in female handball for the improvement of physical performance, such as plyometric training [4], training neuromuscular stabilization [5, 6], training with a medicine ball [7], complex training [8] and training with elastic bands [9]. Moreover, this training programme improves two or three motor abilities, yet other abilities remain neglected. Therefore, well-designed small-sided games can, at the same time, develop the functional, motor and technical-tactical abilities of athletes, improve game play and allow coaches to use training time economically [10]. Training of different abilities and technical-tactical skills, during the annual planning, should be particularly taken into account because of the ultimate impact on the improvement of handball players' performance [11]. Therefore, coaches often use small-sided games as specific condition training, which enhances physiological demands, developing technical and tactical skills [12–14] while effectively using time and maintaining players' motivation [11]

Small-sided games (SSG) represent specially designed handball games for improving aerobic capacity and maintaining other important handball skills [15, 16]. High-intensity interval training (HIIT) is similar to SSG [14] and also used in handball as an effective method for improving some of these skills [17]. The similarity between these two types of training is in the short period of high-intensity movement, followed by a pre-determined period of rest [13]. Based on that, it can be noted that small-sided games and high-intensity interval training use short high-intensity interval running (seconds to a few minutes) interspersed with short periods of rest (interval rest). Also, the authors [18] have noted that both types of training belong to the same training methods (high-intensity aerobic training) which improve players' ability to perform high-intensity activities and improve players' ability to recover after high-intensity activities [19]. However, these training methods also have many differences that we must not ignore.

The purpose of the present study is to determine which training group [small-sided games combined with handball training (SSG group) and high-intensity interval training combined with handball training (HIIT group)] is more effective in improving physical performance in female handball players during the pre-competitive period. It was hypothesized that SSG and HIIT groups would induce similar improvements in physical performance of young female handball players.

MATERIALS AND METHODS

Subjects

Twenty-four young female handball players who were members of the top team of the First League (National Serbia League) volunteered to participate in this study. The first group is the SSG group, n = 12; age: 16.06 ± 0.80 years, body mass 61.27 ± 3.68 kg, body height 1.64 ± 4.7 m. The second group is the HIIT group, n = 12; age: 16.20 ± 1.28 years, body mass 62.46 ± 7.86 kg, body height 1.68 ± 6.8 m. They have at least 6 years of experience (SSG group members have 6.25 ± 1.71 years of training experience while HIIT group members have 6.08 ± 1.38 years of training experience) in systematic training and competition in the national league. The players trained 4 days per week (~90 min) and the training was identical in both groups (technical, tactical, strength, and speed training). All players were healthy and were not taking any medication. During the study, participants were not allowed to participate in another training programme that could potentially bias the results. Parents of participants gave their written consent after receiving a detailed explanation about the experimental protocols. All participants were told about potential risks during the study. All procedures were conducted in accordance with the Declaration of Helsinki [20] and approved by the Ethics Committee of the Faculty of Sport and Physical Education, University of Novi Sad.

Procedures

The study was carried out in the period from January 2018 to March 2018. One week before the initial testing and intervention, participants had a familiarization session. During the familiarization session, the assessment protocols were introduced to all participants. The subjects underwent physical test assessments in an indoor stadium. Before each testing, the subjects performed a standard 15-minute warm-up (which included jogging, dynamic stretching exercises, sprints and jumping drills). During the test, the air temperature ranged from 19°C to 22°C. Testing was conducted in one day starting at 9 AM and finishing by 1PM in the following order: Standard anthropometry (height and body weight), CMJ (cm), SJ (cm), Sprint 0–10 m (s), Sprint 0–20 m (s), Sprint 0–30 m (s), throwing medicine ball (m) and total distance running during Yo-Yo Intermittent Recovery Test Level 1 (m). The rationale for using these tests as a measure of jumping, sprinting, throwing and running is based on the results of previous studies [1] showing that these activities are important for handball games. All pre- and post- training testing procedures were completed in the same order, spaced 8 weeks apart. The subjects were instructed not to be involved in strenuous exercise for at least 24 hours before the testing. None of the subjects were injured 6 months before the initial testing or during the training programme. Players were also asked to keep a regular diet (nutrition and hydration) during the testing, and were prohibited from consuming any known stimulant (e.g. caffeine) or depressant (e.g. alcohol) within 24 hours before testing.

Measurements

Body height was measured to the nearest 0.1 cm using a Martin anthropometer (GPM in Switzerland), while body mass was obtained to the nearest 0.1 kg using a calibrated balance beam (Avery Ltd, Model 3306 ABV).

Squat Jump (SJ) and Countermovement Jump (CMJ) were determined by a force platform (Kistler Instrument AG, Quattro Jump, 9290AD, Switzerland). This platform has a Bosco protocol, which objectively allows measurements of force and flight time and the calculation of jump height (cm) [21]. Each athlete performed 3 trials of each jump and the best result was recorded for further analysis.

Sprint ability was evaluated by a 30 m Sprint Test from a standing start. Subjects ran 3 times with 3-minute breaks between each sprint.

Time was recorded using the photocell system MICROGATE (Witty Sem, Microgate, Bolzano, Italy) placed 10 m, 20 m and 30 m from the start line. The athletes performed 3 trials and the fastest times were recorded for further analysis.

Throwing a medicine ball (1 kg) from a lying position was performed using the 21.5 cm diameter 1 kg rubber medicine ball (Tigar, Pirot, Serbia) as described by Metikoš et al. [22]. The results represent the distance from zero point to the point of first contact of the ball with the ground. Throwing distance was measured to the nearest 1 cm. Three trials were recorded, but the best result was taken for further statistical analyses.

Yo-Yo Intermittent Recovery Test Level 1 was performed as described by Krustrup et al. [23] The total distance (m) covered during Yo-YoIRT1 was considered as the testing score.

Training programme

Training programmes started 1 week after the baseline testing (January, 2018) and lasted 8 weeks in the pre-competitive period. After the training programmes (8 weeks), a final testing was conducted (March, 2018). Training programmes were conducted on 4 days per week (Monday, Wednesday, Thursday, and Friday) and training lasted ~90 min. The SSG group had handball training on 2 days per week (Monday and Thursday) + 2 days per week (Wednesday and Friday) of small-sided games. The HIIT group had handball training on 2 days per week (Monday and Thursday) + 2 days per week of high-intensity interval training (Wednesday and Friday). The SSG group applied small-sided games in combination with handball training.

Handball training – 15 min general activity (jogging, running, sprinting, jumping, sideways movement, backward running); 15 min warm-up with the ball; 30 min of drill that includes low- and high-intensity movements such as jump shots, throws, blocking, passing the ball, change of direction, one-on-one situations; 15 min static of stretching.

Small-sided games – 15 min general activity; 15 min warm-up with the ball; ~45 small-sided games; 15 min static stretching. The SSG group performed five 2.25 min to 3.10 min bouts of small handball games with a passive recovery of 1 minute between bouts (Table 1). The small-sided handball games were organized in four teams (3 vs. 3) excluding goalkeepers, on a playing court with dimensions 20x20 m. The players adhered to the modified rules as described by Dello Iacono et al. [24].

The HIIT group applied high-intensity interval training in combination with handball training.

Handball training in the HIIT group was the same as in the SSG group.

High-intensity interval training – 15 min general activity; 15 min warm-up with the ball; ~45 min high-intensity interval running, 15 min static stretching.

HIIT is based on two sessions of running at the final speed of the Yo-YoIRT1 test (maximal aerobic speed – MAS). The sessions were composed of short 15 s intermittent running (velocities ranging from 90 to 95% of MAS reached at the end of the Yo-YoIRT1 according to Krustrup et al. [22]) and 15 s of active recovery. All exercises were performed on a short track with players placed in different corridors according to their MAS. Further details of the training programme

TABLE 1. Description of the training schedule over the 8-week training period in SSG group

Training period	Training day	Training program / intensity
1 week	Monday	Handball training
	Wednesday	Small-sided games (game 5 x 2 min 25 s / passive recovery 1 min)
	Thursday	Handball training
	Friday	Small-sided games (game 5 x 2 min 25 s /passive recovery 1 min)
2 week	Monday	Handball training
	Wednesday	Small-sided games (game 5 x 2 min 35 s /passive recovery 1 min)
	Thursday	Handball training
	Friday	Small-sided games (game 5 x 2 min 55 s / passive recovery 1 min)
3 week	Monday	Handball training
	Wednesday	Small-sided games (game 5 x 2 min 55 s /passive recovery 1 min)
	Thursday	Handball training
	Friday	Small-sided games (game 5 x 2 min 55 s /passive recovery 1 min)
4 week	Monday	Handball training
	Wednesday	Small-sided games (game 5 x 3 min /passive recovery 1 min)
	Thursday	Handball training
	Friday	Small-sided games (game 5 x 3 min /passive recovery 1 min)
5 week	Monday	Handball training
	Wednesday	Small-sided games (game 5 x 3 min /passive recovery 1 min)
	Thursday	Handball training
	Friday	Small-sided games (game 5 x 3 min /passive recovery 1 min)
6 week	Monday	Handball training
	Wednesday	Small-sided games (game 5 x 3 min 10 s /passive recovery 1 min)
	Thursday	Handball training
	Friday	Small-sided games (game 5 x 3 min 10 s /passive recovery 1 min)
7 week	Monday	Handball training
	Wednesday	Small-sided games (game 5 x 3 min /passive recovery 1 min)
	Thursday	Handball training
	Friday	Small-sided games (game 5 x 3 min/passive recovery 1 min)
8 week	Monday	Handball training
	Wednesday	Small-sided games (game 5 x 2 min 55 s /passive recovery 1 min)
	Thursday	Handball training
	Friday	Small-sided games (game 5 x 2 min 55 s /passive recovery 1 min)

TABLE 2. Description of the training schedule over the 8-week training period in HIIT group

Training period	Training day	Training program	Number series x time running	Interval running (intensity running)	Interval recovery	Recovery between series
1 week	Monday	Handball training				
	Wednesday	HIIT	2 x 6 min	15 s (90% of MAS)	15 s	3 min
	Thursday	Handball training				
	Friday	HIIT	2 x 6 min	15 s (90% of MAS)	15 s	3 min
2 week	Monday	Handball training				
	Wednesday	HIIT	2x 6 min 30 s	15 s (90% of MAS)	15 s	3 min
	Thursday	Handball training				
	Friday	HIIT	2x 6 min 30 s	15 s (90% of MAS)	15 s	3 min
3 week	Monday	Handball training				
	Wednesday	HIIT	2x 7 min	15 s (92% of MAS)	15 s	3 min
	Thursday	Handball training				
	Friday	HIIT	2x 7 min	15 s (92% of MAS)	15 s	3 min
4 week	Monday	Handball training				
	Wednesday	HIIT	2x 7 min 30 s	15 s (92% of MAS)	15 s	3 min
	Thursday	Handball training				
	Friday	HIIT	2x 7 min 30 s	15 s (92% of MAS)	15 s	3 min
5 week	Monday	Handball training				
	Wednesday	HIIT	2x 7 min 30 s	15 s (92% of MAS)	15 s	3 min
	Thursday	Handball training				
	Friday	HIIT	2x 7 min 30 s	15 s (92% of MAS)	15 s	3 min
6 week	Monday	Handball training				
	Wednesday	HIIT	2x 8 min 15 s	15 s (92% of MAS)	15 s	3 min
	Thursday	Handball training				
	Friday	HIIT	2x 8 min 15 s	15 s (92% of MAS)	15 s	3 min
7 week	Monday	Handball training				
	Wednesday	HIIT	2x 7 min 30 s	15 s (95% of MAS)	15 s	3 min
	Thursday	Handball training				
	Friday	HIIT	2x 7 min 30 s	15 s (95% of MAS)	15 s	3 min
8 week	Monday	Handball training				
	Wednesday	HIIT	2x 7 min 15 s	15 s (95% of MAS)	15 s	3 min
	Thursday	Handball training				
	Friday	HIIT	2x 7 min 15 s	15 s (95% of MAS)		3 min

Note: MAS – maximal aerobic speed; HIIT – high-intensity interval training.

are outlined in Table 2. The training programme is similar to the training programme described by Dello Iacono et al. [24].

Heart rate responses

Heart rate responses were continuously monitored during all the SSG and HIIT training sessions to provide the average HR and maximal HR reached during each conditioning intervention. Heart rate responses were recorded by a T32 Polar Electro, Kempele, Finland. Heart rate response was measured by a Polar WearLink + transmitter, watch Polar RS800cx heart rate monitor, Polar IrDA USB Adapter and Polar ProTrainer 5 software.

Statistical analyses

All data are presented as mean ± SD. The Shapiro-Wilk test assessed the normality of distributions. The reliability of each test was assessed by calculating the intraclass correlation coefficients (ICC), according to the literature [25]. Reliability was defined as poor (ICC < 0.50), moderate (ICC 0.50 to 0.75), or good (ICC > 0.75) using previously established criteria [26]. Analysis of variance (ANOVA) was used to determine differences between groups on initial measurement. Multivariate analysis of variance (MANOVA) was used to determine differences between groups in HRmean and average HRmax. A mixed-design repeated measures factorial analysis of variance was used to test for interactions and main effects for time (initial vs. final) and

TABLE 3. Pretest and posttest results for physical performance in young female handball players

Variable Group	Pretest (Mean ± SD)	Posttest (Mean ± SD)	ES	%change	F values, p-values, η^2_p
CMJ (cm)					Group: F = 0.00, p = 0.94, η^2_p = 0.00
SSG group	33.17 ± 3.36	34.51 ± 2.95*	0.42	4.04	
					Time: F = 15.44, **p = 0.00**, η^2_p = 0.41
HIIT group	33.48 ± 1.87	34.36 ± 1.85*	0.47	2.63	
					Interaction: F = 0.67, p = 0.42, η^2_p = 0.30
SJ (cm)					Group: F = 0.14, p = 0.71, η^2_p = 0.01
SSG group	32.03 ± 2.92	33.16 ± 3.65*	0.34	3.53	
					Time: F = 20.88, **p = 0.00**, η^2_p = 0.49
HIIT group	31.48 ± 1.72	32.95 ± 1.68*	0.86	4.67	
					Interaction: F = 0.37, p = 0.55, η^2_p = 0.02
Sprint 0–10(m) #					Group: F = 1.89, p = 0.18, η^2_p = 0.08
SSG group	2.02 ± 0.12	2.00 ± 0.13	-0.16	0.99	
					Time: F = 0.45, p = 0.51, η^2_p = 0.02
HIIT group	2.07 ± 0.11	2.06 ± 0.09	-0.00	0.48	
					Interaction: F = 0.16, p = 0.69, η^2_p = 0.01
Sprint 0–20 (m) #					Group: F = 0.04, p = 0.84, η^2_p = 0.00
SSG group	3.58 ± 0.18	3.52 ± 0.17*	-0.34	1.68	
					Time: F = 7.42, **p = 0.01** η^2_p = 0.25
HIIT group	3.60 ± 0.14	3.53 ± 0.12*	-0.54	1.94	
					Interaction: F = 0.07, p = 0.78, η^2_p = 0.00
Sprint 0–30 (m) #					Group: F = 0.08, p = 0.78, η^2_p = 0.00
SSG group	5.09 ± 0.26	5.07 ± 0.24	-0.07	0.39	
					Time: F = 6.13, **p = 0.02**, η^2_p = 0.22
HIIT group	5.17 ± 0.29	5.05 ± 0.21*	-0.47	2.37	
					Interaction: F = 2.60, p = 0.12, η^2_p = 0.11
TB (m)					Group: F = 0.98, p = 0.33, η^2_p = 0.43
SSG group	7.93 ± 1.04	8.44 ± 0.58*	0.60	6.43	
					Time: F = 7.00, **p = 0.01**, η^2_p = 0.24
HIIT group	8.22 ± 1.11	8.53 ± 1.0.82*	-0.07	3.77	
					Interaction: F = 2.78, p = 0.11, η^2_p = 0.12
Yo-YoIRT1(m)					Group: F = 6.14, **p = 0.02**, η^2_p = 0.22
SSG group	520.00 ± 61.49	611.67 ± 100.35*	1.10	17.63	
					Time: F = 86.02, **p = 0.00**, η^2_p = 0.80
HIIT group	563.33 ± 73.28	723.33 ± 86.06+ *†	2.00	28.40	
					Interaction: F = 5.89, **p = 0.02**, η^2_p = 0.21

- Note: SSG - small-sided handball games group; HIIT - high intensity interval group; CMJ-Counter movement jump; SJ-Squat jump; TB-Throwing medicine ball; Yo-YoIRT1 (m) - Yo-Yo Intermittent recovery test level 1 (total distance running (m)); # variable with opposite metric orientation; ES – effect size; % changes – Pretest and post test changes; F – statistics; p – significant difference of $p \leq 0.05$; η^2_p Partial Eta Squared; * significant pre-post test changes at $p \leq 0.05$ (the simple main effect of time) ; + groups significantly different at $p \leq 0.05$ (the simple main effect of group);† significant main effect of interaction at $p \leq 0.05$

group (SSG vs. HIIT) on the physical performance variable. Cohen's effect size (ES) statistic was used to determine the practical significance of observations [27]. ES was classified as follows: < 0.2 was defined as trivial; 0.2–0.6 was defined as small; 0.6–1.2 was defined as moderate; 1.2–2.0 was defined as large; > 2.0 was defined as very large; and > 4.0 was defined as extremely large [28]. Statistical analyses were performed with SPSS software (Version 20.0; IBM SPSS, Inc., Chicago, IL, USA).

RESULTS

Good reliability coefficients were obtained for all tests, with ICC ranging from 0.81 to 0.93.

The Shapiro-Wilk test showed that data were normally distributed. There was no significant difference ($p > 0.05$) in HRmean between the SSG group (171.08 ± 5.02 bpm) and HIIT group (173.75 ± 4.20 bpm) during the training. The average HRmax reached during the training in the SSG group was 194.92 ± 3.87, similar to that recorded by the HIIT group (195.42 ± 3.42). There were no significant differences ($p > 0.05$) in average HRmax between groups.

Baseline and the effect of training methods on physical performance in young female handball players are summarized in Table 3. Initial data indicated that there were no statistically significant between-group differences in vertical jump (CMJ – $p = 0.78$; SJ – $p = 0.57$), Sprint 0–10 m ($p = 0.36$), Sprint 0–20 m ($p = 0.79$), Sprint 0–30 m ($p = 0.51$), throwing a medicine ball ($p = 0.21$) or aerobic endurance (Yo-YoIRT1 (m)) ($p = 0.13$).

Both groups (SSG and HIIT) demonstrated improvements in vertical jump (CMJ) (4.04% and 2.63%, $p \leq 0.05$), but no group or interaction effect was observed ($p > 0.05$). When examining the impact of intervention on vertical jump (SJ), there was a significant main effect for time ($p = 0.00$), with both groups improving their results after the 8-week intervention (SSG 3.53% vs HIIT 4.67%).

There was no effect of time, group, or interaction on Sprint 10 m ($p > 0.05$, Table 3). SSG and HIIT groups demonstrated improvements in Sprint 20 m (1.68% and 1.94%, $p \leq 0.05$), but no group or interaction effects were observed ($p > 0.05$). When the impact of the SSG and HIIT programmes on the Sprint 30 m was analysed, there was a significant main effect for time after eight-week intervention (0.39% and 2.37%, $p \leq 0.05$). There was no effect of group or interaction on Sprint 30 m ($p \geq 0.05$).

There was a significant main effect for time when examining the impact of the SSG and HIIT programmes on upper-body explosive strength (throwing a medicine ball) (6.43% and 3.77%, $p \leq 0.05$). There were no effects of group or interaction on upper-body explosive strength following the 8-week training programme.

There was an interaction ($F = 5.89$; $p = 0.02$; $\eta^2_p = 0.21$), time and group effect ($p \leq 0.05$) for aerobic endurance (Yo-YoIRT1 (m)). The SSG group improved aerobic endurance by 17.63% while a 28.40% improvement was observed in the HIIT group.

DISCUSSION

The present study aims to compare the effects of training groups (SSG vs HIIT) on physical performance in young female handball players during the pre-competitive period. The results indicated that both training methods (SSG and HIIT), after eight weeks of training, produced improvement in physical performance in female handball players, but the HIIT group achieved greater improvements than the SSG group. Moreover, both groups improved results in vertical jump (CMJ and SJ), 10 m sprint, 20 m sprint, and throwing a ball over eight weeks of training, but the HIIT group showed significantly greater increases in total distance running during Yo-YoIRT1 (m). Finally, a combination of high-intensity interval training and handball training, during eight weeks in the pre-competition period, improved jumping, sprinting and throwing and achieved better results in Yo-YoIRT1 (m) compared to a combination of small-sided games and handball training in young female handball players.

These results demonstrate that a combination of small-sided games and handball training or a combination of high-intensity interval training, in the pre-competition period, can be considered as a useful tool for the improvement of jumping ability, sprinting, throwing and endurance running. Our findings are in line with other research [29, 30, 15, 16]. In a systematic review and meta-analysis, the authors [31] state that when small-sided games are applied 2 to 3 times per week moderate to large improvements are achieved in speed, jumping, agility, repeated sprint performance and aerobic capacity in a team sport. A study [29] on young female and male handball players showed that small-sided handball games can be an effective method for improvement of vertical jump (3.5%) while high-intensity interval training resulted in an improvement of 3.2%. A related study on male elite handball players (age 25.6 ± 5) showed improvement of vertical jump by 10.96% after 8 weeks of small-sided handball games, while high-intensity interval training improved it by only 7.58% [30]. The present study showed slightly smaller improvements compared to these findings; the SSG group improved vertical jump (CMJ (cm)) by 4.04% while in the HIIT group it improved by 2.63%. The main reason why the SSG group has more advantages compared to the HIIT group is that during small-sided handball games there are more activities that require a jump than during high-intensity interval training [30]. Dello Iacono et al. [30] found improvement in a 20-m sprint after small-sided handball games by 3.91% compared to high-intensity interval training with 1.79%. In the present study, after 8 weeks, the SSG group improved the 20-m sprint by 1.68%, and the HIIT group improved it by 1.94%. The discrepancy between the results was due to differences in participants engaged in studies, pauses between running and the duration of a training programme. It should be especially noted that participants in this study were young female players who were not at elite level, and they are still in biological maturation, which is very important for the further development of speed [32]. In the present study, results for throwing a medicine ball for SSG (6.43%) were higher than for HIIT (3.77%). These findings were a consequence of explosive actions of the upper body (throwing

the ball, pushing players) during small-sided games, which probably caused a better improvement in throwing a ball in the SSG group compared to the HIIT group [33]. A new finding from the present research was that the HIIT group made significantly greater improvement in Yo-YoIRT1 (m) than the SSG group. Since both groups participated in the same traditional handball training, during the study period, such differences in endurance running are likely due to the specific training adaptations that resulted from high-intensity interval training. Some authors [17] noted significant gains in Yo-YoIRT1 (m) after 7 weeks of high-intensity interval training in handball compared to small-sided handball games. In soccer, after 8 weeks of high-intensity interval training, greater results are achieved in Yo-YoIRT1 (m) than in small-sided games [34]. Buchheit, Lepretre, Behaegel et al. [35] explain that small-sided games may not represent such an appropriate exercise stimulus for individual players as high-intensity interval training. The authors consider that high-intensity interval training is effective because the intensity can be individualized and controlled, such as running speed associated with VO_2max [29] or the speed achieved at the end of Yo-YoIRT1 [30]. Our hypothesis stated at the beginning of the paper can be accepted because both methods of training improved physical performance in young female handball players, while the HIIT group achieved better results only in the endurance test. Despite many benefits observed in this study, there are a few limitations. Firstly, our study lacked a control group. However, the absence of a control group is common in studies comparing training interventions. Secondly, in this study a field test was used to assess total running distance and not a laboratory test, which would have given us more valid values of VO_2max.

CONCLUSIONS

This study demonstrated that an 8-week intervention period, including a combination of small sided games and handball training or a combination of high-intensity interval training and handball training, could improve the physical performance of young female handball players during the preparation period for a season. Both types of training (SSG and HIIT) were found to be effective for the improvement of countermovement jump, squat jump, sprint 0–20 m, sprint 0–30 m, throwing a medicine ball, and total distance running in Yo-YoIRT1 of young female handball players. Specifically, a combination of high-intensity interval training and handball training was more effective in Yo-Yo IRT1 (m) compared to a combination of small-sided games and handball training. Therefore, the results of this study reveal that small-sided games are as effective as high-intensity interval training in terms of improving the pre-season physical performance of young female handball players. Moreover, alongside a significant improvement in physical performance that is similar to HIIT training, SSG produce greater enjoyment compared to HIIT [36], which is very important for younger players. These outcomes provide information to handball coaches that situational conditioning training (small-sided handball training) can improve some kinds of physical performance essential to handball similar to traditional conditioning training (high-intensity interval training) in the pre-competitive period in young female handball players. Future studies should measure handball-specific tests, such as specific agility, reactive agility in handball, and technical and tactical skills.

Acknowledgements

This research recived no specific grant from any funding agency in the public, commercial, or non-profit sector.

Declaration of conflicts of interest

The authors state that they have no conflict of interest.

REFERENCES

1. Povoas SC, Seabra AF, Ascensao AA, Magalhaes J, Soares JM, Rebelo AN. Physical and physiological demands of elite team handball. J Strength Cond Res. 2012;26(12):3365–3375.
2. Dello Iacono A, Martone D, Zagatto AM, Meckel Y, Sindiani M, Milic M, Padulo J. Effect of contact and no-contact small-sided games on elite handball players. J Sports Sci. 2018; 36(1):14–22.
3. Naisidou S, Kepesidou M, Kontostergiou M, Zapartidis I. Differences of physical abilities between successful and less successful young female athletes. J Phys Educ Sport. 2017;17(1):294–299.
4. Hammami M, Ramirez-Campillo R, Gaamouri N, Aloui G, Shephard RJ, Chelly MS. Effects of a combined upper-and lower limb plyometric training program on high-intensity actions in female U 14 handball players. Pediatr Exerc Sci. 2019;31(4):465–472.
5. Genevois C, Berthier P, Guidou V, Muller F, Thiebault B, Rogowski I. Effects of 6-week sling-based training of the external-rotation muscles on the shoulder profile in elite female high scholl handball players. J Sport Rehab. 2014; 23(4):286–295
6. Genc H, Cigerci AE, Sever, O. Effect of 8-week core training exercises of physical and physiological parameters of female handball players. Phys Educ Students..2019;23(6):297–305.
7. Raeder C, Fernandez-Fernandez J, Ferrauti A. Effects of six weeks of medicine ball training on throwing velocity, throwing precision, and isokinetic strength of shoulder rotators in female handball players. J Strength Cond Res. 2015;29(7),1904–1914.
8. Hammami M, Gaamouri N, Aloui G, Shephard, RJ, Chelly MS. Effects of a complex strength-training program on athletic performance of junior female handball players. Inter J Sport Physiol Perf. 2019;14(2):1–10.9.
9. Mascarin NC, de Lira CAB, Vancini RL, de Castro Pochini A, da Sivla AC, dos Santos Andrade M. Strength training using elastic bands: improvement of muscle power and throwing performance in young female handball players. J Sport Rehabil 2017;26(3):245–252.
10. Hill-Haas SV, Dawson B, Impellizzeri FM, Coutts AJ. Physiology of small-sided games training in football. Sports Med. 2011;41(3):199–220.

11. Mazurek K, Zmijewski P, Makaruk H, Mroz A, Czajkowska A, Witek K. et al. Effects of short-term plyometric training on physical performance in male handball players. J Human Kinet. 2018; 63(1):137–148.
12. Dellal A, Chamari K, Owen AL, Wong DP, Lago-Penas C, Hill-Haas S. Influence of technical instructions on the physiological and physical demands of small-sided soccer games. Eur J Sport Sci. 2011; 11(5):341–346.
13. Halouani J, Chtourou H, Gabbett T, Chouachi A, Chamari, K. Small-sided games in team sports training: a brief review. J Strength Cond Res. 2014; 28(12):3594–3618.
14. Hoffmann JJ, Reed JP, Leiting K, Chiang, CY, Stone, MH. Repeated sprints, high-intensity interval training, small-sided games: Theory and application to field sports. Inter J Sports Physiol Perf. 2014;9(2): 352–357.
15. Chittibabu B. Effect of small sided handball game on aerobic capacity and repeated sprint ability of male handball players. Turk J Sport Exerc. 2014;16(2):22–27.
16. Dello Iacono AD, Ardigo LP, Meckel Y, Padulo J. Effect of small-sided games and repeated shuffle sprint training on physical performance in elite handball players. J Strength Cond Res. 2016; 30(3):830–840.
17. Hermassi S, Chelly MS, Fieseler G, Bartels T, Schulze S, Delank K. Effects of in session explosive strength training on maximal leg strength, jumping, sprinting and intermittent aerobic performance in male handball athletes. Sportverletz Sportschaden. 2017;31(3):167–173.
18. Markovic G, Bradic A. Nogomet-integralni kondicijski trening. Zagreb, GEA Sport; 2008.
19. Iaia FM, Rampini E, Bangsbo J. High-intensity training in football. Inter J Sports Physiol Perf. 2009; 4(3):291–306.
20. World Medical Association. Declaration of Helsinki Ethical principles for medicial research involving human subjects. Jahrbuch fur Wissenchaft Und Ethik. 2009;14(1):233–238.
21. Bosco C, Luhtanen P, Komi PV. A simple method for measurement of mechanical power in jumping. Eur J Appl Physiol Occup Physiol. 1983;50(2):273–282.
22. Metikos D, Prot F, Hofman E, Pintar Oreb, G. Mjerenje bazičnih motoričkih dimenzija sportaša. Zagreb: Fakultet za fizičku kulturu; 1989.
23. Krustrup P, Mohr M, Amstrup T, Rysgaard T, Johansen J, Steensberg A, et al. The Yo-Yo Intermittent Recovery Test: Physiological Response, Reliability, and Validity. Med Sci Sports Exerc. 2003; 35(4):697–705.
24. Dello Iacono AD, 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):835–843.
25. Weir JP. Quantifying test-retest reliability using the intraclass correlation coefficient and the SEM. J Strength Cond Res. 2005; 19(1):231–240.
26. Portney LG, Watkins MP. Fundations of Clinical Research: Applications to Practice.2009.3rd ed. NJ: Pearson Prentice Hall, Upper Saddle River.
27. Cohen J. Statistical power analysis for the behavioral sciences (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum; 1998.
28. Hopkins W, Marshall S, Betterham A, Hanin J. Progressive statistics for studies in sports medicine and exercise science. Med Sci Sports Exerc. 2009;41(1):3–13.
29. 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(4):251–258.
30. Dello Iacono AD, 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):835–843.
31. Hammami A, Gabbett TJ, Slimani M, Bouhlel E. Does small-sided games training improve physical-fitness and specific skills for team sports? A systematic review with meta-analysis. J Sports Med Physical Fitness. 2017:1–25.
32. Dragijsky M, Maly T, Zahlka F, Kunzmann E, Hank, M. Seasonal variation of agility, speed and endurance performance in young elite soccer players. Sport. 2017;5(1):12.
33. Delextrat A, Martinez A. Small-sided game training improves aerobic capacity and technical skills in basketball players. Int J Sports Med. 2014;35(5):385–391.
34. Los Arcos A, Vazquez JS, Martin J, Lerga J, Sanchez 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).
35. Buchheit M, Lepretre PM, Behaegel AL, Millet GP, Cuvelier G, Ahmaidi S, Cardiorespiratory responses during running and sport-specific exercises in handball players. J Sci Med Sport. 2009; 12(3): 399–405.
36. Selmi O, Ouergui I, Levitt DE, Nikolaidis PT, Knechtle B, Bouassida A, Small-Sided Games are More Enjoyable Than High-Intensity Interval Training of Similar Exercise Intensity in Soccer. Open Access J Sports Med. 2020;11:77–84.