



Small-Sided Games Versus High-Intensity Interval Training: Effects on Aerobic Fitness, Agility, and Psychological Responses in Collegiate Female Field Hockey Players

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Abstract

Objectives. The study aimed to examine the impact of small-sided games (SSG) and high-intensity interval training (HIIT) on selected physical and psychological variables among collegiate female field hockey players.

Materials and Methods. Thirty collegiate female field hockey players (age: 20.20 ± 1.58 years) were randomly selected and divided into an SSG group ($n = 15$) and an HIIT group ($n = 15$). Both groups participated in a six-week training program (two sessions a week) alongside regular team practice. The SSG group played 4 vs 4 games on a 30 x 40 m field, while the HIIT group performed 15-s running bouts at 110% maximal aerobic speed (MAS) with 15-s passive recovery intervals. Pre- and post-intervention measurements were conducted for maximal aerobic speed, agility (Modified T-test), neuromuscular power (five-jump test), enjoyment (PACES), and mood state (total mood disturbance; TMD). Independent t-tests and ANCOVA ($p < 0.05$) were used for data analysis.

Results. No significant differences were observed at baseline ($p > 0.05$). Both groups enhanced MAS, but the SSG group demonstrated greater improvements in agility and psychological variables. ANCOVA revealed significant group effects for MAS ($p = 0.014$), agility ($p = 0.002$), PACES ($p = 0.001$), and TMD ($p = 0.001$), favoring SSG. Neuromuscular power did not show any significant differences between the groups.

Conclusions. SSG yielded superior results in agility and psychological responses while being equally effective in improving aerobic fitness. These findings confirm the application of SSG as an ecologically valid and effective conditioning strategy for collegiate field hockey players.

Keywords: small-sided games, high-intensity interval training, field hockey, aerobic fitness, agility, PACES.

Introduction

Field hockey is characterized by intermittent high-intensity activity patterns involving frequent accelerations, decelerations, and rapid directional changes performed in a dynamic competitive environment. Players perform a range of activities during match play, including walking, jogging, sprinting, and executing technical actions such as passing, dribbling, and tackling. These demands place considerable stress on both aerobic and anaerobic energy systems (Spencer et al., 2004; Macutkiewicz and Sunderland, 2011). This therefore makes well-developed neuromuscular performance, agility, and aerobic capacity crucial in

sustaining performance during competition. Besides physical preparedness, psychological variables like pleasure, motivation, and mood have been reported to be essential determinants of training compliance and progress in performance (Scanlan et al., 2014). Traditional conditioning approaches in team sports have primarily relied on structured running-based methods, especially high-intensity interval training (HIIT), to enhance aerobic fitness. HIIT is typically performed in repeated bursts of high-intensity running separated by short intervals of rest, typically performed at or close to anaerobic exhaustion rate. Previous research has consistently demonstrated that HIIT has beneficial effects on cardiovascular function, maximal oxygen uptake and repeated sprint ability (Buchheit & Laursen, 2013; Iaia & Bangsbo, 2010). Consequently, HIIT is now a common means of creating physiological stress-inducing effects in

training numerous team-based sports, such as soccer, rugby and field hockey (Helgerud et al., 2001; Dupont et al., 2004). As a result, HIIT has become a widely adopted method for inducing physiological stress efficiently across various team sports, including soccer, rugby, and field hockey (Helgerud et al., 2001; Dupont et al., 2004).

Despite its physiological effectiveness, HIIT presents several limitations when used in skill-based, open-field sports. The majority of HIIT protocols rely on linear and repetitive running patterns that do not entirely simulate the multidirectional movement, the perceptual tasks and decision-making processes of the competitive settings. Consequently, gains in the physical capacity do not always prove effective when it comes to sport-related performance (Impellizzeri et al., 2006). Furthermore, interval running may be perceived as monotonous, which can decrease pleasure and enthusiasm especially in a long-term training program, and this can influence the participation and compliance of the athlete (Halson, 2014).

As a reaction to such constraints, small-sided games (SSG) have been developed as an alternative means of training, that incorporates physical, technical, and tactical aspects along with sport-specific context. Small-sided games are a subset of the game that is played with a reduced number of players and/or a smaller playing field, which coaches can adjust the training intensity by varying the number of players, size of the playing field, and the rules of the game (Hill-Haas et al., 2011). Past studies, especially on soccer, have demonstrated that SSG has the potential to induce physiological responses just as intense as those that high-intensity interval training can, such as increased heart rate and duration of time spent in aerobic areas of training (Dellal et al., 2012; Owen et al., 2012; Hill-Haas et al., 2009).

In addition to the physiological responses, small-sided games offer a dynamic training environment which involves constant interaction with team-mates and opponents, quick reaction to decision-making, and frequent practice of sport-specific skills. These features align with the ecological theories of learning skills, in which perception and action are intimately bound together in representative task-like conditions (Davids et al., 2013). Subsequently, SSG could lead to higher rates of transfer of training adaptations to competition. Moreover, interactive and competitive features of training in game form have been linked to increased pleasure and intrinsic motivation than traditional methods of conditioning (Selmi et al., 2020).

An upper hand in the reciprocation of similar results, earlier studies in soccer and the other invasion sports have shown where SSG-based training interventions have led to aerobic fitness, agility and movement efficiency improvements (Rampinini et al., 2007; Hill-Haas et al., 2009). These are usually explained by the synergistic outcomes of high-intensity motion patterns, repeated changes of direction, and sport-specific motor requirements of the game-based activities. Conversely, the traditional HIIT is based more on the provision of physiological changes via planned running, and little focused on motor variability and the involvement of perceptions (Buchheit & Laursen, 2013).

However, as much as the scientific evidence surrounding the effectiveness of small-sided games continues to increase, there are some conceptual weaknesses in literature on the topic. Comparisons of training methods have mainly

concerned outcome-based comparisons with little consideration to the underlying mechanisms that create these adaptations. Specifically, the role of physiological load, neuromuscular coordination and cognitive-perceptual demands in sport-specific training situations has not been adequately addressed. Also, the studies exploring the correlations between them in female field hockey athletes are limited, even though the unique technical and tactical features of this sport (Macutkiewicz and Sunderland, 2011).

From a mechanistic perspective, small-sided games can be considered a combined training stimulus that stops at the same time to interact with several systems of adaptation. In contrast to HIIT that mainly causes cardiovascular and metabolic loads by using predetermined patterns of running, SSG presents uninterrupted perception action coupling, reactive decision-making, and bidirectional movement. All these factors could lead to better neuromuscular coordination, higher adaptability in movements, and elevated psychological involvement. Thus, variations in training responses between SSG and HIIT may not be solely attributed to training intensity but also the interplay between physiological, motor and cognitive demands.

Here, the choice of outcome variables can be considered to be a system of adaptation in itself. Maximal aerobic speed (a measure of cardiovascular performance), agility (neuromuscular coordination and change-of-direction ability), and neuromuscular power (capacity to produce explosive force) are all indicators of neuromuscular fitness. Variables of an affective nature like enjoyment and mood state can give us a glimpse into the psychological factors that affect training adherence and performance maintenance. A combination of these variables will make it possible to evaluate the training effectiveness in a multidimensional manner, including physiological, motor, and psychological aspects. Although there has been an increased literature of research on the comparison of small-sided game and high-intensity interval training, the scientific problem is not well described. The available literature has mainly centred on the comparison of outcomes, whereas the mechanistic premise of adapting physiological, neuromuscular and psychological systems in female field hockey players has been dissatisfactory.

Therefore, the aim of the current study was to compare the differences in six weeks of mini-games and high-intensity running on the chosen physical and psychological indicators among the female athletes of field hockey in collegiate institutions. In detail, the maximal aerobic speed, agility, neuromuscular power, enjoyment, and mood state were measured before and after the intervention. The hypothesis was that both training approaches would enhance aerobic fitness, and the small-sided games would yield more during agility and psychological reactions as they are sport-specific and interactive.

Materials and Methods

Study Design

In the current research, one applied experimental design was the randomised pre-test and post-test that was used to study the functioning of two conditioning stimuli, including small-sided games (SSG) and high-intensity interval training (HIIT), on a chosen set of physical and

psychological variables of the impact of these programmes on the chosen group of participants in the case of the study of collegiate women in the field hockey team. The respondents were chosen randomly to be put in an experimental group that exercised SSG or a control group that exercised HIIT. The two groups went through a coordinated six weeks conditioning programme besides their normal field hockey practice. The pre-intervention experiments were done a week prior to the commencement of the training programme whereas the post-intervention tests were taken right after the six weeks of the intervention. The study design enabled the comparison to be made on effectiveness of the sport-specific conditioning intervention utilising small-sided games in comparison to the traditional interval-based conditioning.

Sample Size Estimation

G*Power software (version 3.1) was used to conduct an a priori power analysis to establish the necessary number of samples required to achieve significant differences between groups. Taking a moderate effect size ($f = 0.25$), an 0.05 level of alpha, and 0.80 level of statistical power in analysing covariance (ANCOVA), the estimated minimum of 28 participants were necessary. Consequently, the recruiting of athletes involved was 30, which is sufficient to achieve a robust statistical power of the study (Faul et al., 2007).

Participants

This study was done on thirty female field hockey players of colleges (age 18 to 23 years) who came forward to volunteer in this research. All the athletes were intercollegiate players with an experience of three years of playing and were themselves regularly subjected to institutional training and competition. The participants were randomly divided into the experimental small-sided games group (SSG; $n = 15$) or the control group of high-intensity interval training (HIIT; $n = 15$) based on a randomization selection by computer. All participants gave written informed consent and were briefed on the procedures that will be followed during the study beforehand. The players who have sustained injuries, musculoskeletal disorders, or other medical conditions that could restrict the exercise to high intensity were excluded. The participants were also advised to stick to their normal diet and not to participate in many other conditioning programmes in the course of intervention. Figure 1 demonstrates the participant recruitment, allocation, follow-up and analysis processes. The study was conducted in accordance with the Declaration of Helsinki, and ethical approval was obtained from the institutional research ethics committee prior to commencement.

Training Intervention

The duration of the intervention was six weeks (Table 1), with the participants undergoing two sessions of the conditioning along with their routine training in field hockey. The duration of every session was around 30 to 35 minutes. The experimental and control group adhered to various conditioning regimens, but had similar training frequency and training duration. The experimental group engaged in small-sided games (SSG) player-to-player and setting-to-setting variations of match situations consisting of small playing areas and a smaller number of players. These games were meant to simulate match-specific

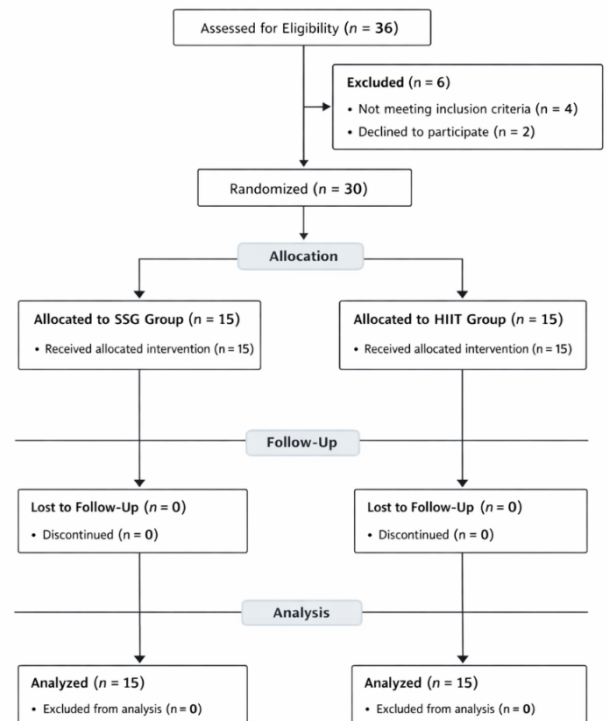


Fig. 1. CONSORT Flow Diagram

requirements in the sense that they included ball involvement on a continuous basis, direction changes as well as timely tactical decision making. The control group performed high-intensity interval training (HIIT) consisting of structured intermittent running bouts at intensities exceeding maximal aerobic speed (MAS). The protocol contained short-duration running intervals repeated and separated with short periods of passivity. The intensity and volume of training was gradually enhanced in the course of the six-week period through manipulation of the duration of gameplay, the number of participants, field area, and the length of running periods.

Training Load Control

Training load was monitored throughout the intervention period to ensure consistency between groups. After every training session, the participants provided the rating of perceived exertion (sRPE) that was measured on the Borg CR-10 scale. The internal training load was determined by multiplying the sRPE score and session duration. Also, an assessment of the heart rate was done during chosen sessions to ensure that the participants worked in a range of target intensity which was about 85-95% of the maximum heart rates. Such procedures made sure that the two training programmes placed similar physiological stress although training format was different (Foster et al., 2001).

Testing Procedures

Every participant was physically and psychologically evaluated before and after the training intervention. All of the tests were done on the same field and similar environmental conditions, to maintain the consistency. All the participants underwent a standardised 10-minute warm-up which included light jogging, dynamic stretching and

Table 1. Six-Week Training Intervention Schedule for the Experimental (SSG) and Control (HIIT) Groups

Week	Experimental Group – Small-Sided Games (SSG)	Control Group – High-Intensity Interval Training (HIIT)
Week 1	4 vs 4 games on 30 × 40 m field; 4 bouts × 4 min; 2 min passive recovery between bouts. Emphasis on ball possession and continuous play.	Intermittent running: 15 s at 110% MAS + 15 s passive recovery; 4 sets × 4 min; 2 min passive recovery between sets.
Week 2	4 vs 4 games; 4 bouts × 4 min; field size unchanged. Players encouraged to increase tempo and maintain high pressing intensity.	Same protocol as Week 1; athletes instructed to maintain running speed above MAS target; 4 sets × 4 min intervals.
Week 3	4 vs 4 games; 5 bouts × 4 min; 2 min recovery; additional tactical rule introduced (maximum 3 touches per player) to increase movement intensity.	Intermittent running: 15 s at 110% MAS + 15 s passive recovery; 5 sets × 4 min intervals; 2 min recovery between sets.
Week 4	5 vs 5 games on 35 × 45 m field; 4 bouts × 5 min; 2 min recovery; emphasis on quick ball circulation and attacking play.	Intermittent running: 20 s at 110% MAS + 20 s recovery; 4 sets × 5 min; 2 min passive recovery between sets.
Week 5	4 vs 4 games; reduced field size (28 × 38 m) to increase intensity; 5 bouts × 5 min; 2 min recovery; rule: immediate transition after ball loss.	Intermittent running: 20 s at 110% MAS + 20 s recovery; 5 sets × 5 min; 2 min recovery between sets.
Week 6	Mixed SSG formats (3 vs 3 and 4 vs 4); field size 25 × 35 m; 5 bouts × 5 min; 2 min recovery; maximum competitive intensity encouraged.	Intermittent running: 20 s at 115% MAS + 20 s recovery; 5 sets × 5 min; 2 min recovery between sets.

mobility exercises followed by testing. This was to achieve reduced risk on injury and enhance reliability of testing through standardised warm up procedures (Bishop, 2003).

Maximal Aerobic Speed (MAS)

The aerobic fitness was evaluated by a progressive running test which is aimed to identify the maximal aerobic speed. Participants were required to run at progressively increasing speeds until volitional exhaustion. Maximal aerobic speed was the highest running speed that was attained during the test. The assessment of maximal aerobic speed that has been extensively applied among team sport athletes is progressive field tests, which have high validity and reliability (Buchheit, 2008).

Agility Test

Agility performance was determined by the use of Modified Agility T-test used to assess the capacity to speed up, slow down and change direction quickly. The participants were made to run at full speed, jog along and reverse in a fixed route. Digital stopwatch was used in determining the total time of completion. The T-Test has been found to be very reliable and valid in the measure of agility among athletes (Pauole et al., 2000).

Five-Jump Test

Neuromuscular power of lower body was measured in the form of the five-jump test (5JT). The participants were required to take 5 successive horizontal jumps using alternate legs after standing position. A measuring tape was used to determine the total distance between the starting point to the ultimate landing location. The five-jump test has been found to be a good field test in the assessment of explosive power of lower-body among athletes (Chamari et al., 2004).

Psychological Measures

The effects of the training interventions were assessed based on validated questionnaires psychological reactions to the examination.

Physical Activity Enjoyment Scale (PACES)

The Physical activity enjoyment scale (PACES) was used to measure enjoyment related to the training. The scale of the questionnaire includes various questions where the higher the score the more enjoyable it is to take part in physical activity (Kendzierski and DeCarlo, 1991).

Total Mood Disturbance (TMD):

The profile of mood states (POMS) questionnaire was used to measure mood states. The individual mood component scores were added to obtain the total mood disturbance scores using the scoring procedures (McNair et al., 1971).

Reliability of Tests

The performance tests utilised in the current study have shown that they are highly reliable in their test in the past studies. Most of the tests high test-retest reliability experiments displaying high test-retest reliability coefficients of more than 0.85 have demonstrated high test-retest reliability (Table 2), consistent measurements in populations involving athletes (Pauole et al., 2000; Chamari et al., 2004).

Table 2. Reliability of Selected Performance Tests

Test	Variable	Reliability (ICC)
Progressive Running Test	Maximal Aerobic Speed	0.91
Modified T-Test	Agility	0.89
Five Jump Test	Lower-body Power	0.92

All tests demonstrated high reliability (ICC > 0.85), indicating good measurement consistency.

Statistical Analysis

Statistical analyses were conducted using SPSS version 25.0. All variables were determined by the calculus of

descriptive statistics in the form of the mean standard deviation. Before inferential analyses, the assumptions of normality and homogeneity of variance were tested in Shapiro/wilk test and Levene test respectively. Independent samples t-tests were used to assess the differences in the baselines across the groups. Analysis of covariance (ANCOVA) was used to determine the effects of the intervention by putting in the pretest scores as covariates to correct the baseline differences. The magnitude of training effect was computed by using Cohen d. All analyses were set at $p < 0.05$ which is the statistical significance (Cohen, 1988).

Results

The descriptive characteristics of the participants at baseline are presented (Table 3).

Table 3. Baseline Descriptive Characteristics of the Participants

Variable	Experimental Group (SSG) (n = 15)	Control Group (HIIT) (n = 15)
	Mean ± SD	Mean ± SD
Age (years)	20.13 ± 1.62	20.27 ± 1.54
Height (cm)	163.45 ± 5.11	162.98 ± 4.87
Body Mass (kg)	57.82 ± 4.76	58.34 ± 4.58
Playing Experience (years)	5.27 ± 1.41	5.13 ± 1.36
Maximal Aerobic Speed (km·h ⁻¹)	13.48 ± 0.79	13.42 ± 0.83
Agility (Modified T-Test, s)	10.61 ± 0.46	10.65 ± 0.49
5-Jump Test Distance (m)	10.31 ± 0.58	10.27 ± 0.62
PACES Score (Enjoyment)	93.74 ± 6.18	92.96 ± 6.41
Total Mood Disturbance (TMD)	96.21 ± 8.35	97.08 ± 8.11
Hooper Index Score	9.12 ± 1.73	9.27 ± 1.65

Note. Values are presented as Mean ± Standard Deviation (SD). No significant differences were observed between groups at baseline ($p > 0.05$), indicating comparable initial characteristics.

The experimental and control groups (SSG and HIIT, respectively) were similar regarding age, anthropometric issues, and performance indicators during the baseline. There are no significant variations between groups before the intervention, meaning that the participants were not that heterogeneous before the intervention.

The pre- and post-intervention changes in the selected physical and psychological variables are presented (Table 4). Following the six-week training program, both groups demonstrated improvements in maximal aerobic speed (MAS). The SSG group increased from 13.48 ± 0.79 km·h⁻¹ to 14.72 ± 0.68 km·h⁻¹, while the HIIT group improved from 13.42 ± 0.83 km·h⁻¹ to 14.41 ± 0.74 km·h⁻¹. For agility performance, the SSG group showed a greater reduction in agility time compared with the HIIT group. Agility time decreased from 10.61 ± 0.46 s to 9.94 ± 0.41 s in the SSG group, whereas the HIIT group improved only slightly from 10.65 ± 0.49 s to 10.47 ± 0.46 s. Changes in neuromuscular power were low in both groups and did not reach statistical significance. With respect to mental responses, the PACES scores showed a strong increase in the SSG group, improving from 93.74 ± 6.18 to 104.62 ± 5.83 , whereas the HIIT group demonstrated only a minor increase. In contrast, total mood disturbance (TMD) decreased in the SSG group but increased slightly in the HIIT group.

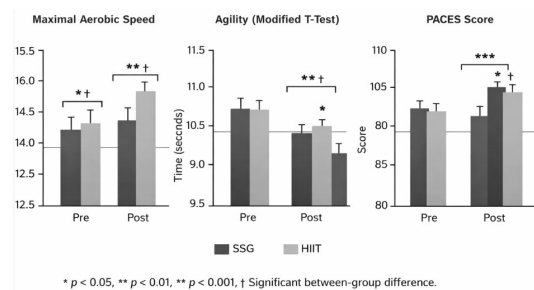


Fig. 2. Pre-Post Changes in MAS, Agility, and PACES

To determine the true intervention effect after adjusting for baseline differences, an analysis of covariance (ANCOVA) was performed. The results of this analysis are presented (Table 5). The ANCOVA analysis revealed a significant group effect for outside aerobic speed ($F = 6.84, p = 0.014$), indicating that the improvement in aerobic fitness was greater in the SSG group compared with the HIIT group. Similarly, a significant group effect was observed for agility performance ($F = 11.72, p = 0.002$), demonstrating that the SSG training program produced significantly greater improvements in agility. In contrast, no significant group difference was found for neuromuscular power (five-jump

Table 4. Pre- and Post-Intervention Changes in Physical and Psychological Variables

Variable	Group	Pre-Test Mean ± SD	Post-Test Mean ± SD	Mean Change	Effect Size (d)	p-value
Maximal Aerobic Speed (km·h ⁻¹)	SSG	13.48 ± 0.79	14.72 ± 0.68	+1.24	1.69	0.001*
	HIIT	13.42 ± 0.83	14.41 ± 0.74	+0.99	1.25	0.003*
Agility (Modified T-Test, s)	SSG	10.61 ± 0.46	9.94 ± 0.41	-0.67	1.54	0.001*
	HIIT	10.65 ± 0.49	10.47 ± 0.46	-0.18	0.38	0.089
Five-Jump Test (m)	SSG	10.31 ± 0.58	10.49 ± 0.57	+0.18	0.31	0.122
	HIIT	10.27 ± 0.62	10.43 ± 0.61	+0.16	0.26	0.148
PACES Score	SSG	93.74 ± 6.18	104.62 ± 5.83	+10.88	1.82	0.001*
	HIIT	92.96 ± 6.41	95.31 ± 6.07	+2.35	0.37	0.094
Total Mood Disturbance	SSG	96.21 ± 8.35	88.42 ± 7.12	-7.79	0.98	0.004*
	HIIT	97.08 ± 8.11	101.36 ± 8.45	+4.28	0.52	0.071

*Significant at $p < 0.05$

Table 5. Analysis of Covariance (ANCOVA) Results for Post-Test Scores

Variable	Source	Sum of Squares	df	Mean Square	F-value	p-value	Partial Eta Squared (η^2)
Maximal Aerobic Speed	BG	1.36	1	1.36	6.84	0.014*	0.20
	WG	5.37	27	0.20			
Agility (Modified T-Test)	BG	2.14	1	2.14	11.72	0.002*	0.30
	WG	4.94	27	0.18			
Five-Jump Test	BG	0.18	1	0.18	1.02	0.321	0.04
	WG	4.75	27	0.18			
PACES Score	BG	689.31	1	689.31	19.63	0.001*	0.42
	WG	947.22	27	35.08			
Total Mood Disturbance	BG	1265.48	1	1265.48	16.94	0.001*	0.39
	WG	2015.73	27	74.65			

* Statistically significant at $p < 0.05$

test). For the mental variables, the analysis showed significant group effects for PACES ($F = 19.63$, $p = 0.001$) and total mood disturbance ($F = 16.94$, $p = 0.001$), indicating that the SSG intervention resulted in greater improvements in enjoyment and mood state compared with HIIT.

Figure 2 illustrates the variables demonstrating significant post-intervention effects between groups. Significant improvements were observed for maximal aerobic speed, agility performance, and enjoyment (PACES), with greater adaptations in the small-sided games group. In contrast, no significant between-group effect was found for neuromuscular power, as assessed by the five-jump test.

Discussion

The findings indicate that six weeks of small-sided games (SSG) and high-intensity interval training (HIIT) positively influenced selected physical and psychological variables in collegiate female field hockey players. While both training modalities significantly improved maximal aerobic speed, SSG resulted in greater improvements in agility and psychological responses. No significant changes were observed in neuromuscular power. These findings extend previous research by providing a more integrated understanding of how different conditioning strategies influence multiple systems of adaptation in team-sport athletes (Buchheit and Laursen, 2013; Hill-Haas et al., 2011).

The improvements in maximal aerobic speed in both groups may be attributed to different, yet complementary, physiological processes. High-intensity interval training has been proven to be an effective stimulus of central cardiovascular adaptations, such as augmented stroke volume, augmented cardiac output, and augmented oxygen transport capacity (Helgerud et al., 2001; Buchheit & Laursen, 2013). Such adaptations are mainly instigated by recurrent exposure to near-maximal intensities in a controlled format. Conversely, small-sided games probably cause similar aerobic adaptations with intermittent high-intensity exercise interspersed with game-based exercise. The repeated alternations between offensive and defensive movements, the frequent accelerations and decelerations can cause significant metabolic loads, which can in turn trigger central and peripheral adaptations (Hill-Haas et al.,

2009). The marginally higher increase in the SSG group may be explained by the fact that effort is variable and self-regulated during the game play, and thus can facilitate long-term engagement at high intensities.

One of the main findings was the significantly greater improvement in agility performance following SSG compared with HIIT. This distinction may be explained by the principle of specificity and the system of ecological processes. Small-sided games naturally involve athletes reacting to ever-evolving environmental factors, such as the position of opponents, ball control, and space. These conditions facilitate perception-action coupling, wherein decision-making and motor execution are closely coupled (Davids et al., 2013). Consequently, athletes will be exposed to repetitive, sport-specific stimuli that can improve neuromotor coordination, reactive strength and movement efficiency. Conversely, HIIT protocols are usually predetermined, linear running patterns with little variation and limited mental activity. Although useful in enhancing metabolic capacity, these conditions might be inadequate to activate neuromotor processes involved in quick change-of-direction performance. As such, the higher agility improvements in the SSG group might be attributed to the combination of cognitive and motor tasks and not physical load per se (Rampinini et al., 2007; Davids et al., 2013).

In contrast, neither training modality resulted in significant changes in neuromuscular power, as assessed by the five-jump test. This observation indicates that the main focus of both SSG and HIIT is on metabolic and coordinative modifications, as opposed to the maximal production of force. Though small-sided games require numerous accelerations and explosive motions, the magnitude and mechanical loading might be insufficient to cause significant neuromuscular adjustments related to the stretch shortening cycle. Likewise, HIIT training programs focus on the development of energy systems, as opposed to maximal output. Past studies have always shown that the enhancement in explosive power is better through resistance training or plyometric training that is specifically geared towards neuromuscular activation and force production (Markovic & Mikulic, 2010). Thus, the lack of meaningful differences in neuromuscular power in the findings can probably be explained by the specificity of the training stimuli.

The observed psychological responses provide further insight into the differences in the effects of the two training modalities. Participants in the SSG group demonstrated greater improvements in enjoyment and decrease in mood disturbance than the HIIT group. These findings may be explained in terms of self-determination theory, which lays stress on autonomy, competence, and relatedness in the process of developing intrinsic motivation. These elements are inherent in small-sided games as they offer a chance to make decisions, socialize, and express their skills in a competitive setting. These conditions will probably increase intrinsic motivation and positive affective reactions (Selmi et al., 2020). HIIT, on the contrary, is repetitive, externally regulated activity with a small range of variability, which can potentially decrease engagement and perceived monotony. Since psychological aspects are significant in the training of adherence and long-term development of athletes, these findings indicate the value-added of game-based training methods (Scanlan et al., 2014).

In a more general sense, These findings support the concept that training adaptations in team sports are the outcome of the interactions between physiological, neuromuscular, and cognitive systems, but not the reaction to the physical load independently. Small-sided games seem to be a multidimensional training stimulus, which concurrently activates these areas, which improves performance and engagement. Although conventional forms of conditioning like HIIT are still effective in enhancing aerobic capacity, they may not be as effective in transferring to sport-specific performance when not supplemented with context-specific training. These findings support the role of incorporating representative learning settings in conditioning programs to achieve the fullest training benefits (Hill-Haas et al., 2011).

These findings imply that conditioning in team sports must not be thought of as a single physiological loading, but as a combination of metabolic stress, neuromotor coordination, and perceptual-cognitive demands. In this regard, training strategies like small-sided games might have better ecological validity in promoting transfer of adaptations to competitive performance.

Although the study has its strengths, a number of limitations must be noted. The intervention period was not very long (six weeks), and this might not have been enough to produce any meaningful neuromuscular changes. Also, the sample was restricted to a certain population of collegiate female field hockey players, which can influence the extrapolation of the findings. In addition, the research lacked direct physiological observation like oxygen uptake, blood lactate level, or GPS-tracked movement data, which would have helped to gain a more in-depth understanding of the processes behind the identified adaptations. Further studies are advised to include longer intervention periods, larger samples, and objective physiological and match-related performance outcomes to gain a better understanding of the processes of adaptation.

Conclusions

This study examined the effects of six weeks of small-sided games (SSG) and high-intensity interval training (HIIT) on selected physical and psychological variables in collegiate female field hockey players. Both training modalities

significantly improved maximal aerobic speed, indicating their effectiveness in enhancing aerobic fitness. However, SSG produced greater improvements in agility and psychological responses, likely due to its sport-specific, multidirectional, and interactive nature. Neither intervention resulted in significant changes in neuromuscular power, suggesting that additional strength or plyometric training may be required to enhance explosive performance. Overall, these findings support the use of small-sided games as an effective and practical conditioning strategy that simultaneously develops physical performance and psychological engagement in team-sport athletes.

Conflict of Interest

The authors declare no conflict of interest.

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Ethical Approval

The study was conducted in accordance with the ethical guidelines of the Institutional Research Ethics Committee of Hindustan Institute of Technology and Science, Chennai, Tamil Nadu, India (HITS/CRC/004/24SR923002) in carrying out the study. All the participants were informed by signing a written informed consent prior to the participation. The paper had been in adherence to the principles of the Declaration of Helsinki (2013 update).

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This research received no external funding.

Data Availability Statement

The data supporting the findings of this study are derived from the author's ongoing PhD research and are not publicly available due to institutional and ethical constraints. However, data may be made available from the corresponding author upon reasonable request, subject to institutional approval.

AI Transparency Statement

The authors confirm that no artificial intelligence tools were used to generate the scientific content of this manuscript. Language editing assistance was used to improve clarity and readability, and all content was critically reviewed and approved by the authors.

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Ігри неповними складами проти високоінтенсивних інтервальних тренувань: вплив на аеробну підготовленість, спритність та психологічні реакції студенток-хокеїсток на траві

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Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 9 с., 5 табл., 2 рис., 26 джерел.

Мета дослідження. Мета дослідження полягала у вивченні впливу ігор неповними складами (ІНС) та високоінтенсивних інтервальних тренувань (ВІТ) на обрані фізичні та психологічні показники студенток-хокеїсток на траві.

Матеріали і методи. Тридцять студенток-хокеїсток на траві (вік: $20,20 \pm 1,58$ року) були відібрані за методом рандомізації та розділені на групу ІНС ($n = 15$) та групу ВІТ ($n = 15$). Обидві групи брали участь у шеститижневій програмі тренувань (два заняття на тиждень) паралельно з регулярною практикою командних тренувань. Група ІНС грала у форматі 4 проти 4 на майданчику розміром 30×40 м, тоді як група ВІТ виконувала 15-секундні бігові серії на рівні 110% від максимальної аеробної швидкості (МАШ) з 15-секундними інтервалами пасивного відновлення. На перед- та постінтервенційному етапах проводилися вимірювання показників максимальної аеробної швидкості, спритності (модифікований Т-критерій Стьюдента), нервово-м'язової потужності (тест на 5 стрибків), рівня задоволення від занять фізичною активністю (шкала PACES) та психоемоційного стану (загальне порушення настрою; ЗПН). Для аналізу даних використовувалися t-критерії для незалежних вибірок та коваріаційний аналіз ($p < 0,05$).

Результати. На початковому етапі дослідження значущих відмінностей не спостерігалось ($p > 0,05$). В обох групах покращився показник МАШ, проте група ІНС продемонструвала суттєвіші зрушення у показниках спритності та психологічних змінних. Коваріаційний аналіз виявив значущі групові ефекти щодо показників МАШ ($p = 0,014$), спритності ($p = 0,002$), PACES ($p = 0,001$) та ЗПН ($p = 0,001$) на користь тренувань за методикою ІНС. Показники нервово-м'язової потужності не продемонстрували статистично значущих відмінностей між групами.

Висновки. Ігри неповними складами забезпечили кращі результати у розвитку спритності та психологічних реакцій, продемонструвавши рівноцінну ефективність щодо покращення аеробної підготовленості. Ці результати підтверджують доцільність застосування методики ІНС як екологічно валідної та ефективної кондиційної стратегії підготовки студенток-хокеїсток на траві.

Ключові слова: ігри неповними складами, високоінтенсивне інтервальне тренування, хокей на траві, аеробна підготовленість, спритність, PACES.

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