ORIGINAL ARTICLE

Optimizing the potentials of field hockey players through complex and contrast training on physiological and biochemical responses

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ABSTRACT

In the current scenario of field hockey, players are continuously looking for new ways to improve their performance on the field, particularly in terms of power moves. Throughout this exploration, the current study examined the specific effects of complex and contrast training on field hockey player's physiological and biochemical responses. A total of 45 male field hockey players (mean (SD); weight: 63.62 (4.54) kg, height: 1.67(0.06) cm, and age: 19.42(1.18) yrs.) were randomly assigned to three equal groups namely complex training group (COM), contrast training group (CNST) and control group (CON). All the selected physiological and biochemical outcome measures have been tested baseline (T1) and after 12- weeks of training intervention (T2) assessments. Since the CON group was practicing field hockey every day, they were regarded as an active CON group. The intervention in the given period significantly improved VC and VO_{2max}, positively impacting respiratory function. However, no notable changes were observed in RHR, HDL, and LDL levels. Forthcoming research may emphasize the refining of intervention protocols to address these areas and further understand the underlying mechanisms for optimal cardiovascular health and performance enhancement for field hockey players.
Keywords: Sport medicine, High-density lipoprotein, Low-density lipoprotein, Training intervention, Vital capacity, VO_{2max}, Resting heart rate.

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INTRODUCTION

A long-standing sport, field hockey has experienced significant and quick transformation in recent years. The introduction of artificial turf (Young, 2019), changes in the free hit rule (Tromp and Holmes, 2017), one versus one tie-breaker from sport penalty stroke (Hoskens et al., 2023), elimination of the offside rule (Asembo et al., 1998), and changes in the duration and period of the match from 35 minutes two half to 15 minutes four quarters has altered the technical, tactical, and physiological demands of the players at every level, but especially at the professional level. Playing field hockey requires brief bursts of vigorous running, which may demand an equal amount of anaerobic and aerobic energy to cover longer distances (Kusnanik et al., 2018). Field hockey looks to be aerobically demanding due to its constant motion (Mcguinness et al., 2017), but it also demands regular anaerobic exertion for power movements (Lemmink and Visscher, 2006). Modern field hockey is heavily reliant on physiology as it directly affects players' performance and endurance. Besides strength and agility (Krishnan and Rajawadha, 2020), the sport requires a high level of cardiorespiratory (Fedotova, 2001) as well as cardiovascular fitness (Lin et al., 2023) and endurance. To maintain the intense running, sprinting, and quick changes of direction throughout the game, players must possess excellent aerobic capacity (15 minutes of each quarter). In exercise physiology research, the development of physical fitness has been linked with the improvement of basic biochemical processes in exercise metabolism (White and Ismail, 1978). On-field performance is optimized by the biochemical composition of the athlete (Seshadri et al., 2019). By monitoring these variables on a regular basis, field hockey players can gain valuable insight into their health, metabolism, and cardiovascular system (Manna et al., 2011). Several training interventions have been proven to be effective on the physiological aspects of field hockey players (Hanjabam and Kailashiya, 2014; Roberts, 2016; Sarkar et al., 2019; H. B. Sharma and Kailashiya, 2018). However, some of the training interventions have explored positive results in biochemical variables (Hazar et al., 2015; Manna et al., 2009, 2016). Those interventions include plyometric training (Rangaraj and Ganapathy, 2024) and strength training (Hanjabam and Kailashiya, 2014).

Plyometrics involves high-intensity movements that combine rapid eccentric and concentric muscle contractions. It is one of the most important components of modern athletic conditioning programs. This program should be tailored to an athlete's position and sport to enhance its specificity and imitate its assigned sport-specific activities. it can be specific in terms of movements, weights, angular velocities, and metabolic demands (Davies et al., 2015). Plyometric exercise is beneficial for a variety of health and sports-related issues as of yet. Plyometric exercise, for instance, has been shown to improve bone mass in addition to improving muscle strength, endurance, agility, and running (Grgic et al., 2021). Resistance training has the potential to improve general health and well-being by improving bone, muscle, tendon, and ligament strength and toughness; strengthening joints; preventing injuries; increasing bone density; improving metabolism; improving cardiac function; and raising the good cholesterol (Azeem and Mohammed, 2019). The term strength training is often used synonymously with resistance training (Stricker et al., 2020). Some of the previous studies reported that combined resistance and plyometric training intervention had explored positive effects when compared to isolated training (Ahmad dar and Kalimuthu, 2021; Allégue et al., 2023). Complex training (COM) is a broad, efficient approach to physical training that combines a number of methods to maximize an athlete's physical fitness and performance. In order to improve power, speed, and overall athletic ability, strength training exercises are usually combined with explosive movements or stretch-shortening cycles. In order to increase the power output during the plyometric activity, COM mixes biomechanically identical plyometric activities with heavy resistance exercises in the same program. For instance, squats jump right after heavy-weight squats (Bevan et al., 2009). Furthermore, as would happen in the absence of the previous heavy resistance set, this results in an improved performance of the next lighter set (Matthews et al., 2009). Contrast training (CNST) is described as integrating the use of heavy loads and lighter load exercises in the same training session (Alves et al., 2010). These modes employ the same exercise technique, but at different intensities, to take advantage of the PAP effect. CNST is particularly described as a collection of exercises that uses contrasting heavy and light loads. All high-load strength exercises are performed at the start of the session, and all lower-load power activities are performed at the second half (Cormier et al., 2020b). For instance, during the first half of the training session (beginning); weight training activities like hard squats and bench presses, can be practiced. During the second half of the session (at the end); plyometric workouts like medicine balls throw can be practiced. COM and CNST are both forms of high-intensity training that combine resistance training with plyometrics to enhance explosive power and athletic performance. In COM, plyometric exercises are performed after a strenuous resistance workout with the goal of enhancing power output through the use of post-activation potentiation. It is necessary to carefully manipulate training variables, including intensity, volume, and frequency, in order to achieve maximal benefits from the intervention (Murlasits et al., 2012).

Several studies focused on the acute effectiveness of COM as well CNST among various trained populations(Clark et al., 2006; Liossis et al., 2013; Matthews et al., 2009; Smilios et al., 2005). Some of the studies focused on the long-term effectiveness of COM as well CNST among different sports populations such as football (El-Shafee, 2017; Garci´A-Pinillos et al., 2014; M. Hammami et al., 2017; M. Hammami, Gaamouri, Shephard, et al., 2019; M. Z. Hammami et al., 2017; Spineti et al., 2019), handball (M. Hammami, Gaamouri, Aloui, et al., 2019), basketball (Román et al., 2017; Santos and Janeira, 2008), rugby (Argus et al., 2012; Bevan et al., 2009), and volleyball (Umaran et al., 2020). However, few studies explored the induced effect of COM and CNST among field hockey players (Rathi et al., 2023; Thapa et al., 2023). Thus far, limited studies have observed the effect of COM and CNST on vital capacity, VO_{2max}, and resting heart rate (Kanniyan and Syed, 2013) under physiological variables (Rajeshkumar and Muralitharan, 2023) among trained athletes, especially on field hockey players. Only a few studies have explored the influence of various training on HDL and LDL under biochemical variables among trained athletes (Bal et al., 2012; Manna et al., 2010; Ouerghi et al., 2014). For evaluating training and assessing the health, metabolism, and cardiovascular status of field hockey players, physiological and biochemical variables play a key role. Coaches may benefit from regular monitoring of physiological and biochemical variables during training at various stages of growth and development for the purpose of training and selecting players at different ages (Manna et al., 2010). Thus, the focus of the current study is to determine how COM and CNST affect field hockey player's vital capacity, VO_{2max}, resting heart rate, and levels of HDL and LDL.

METHODS AND MATERIALS

Participants

The required sample size for the study was determined using G*Power 3.1.9.6 (Kang, 2021), developed by Franz Faul from the University of Kiel, Germany. The following variables were included in the a priori: compute required sample size - given, power, and effect size for within-between interaction in repeated measures ANOVA: three groups, two measurements, alpha error < .05, desired power (1-ß error) = 0.80 (Park et al., 2020), Non-sphericity correction = 1, the correlation between repeated measures = 0.5, and effect size (f) of 0. 25 (Cohen, 1992). The computed sample size indicated that a minimum of 42 participants would be required to achieve statistical significance in the study (Figure1). A slightly larger sample size of 50 male participants was recruited in order to account for potential participant dropout. This approach was taken to ensure the study's strength and reliability, allowing for a margin of safety in case of unexpected participant withdrawal. According to the exclusion and inclusion criteria, 50 field hockey players agreed to participate in the present study from Union Christian College, Aluva, India, who had six years of playing experience in the field hockey. Prior to the recruitment of the all-field hockey players the researcher had given the whole ideas and objectives of the study verbally as well as written sheet. All the field hockey players completed the informed consent sheet prior to the start of any procedure. However, completing the remaining phases of the study, five field hockey players were excluded due to their pre-existing injury record. While collecting the T1 assessment 45 participants (mean (SD); weight: 63.62(4.54) kg, height: 1.67(.06) cm, and age: 19.42(1.18) yrs.) were considered as study sample (n = 45). The selected samples had no history of Musculo skeletal injuries. According to the Helsinki Declaration, the study was approved by the Institutional Ethical Committee at Pondicherry University, India. After twelve weeks of COM and CNST intervention, T2 was completed for the study samples (n = 45). There were no dropouts after the commencement of the training program.

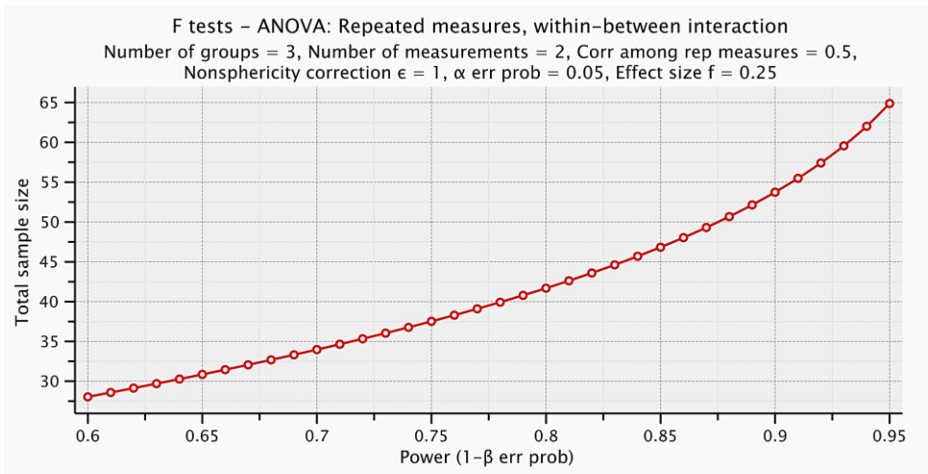

Figure 1. Sample size estimation through G*Power software.

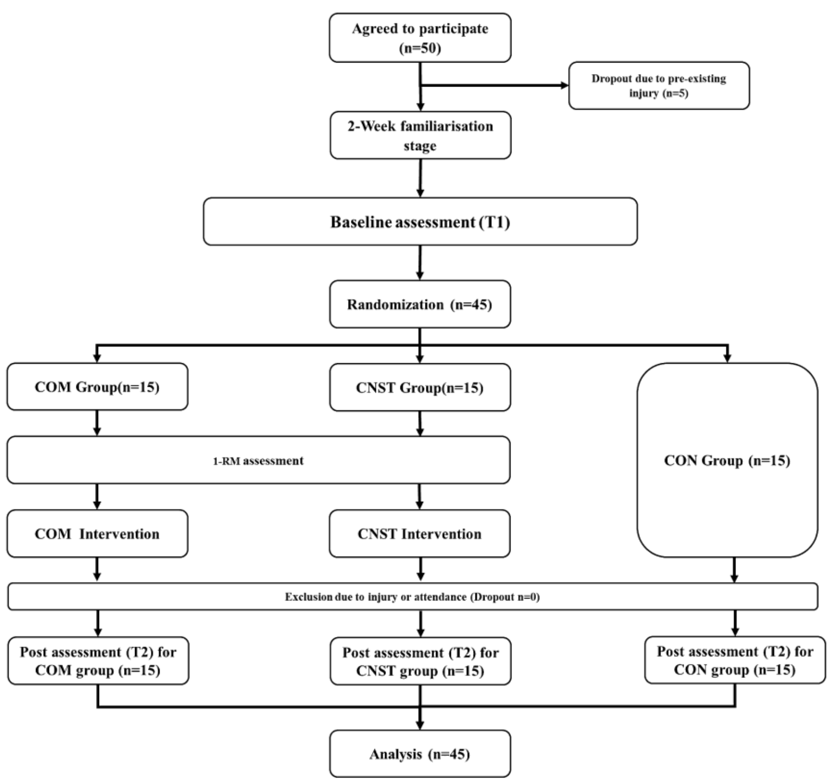

Figure 2. Sampling size in different stages of research.

Study design

A 3x2 mixed model design (group x time) was used in this current study, and the purposive sampling technique was implemented to assign inclusion criteria for the sample selection. After the T1 assessment, 45 field hockey players were randomly allocated to the two experimental (COM = 15 and CNST = 15) groups and the control group (CON = 15). Before the 12- weeks of COM and CNST intervention, the participants of the two experimental groups had two weeks of familiarisation stage, and the CON group underwent regular activity. Training interventions were done using the proper progressive load method, which was based on the one-repetition maximum for each individual. The outcome measures of vital capacity, resting heart rate, VO_{2max}, HDL, and LDL were tested in T1 (before intervention) and T2 (after intervention) assessments. Following the randomization of the research samples (n = 45), no participant was dropped for any reason. Finally, a total of 45 field hockey players were included in the T2 assessment. The whole process and sampling sizes in different stages are presented in Figure 2.

Intervention

At Union Christian College Aluva, 12- weeks of complex and contrast training intervention were held for the field hockey players, with each training session for 60 minutes, which included the general and specific warming up, training intervention, and cooling down and three sessions in a week (Monday to Saturday) were conducted with proper resting periods. For the two training intervention groups (CON and CNST), two weeks of familiarisation were conducted before the study intervention to ensure the participants were well-adapted to the training. The training intervention began with an intensity of 60–70% for each participant and each training group.

Table 1. COM training program.

Indicator	Exercise	Set	Repetition
Week 1-3 60-70% 1RM	Chin-ups	1-2	8-10
	Medicine ball overhead pass	1-2	6-8
	Leg curl	1-2	8-10
	Single-leg lateral hop	1-2	6-8
	Chest press	1-2	8-10
	Box jump	1-2	6-8
Week 4-6 65-75% 1RM	Chin-ups	2-3	8-12
	Medicine ball overhead pass	2-3	6-10
	Leg curl	2-3	8-12
	Single-leg lateral hop	2-3	6-10
	Chest press	2-3	8-12
	Box jump	2-3	6-10
Week 7-9 70-80% 1RM	Chin-ups	2-3	10-12
	Medicine ball overhead pass	2-3	8-10
	Leg curl	2-3	10-12
	Single-leg lateral hop	2-3	8-10
	Chest press	2-3	10-12
	Box jump	2-3	8-10
Week 10-12 75-85% 1RM	Chin-ups	3-4	10-12
	Medicine ball overhead pass	3-4	8-10
	Leg curl	3-4	10-12
	Single-leg lateral hop	3-4	8-10
	Chest press	3-4	10-12
	Box jump	3-4	8-10

Note. 1 RM = 1 repetition maximum.

Table 2. CNST training program.

Indicator	Exercise	Set	Repetition
Week 1-3 60-70% 1RM	Half squat	1-2	8-10
	Bench press	1-2	8-10
	Calf press or leg press	1-2	8-10
	Vertical jump	1-2	6-8
	Medicine ball standing side wall throw	1-2	6-8
	Zig zag hops	1-2	6-8
Week 4-6 65-75% 1RM	Half squat	2-3	8-12
	Bench press	2-3	8-12
	Calf press or leg press	2-3	8-12
	Vertical jump	2-3	6-10
	Medicine ball standing side wall throw	2-3	6-10
	Zig zag hops	2-3	6-10
Week 7-9 70-80% 1RM	Half squat	2-3	10-12
	Bench press	2-3	10-12
	Calf press or leg press	2-3	10-12
	Vertical jump	2-3	8-10
	Medicine ball standing side wall throw	2-3	8-10
	Zig zag hops	2-3	8-10
Week 10-12 75-85% 1RM	Half squat	3-4	10-12
	Bench press	3-4	10-12
	Calf press or leg press	3-4	10-12
	Vertical jump	3-4	8-10
	Medicine ball standing side wall throw	3-4	8-10
	Zig zag hops	3-4	8-10

Note. 1 RM = 1 repetition maximum.

The intensity was implemented based on the one-repetition maximum test conducted for each participant. Both COM and CNST training were a combination of plyometric and resistance training. In COM training, biomechanically similar weight training exercises are alternated with lighter-load power exercises, set-for-set (e.g., chin-ups followed by medicine ball overhead pass) (Cormier et al., 2020a). CNST training is described as a combination of training that incorporates the utilization of contrasting heavy and light loads, with all high-load strength exercises done at the beginning of the session and all low-load power activities at the conclusion (Cormier et al., 2020a). Detailed information about the COM and CNST training intervention can be found in Table 1 and Table 2, respectively.

Load measurement

Individualized training intensity was designed using the frequently used one-repetition maximum test. Prior to the commencement of the familiarization stage, 1RM evaluations were performed using the procedures described in prior research (Atalag et al., 2021). Before each evaluation, a 10-15-minute general warm-up was performed, which included jogging, strides and dynamic stretching, followed by full-body freehand squats, whole-body walking lunges, and whole-body push-ups. A quick warm-up included five to ten repetitions with a load of 40-50%, followed by three to five repetitions at 50-60% of the anticipated 1RM. During the specified warm-up and test, trained spotters assured safety. The weight was then gradually raised in increments of 5 kg or less to reach the 1RM in a maximum of five tries. The time between 1RM efforts was four minutes. For the CON group, there was no 1RM data available.

Outcome measures

Based on the outcome measures used in this study, solid evidence for the conclusions could be drawn. VC, VO_{2max}, and RHR were used in the physiological outcome measures in this study. HDL and LDL levels were determined using a blood sample lab test, which falls under the category of biochemical outcome measures. For this study, all outcome measures were examined using a T1 evaluation and T2 assessment in the morning following 12 weeks of intervention. The spirometer was a viable measure for assessing vital capacity, as was the Queen's College step test, and the palpating technique was also a reliable measure for assessing resting heart rate. To identify the characteristics of the participant's height and weight measured through a standard stadiometer (MCP 2m/200CM Roll Ruler Wall Mounted Growth Stature Meter) and weighing machine (HD-93 Digital weighing machine).

Physiological outcome measures

VC was assessed with a valid tool, namely a spirometer (litters)(Singh and Mitra, 2020). Participants received verbal information prior to taking the test. The participants were asked to shut their noses with clips and inhale deeply before exhaling forcefully into the opening of the spirometer. During the test, participants ensured a tight bond around the mouth and opening of the spirometer. Each participant had three attempts. The best one out of three was selected as a VC score. After each try, the spirometer was carefully examined for the next attempt. RHR was recorded using the palpation technique (Mishra et al., 2023; S. H. Sharma and Singh, 2020) in the early morning before the daily routine. VO_{2max} was assessed indirectly by using the valid test of the Queens College step test procedure(Bandyopadhyay, 2007; Nabi et al., 2015). The step test was carried out at a height of 41.275 cm. The stepping was accomplished for a total of three minutes, with a number of twenty-four steps per minute specified. After completing the task, the carotid pulse rate was measured from the fifth to the thirtieth seconds of recovery. The 30-second pulse rate was converted to beats per minute. Finally, VO_{2max} score was converted using the equation of:

$$\mathrm{VO2max} = 111.3 - (0.42 \times \text{pulse rate beat/min}).$$

Biochemical outcome measures

Blood samples were collected from the participants in the morning session after 12 hours of fasting period (Ayob et al., 2023). All blood samples (HDL and LDL) collections were performed by nurses with all safety requirements and biochemical analyses were carried out in an ISO 9001:2015 certified private laboratory. Fasting biochemical analyses were performed using the automated procedure on EM200 technology.

Statistical analysis

All data were tabulated using Microsoft Excel, and the normality of the data was determined using the Shapiro-Wilks test (Sanpasitt and Apanukul, 2023). The characteristics of the participants (baseline assessment) were calculated using one-way ANOVA to ensure that there was no significant difference between the groups. Three groups were compared, as well as all outcomes, with a baseline 12 weeks after intervention with a paired sample t-test (Thapa et al., 2023). The magnitude of changes between T1 and T2 assessment was calculated using Cohen's d values, which were described as trivial: 0 to 0.2; small: 0.2 to 0.6; moderate: 0.6 to 1.2; large: 1.2 to 2.0; very large: 2.0 to 4.0; nearly perfect: >4.0 (Ndlomo et al., 2023). To compare the changes of three groups for all outcome measures, a 3x2 (group x time) mixed design analysis of variance for repeated measures test to measure the time (pre-test and post-test), group (COM, CNST, and CON) and interaction (group x time) effects (Alhamad et al., 2023). Bonferroni post hoc test was used to identify specific differences between the groups (Alhamad et al., 2023). Additionally, the partial eta-square (PES) was taken from the two-way repeated measures ANOVA test. Effect size (partial eta-square) was used to determine the magnitude of the difference. A large is interpreted as (≥ 0.14), a medium is interpreted as (0.06-0.14), and a small is interpreted as (≤ *0.06*) (Pramanik et al., 2023). to indicate the statistically significant .05 level was fixed. Jeffrey's Amazing Statistics Program (JASP) 0.18.3.0 open-source software was used to perform all the statistical analysis (Ağduman and Daşkesen, 2023; Jannah et al., 2023).

RESULTS

Table 3 presented the characteristics of the participants of two intervention groups (COM and CNST), and the control group (CON) did not show any significant difference in weight (p = .464), height (p = .258), and age (p = .941). The normality of the participant's characteristics was determined using Shapiro-Wilks tests.

Table 3. Characteristics of participants.

Characteristics	**COM**	**CNST**	**CON**	***p***
	Mean (SD)	Mean (SD)	Mean (SD)	
Weight	64.73(4.33)	63.47(5.47)	62.67(3.72)	.464
Height	1.70(0.075)	1.66(0.061)	1.67(0.040)	.258
Age	19.47(1.19)	19.47(1.06)	19.33(1.34)	.941

Table 4 shows the normality of the outcome measures (vital capacity, resting heart rate, VO_{2max}, HDL, and LDL) data that was determined using the Shapiro-Wilks test. All the data of the outcome measures were normally distributed in Kolmogorov-Smirnov as well as the Shapiro-Wilks test.

Table 4. Tests of Normality.

Outcome measures	**Group**	**Shapiro-Wilk**		
		Statistic	**df**	**Sig.**
VC	COM	0.907	15	.123
	CNST	0.921	15	.201
	CON	0.897	15	.084
RHR	COM	0.930	15	.276
	CNST	0.920	15	.191
	CON	0.908	15	.126
VO_{2max}	COM	0.948	15	.491
	CNST	0.943	15	.418
	CON	0.884	15	.055
HDL	COM	0.886	15	.057
	CNST	0.961	15	.716
	CON	0.946	15	.469
LDL	COM	0.957	15	.637
	CNST	0.951	15	.537
	CON	0.939	15	.371

Table 5 Repeated measure analysis of variance reveals that VC had significant changes between the groups (p < .01, PES = 0.448) with large effect, between the time (p < .01, PES = 0.713) with large effect, and interaction between the group x time (p < .01, PES = 0.520) with large effect. RHR did not show any significant difference between group, time and group x time. VO_{2max} did not show significant changes between the

groups (*p* = .066, PES = 0.121) with moderate effect, but significant changes between the time (*p* < .01, PES = 0.520) with large effect, and interaction between the group x time (*p* < .01, PES = 0.315) with large effect.

Table 5. Repeated Measures ANOVA.

Outcome measures	Group	T1 (SD)	T2 (SD)	Group (effect)	Time (effect)	Group x time (interaction)
				(η^2_p)		
VC	COM	3.83(0.243)	4.51(0.194) †▲ #	0.00** (0.448)	0.00** (0.713)	0.00** (0.520)
	CNST	3.87(0.258)	4.45(0.262) †▲			
	CON	3.77(0.263)	3.81(0.252)			
RHR	COM	74.27(2.49)	73.73(2.25)	0.379 (0.045)	0.803 (0.002)	0.228 (0.068)
	CNST	74.13(2.20)	74.00(2.42)			
	CON	74.53(3.07)	75.47(2.33)			
VO_{2max}	COM	39.31(2.51)	43.94(1.81) †▲ #	0.066 (0.121)	0.00** (0.520)	0.00** (0.315)
	CNST	39.15(2.68)	42.88(1.45) †▲			
	CON	39.76(3.05)	40.04(2.80)			
HDL	COM	43.13(3.48)	48.33(2.79)	0.141 (0.089)	0.008** (0.154)	0.415 (0.041)
	CNST	42.93(4.65)	47.93(2.94)			
	CON	42.40(2.72)	42.93(3.01)			
LDL	COM	120.40(9.03)	103.53(8.24)	0.051 (0.132)	0.008** (0.156)	0.97 (0.001)
	CNST	119.27(13.97)	104.33(10.79)			
	CON	120.93(11.13)	119.60(10.11)			

*Note. # Significant difference with training protocol .05, † significant difference with baseline .05. ▲ Significant difference with control .05, η²p partial et square, *p < .05, **p < .01.*

High-density lipoprotein (HDL) level had no significant changes between groups (*p* = .141, PES = 0.089) with moderate effect, and in the interaction between groups and time (*p* = .415, PES = 0.041) with small effect but over time had significant change (*p* < .01, PES = 0.154) with moderate effect. Similar to low-density lipoprotein (LDL), no significant changes were observed between groups (*p* = .51, PES = 0.132) with moderate effect, and in the interaction between groups and time (*p* = .97, PES = 0.001) with small effect but over time had significant change (*p* < .01, PES = 0.156) with moderate effect for LDL level also.

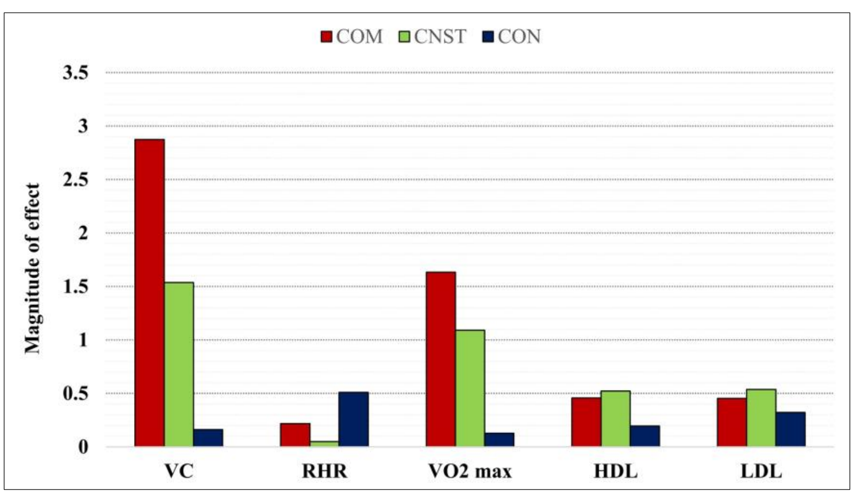

Figure 3. Magnitude of effects in outcome measures between T1 and T2 assessments for COM, CNST and CON groups.

When considering the paired sample t-test, VC had a significant difference between COM ($p < .05$) with a nearly perfect effect and CNST ($p < .05$) group with a large effect, but the CON group did not show any significant difference ($p > .05$) with trivial effect. VO_{2max} had a significant difference between COM ($p < .05$) with a large effect and CNST ($p < .05$) group with a moderate effect, but the CON group did not show any significant difference ($p > .05$) with a trivial effect. Despite this, RHR, HDL and LDL were not significantly different among the three groups (Magnitude of effects presented in Figure 3).

When considering the one-way analysis of variance, the T1 assessment of all the outcome measures did not show any significant difference at the .05 level. VC, VO_{2max} significantly improved in both training interventions (COM and CNST). However, neither the CON group nor the training interventions (COM and CNST) demonstrated significant changes in RHR, HDL, or LDL. When considering the Bonferroni post hoc test, the COM group showed significantly higher improvement in VC and VO_{2max} when compared to CNST as well as the CON group.

DISCUSSION

A number of studies have previously examined the impact of COM on VC and RHR among football players (Rozario and Vallimurugan, 2020) as well as CNST on handball players (Rajkumar, 2020). However, a few authors explored the impact of COM versus CON training on VC, RHR, and VO_{2max} among soccer players (Kanniyan and Syed, 2013), but few of the authors examined the field hockey population. According to these results, VC and VO_{2max} were significantly different between the COM group and the CON group at the end of the 12 weeks of training intervention. In comparison with the two-intervention group, the COM group showed significant improvements. There was no significant difference in the variable RHR between the experimental and control groups. Some of the previous study's results are in line with the current study results (Anitha et al., 2018; Gómez-molina et al., 2018; Kanniyan and Syed, 2013; Manna et al., 2016; Rajeshkumar and Muralitharan, 2023; Sarkar et al., 2019; H. B. Sharma and Kailashiya, 2018). In the study by H. B. Sharma & Kailashiya (2018), sprint-strength and agility training improved aerobic (VO_{2max}), cardiovascular parameters, and performance of male field hockey players after six weeks. Sarkar et al. (2019) assess the impact of an eight-week high-intensity interval training program on anaerobic threshold level VO_{2max} and associated cardio-respiratory parameters. The athlete can eventually exercise at a higher burden with improved cardiac proficiency after completing the 8-week HIIT regimen. One study Indranil Manna et al. (2016), found that RHR did not change significantly after eight weeks of aerobic, anaerobic, and skill development training in field hockey players. The young hockey players in this study had increased their maximum aerobic capacity (VO_{2max}) following six and twelve weeks of training (Manna et al., 2009). Indian players may not achieve the same level of success at the international level as their European counterparts due to their lower VO_{2max} (Manna et al., 2009). This is mostly because increased duration of activity and intensity raises the muscle's myoglobin content since it causes the worked muscles to hypertrophy. Thus, more muscle mass also results in an increased blood flow, which eventually improves the muscle's ability to perform for extended periods of time. Based on the results of the study by Kanniyan & Syed (2013), there are significant differences between the complex training group, contrast training group, and the control group in all cardio-respiratory endurance tests. During a 12-week period of an intervention study, Rajeshkumar & Muralitharan, (2023) found a significant increase in vital capacity and forced vital capacity following the concurrent training program including aerobic and resistance training. Anitha et al. (2018) found that plyometric training significantly improved vital capacity and anaerobic capacity in male volleyball players over the course of 12 weeks. According to study Gómez-molina et al. (2018) novice runner's VO_{2max} was enhanced by 8 weeks of concurrent plyometric training. Some of the previous studies results are not in a line with the current study results (Hanjabam and Kailashiya, 2014; Roberts, 2016). According to Roberts (2016), sports-specific training significantly affected VO_{2max} in field hockey players after six weeks of training, but not after 12 weeks, in the same population, the resting heart rate was significantly reduced over 6 weeks of sprint, strength, and agility training which revealed by Hanjabam & Kailashiya, (2014). Moderate intensity plyometric training had significant decline in RHR among Badminton Players (Rangaraj and Ganapathy, 2024). A study by Indranil Manna et al. (2016) found that elite field hockey players did not experience any significant changes in VO_{2max} after four and eight weeks of aerobic anaerobic and skill training. considerable reduction in training volume, load, and intensity during the course of the program, that might be the possible reason for getting contrary results in these past studies (Gil-rey et al., 2015).

The development of athlete profiles, the evaluation of training adaptations, and the investigation of program effectiveness are fundamental elements of physiological assessment in the laboratory and in the field (Reilly et al., 2009). In the current study, results state that over 12 weeks of COM and CNST training on biochemical variables such as HDL and LDL, there was no significant difference among field hockey players. However, a trivial increase in HDL and a trivial decline in LDL over the 12-week course training intervention (COM and CNST). Some of the previous study results are in line with the current study results (Bal et al., 2012; Farsani and Rezaeimanesh, 2011; Koh and Miller, 2012; Ouerghi et al., 2014). According to the study by Bal et al. (2012) Indian jumpers' total cholesterol levels did not alter significantly after a six-week plyometric training program. The study by Ouerghi et al. (2014) stated that, after 12 weeks, total and low-density lipoprotein cholesterol levels and High-density lipoprotein cholesterol levels had no significant difference in high-intensity interval training addition with regular soccer training; only regular soccer training and control group who did not participate any physical activity. In addition to regular soccer training, low-density lipoprotein cholesterol levels decreased by about 2% in the high-intensity interval training group. There was a minimal increase in High-density lipoprotein cholesterol levels for the high-intensity interval training addition with regular soccer training and regular soccer training. Based on a meta-analysis conducted by Kelley & Kelley (2009), it was concluded that aerobic training improved HDL-C while progressive resistance training did not. According to the research by Koh & Miller, (2016) after six weeks of power-based resistance training for collegiate athletes that includes weightlifting and plyometrics, the lipoprotein parameters were unaffected. Farsani & Rezaeimanesh, (2011) explored the six weeks of aerobic interval training affected certain blood lipids; LDL remained constant in female athletes and students. Some of the previous studies are not in line with the current study results (Kelley and Kelley, 2009; Manna et al., 2010; Sarkar et al., 2023). The study by Indranil Manna et al. (2010) investigates how Indian soccer players' lipid profiles varied according to their training regimen, which included aerobic, anaerobic, and skill development. Also, similar results have been revealed for high-intensity training in team game athletes (Sarkar et al., 2023). Kelley & Kelley, 2009 also suggest that progressive resistance training reduces LDL levels.

Limitations
The study is not without its limitations. Limitations include various characteristics that could impact the generalizability and strength of the findings. Only minimal or slightly above-minimal sample sizes were obtained to determine the study's power value. A 12-week intervention period provides insight into short-term effects, while a duration beyond 12 weeks may provide more robust information. The study focused on the physiological and biochemical variables and inattention to the various relevant performance evaluation measures. There was no control over the diet, socioeconomic status, psychological factors, or environmental factors in all of the three groups, as the study did not control for these factors.

Practical application
In evaluating training and assessing the health, metabolism, and cardiovascular status of field hockey players, physiological and biochemical variables play a key role. Coaches may benefit from regular

monitoring of physiological and biochemical variables during training at various stages of growth and development for the purpose of training and selecting players at different ages. Future research should examine the training duration beyond 12 weeks or adjust the intensity and volume of the training to enhance the effect on lipid profile and cardiovascular parameters.

CONCLUSIONS

In conclusion, both training intervention groups resulted in substantial improvements in VC, suggesting better respiratory function than the CON group. However, RHR was unaltered across all three groups, suggesting that neither the treatments nor the control condition had an effect on RHR. VO_{2max} went up considerably in both the COM and CNST groups as compared to CON, demonstrating better aerobic capacity. Furthermore, compared to CON, the COM and CNST groups showed no better lipid profiles, with higher HDL and lower LDL. However, trivial changes were made in two experimental groups. T1 tests verified the initial comparability of groups. Furthermore, the Bonferroni post hoc test showed superior effectiveness of the COM training, showing substantially higher increases in VC and VO_{2max} when compared to CNST and CON. Overall, our data highlight the efficacy of personalized complex training programs in improving numerous physiological parameters linked to cardiovascular health and fitness in field hockey players but no potential effectiveness on lipid profile. Future studies should look at the long-term effects of complex and contrast training on field hockey players, taking into account injury prevention, recovery, and sustained performance over the course of an entire season. Coaches and trainers can use individualized sophisticated training regimens to improve respiratory function, aerobic capacity, and lipid profiles in field hockey players. Coaches may help athletes achieve peak performance and maintain optimal health by incorporating evidence-based treatments into their training regimens. Continuous monitoring of physiological indicators of the athletes can help to guide the training plan revisions, assuring long-term progress and injury avoidance.

AUTHOR CONTRIBUTIONS

Conceptualization, I.N.K.V. and G.V.; methodology, I.N.K.V. and G.V.; software, I.N.K.V. and S.B.; formal analysis, I.N.K.V., G.V. and S.B.; investigation, I.N.K.V.; resources, I.N.K.V.; data curation, I.N.K.V.; writing—original draft preparation, I.N.K.V. and G.V.; writing—review and editing I.N.K.V., G.V. and S.B; project administration, I.N.K.V. All authors have read and agreed to the published version of the manuscript.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

ETHICAL STATEMENT

An ethical clearance and informed consent were obtained prior to the start of the study. The study received approval from the institutional ethical committee at Pondicherry University (Approval No. HEC/PU/2023/05/07-08-2023). Written/verbal informed consent was taken from all participants. The study was carried out in accordance with the principles enunciated in the Declaration of Helsinki.

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