Efectos de un programa de entrenamiento de acondicionamiento de seis semanas sobre variables fisiológicas clave en jugadoras de bádminton

Effects of a Six-Week Conditioning Training Program on Key Physiological Variables among Female Badminton Players

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Abstract

Introduction: Conditioning training plays a great role, and it is one of the effective training methods in the development of physiological properties of an athlete.
Objective: The study investigates the effects of a six-week conditioning training program on physiological variables among badminton players.
Methodology: A total of twenty (20) state-level female badminton players were selected for the study; further, they were randomly divided into an experimental group (n = 10) and a control group (n = 10). Physiological variables, including vital capacity, blood pressure (systolic and diastolic), blood lactate (pre-activity and post-activity), and VO_2 max, were assessed pre-post-intervention using standard testing protocols.
Results: The findings of the results revealed that there was a significant difference found in blood lactate ($p < .005$), vital capacity ($p < .005$), and VO_2 max ($p < .005$) compared to the control group. Further, blood pressure (systolic) ($P > .492$) and (diastolic) ($P > .861$) were shown to be insignificant compared to the control group.
Discussion: The findings of the study align with and contradict in some existing literature related to physiological development.
Conclusions: This study suggests that a six-week conditioning training program can effectively improve the specific physiological measures of badminton players.

Keywords

Badminton; Blood Lactate; Blood Pressure; Conditioning Training; Vital capacity.

Resumen

Introducción: El entrenamiento de acondicionamiento físico desempeña un papel fundamental y constituye uno de los métodos más eficaces para desarrollar las capacidades fisiológicas de los deportistas.
Objetivo: El estudio analiza los efectos de un programa de entrenamiento de acondicionamiento de seis semanas sobre diversas variables fisiológicas en jugadoras de bádminton.
Metodología: Se seleccionó a un total de veinte (20) jugadoras de bádminton de nivel estatal, las cuales fueron asignadas aleatoriamente a un grupo experimental (n = 10) y a un grupo de control (n = 10). Se evaluaron variables fisiológicas —tales como la capacidad vital, la presión arterial (sistólica y diastólica), el lactato en sangre (antes y después de la actividad) y el VO_2 máx. — tanto antes como después de la intervención, empleando protocolos de prueba estandarizados.
Resultados: Los resultados mostraron diferencias significativas en los niveles de lactato en sangre ($p < 0,005$), la capacidad vital ($p < 0,005$) y el VO_2 máx. ($p < 0,005$) en comparación con el grupo de control. Por el contrario, no se observaron diferencias significativas en la presión arterial sistólica ($p > 0,492$) ni en la diastólica ($p > 0,861$) respecto al grupo de control.
Discusión: Los hallazgos de este estudio coinciden con parte de la literatura existente sobre el desarrollo fisiológico, al tiempo que contradicen otros aspectos de la misma.
Conclusiones: El estudio sugiere que un programa de entrenamiento de acondicionamiento de seis semanas puede mejorar eficazmente parámetros fisiológicos específicos en jugadoras de bádminton.

Palabras clave

Bádminton; Lactato en sangre; Presión arterial; Entrenamiento de acondicionamiento físico; Capacidad vital.

Introduction

The sport of badminton is a high-intensity racket game; it consists of explosive movement, constant changing of directions, and maintaining decent aerobic endurance. The elite athlete has to maintain a proper balance between aerobic and anaerobic energy systems, in order to maintain peak performance in the entire match. During the rallies, the player has to maintain high-intensity bursts of jumps, lunges, and smashes and short intervals of recovery; therefore the metabolic profile of a player determines the success of the athlete (Edel et al., 2024). Ma et al. (2025) report that badminton players require the highest level of cardiovascular fitness to delay the feeling of tiredness as well as high muscle strength to make accurate offensive hits. Due to this reason, conditioning training becomes the foundation of any athlete preparation. It is all about increasing essential physiological parameters such as VO_2 max, the resting heart rate, and the lactic acid threshold in order to increase the performance of an athlete on court. A study conducted by Wang et al., (2025) indicates that in order to transition between a recreational and a competitive athlete, there must be a systematic conditioning training intervention, which helps in the optimization of these internal physiological performances.

The implementation of a six-week conditioning program is commonly referred to as a standard mesocycle of sports science, entailing a period of time that allows enough neurological and morphological changes without overtraining the athlete. During this period, it is found that there is a physiological shift; for example interval-based conditioning helps in improving stroke volume and capillary density, which in turn enhances the oxygen supply to working muscles (Souza et al., 2014). In badminton, where agility and speed-endurance of an athlete act as paramount, a highly structured conditioning training program will be aimed at increasing the phosphagen system, which generates instant power, and the oxidative system, which helps the shuttlers to recover faster between successive points (Yilmaz, 2022). Balaji et al. (2025) found that even temporary particular physical exercise helps in improving blood pressure management and respiratory performance among athletes of racquet sports. It is essential to understand how a structured six-week training has a specific effect on the physiological profile of shuttlers that should allow coaches to develop evidence-based periodization plans.

In addition, the special requirements of badminton conditioning will be different from that of general fitness training. Efficient structured conditioning training should reflect the intermittent nature of the sport, including "stop-and-go" drills, which place demands on the anaerobic glycolytic system. There are several studies that suggest that when conditioning matches the sport's work-to-rest ratios, there is a positive heart recovery profile observed (Zhang et al., 2024). This physical resistance allows players to sustain their precision and concentration during the last moments of a third-set tiebreak, when fatigue leads to a decrease in performance (Mendez-Villanueva et al., 2007). Green et al. (2023) found that there is a significant correlation between a player's physiological profile (especially the anaerobic power and aerobic capacity) and national rank positions. Focusing on variables such as lung capacity and haemoglobin levels, researchers can measure the internal "load" and resulting "gain" experienced through a rigorous six-week conditioning training, which ultimately led to peak performance in time for tournament cycles.

Despite the multiple studies which focus on the effect of conditioning training among shuttlers, contemporary conditioning regimens are predominantly based on a "unisex" model that is mainly influenced by male data during physiological testing (Gasibat et al., 2023). This is a major limitation in research as it fails to take into account the individual biological profile of female shuttlers, which rests on the relationship among low concentrations of hemoglobin, thoracic characteristics, and variations in physiological hormonal levels involved in lactate clearance and cardiovascular stability (Tai et al., 2022). Although long-term athletic development has been thoroughly documented, we still lack longitudinal information (specifically a 6-week long focused mesocycle) about the "respiratory-metabolic-cardiovascular triad" with female shuttlers. Further, existing research typically focuses either on single markers of stress/hormone status or groups genders together, which led to a lack of complete understanding among coaches regarding how an internal physiological model of a female athlete's training adaptation to high-intensity training over short-term blocks works. Therefore, evidence-based studies that extend beyond male-focused models should be addressed in order to question if a 6-week intervention is enough time to produce measurable changes in physiological parameters. The current study aims to bridge the above-cited gaps through providing a descriptive account model of tailored conditioning training for female shuttlers to improve both physical performance and overall long-term health.

Method

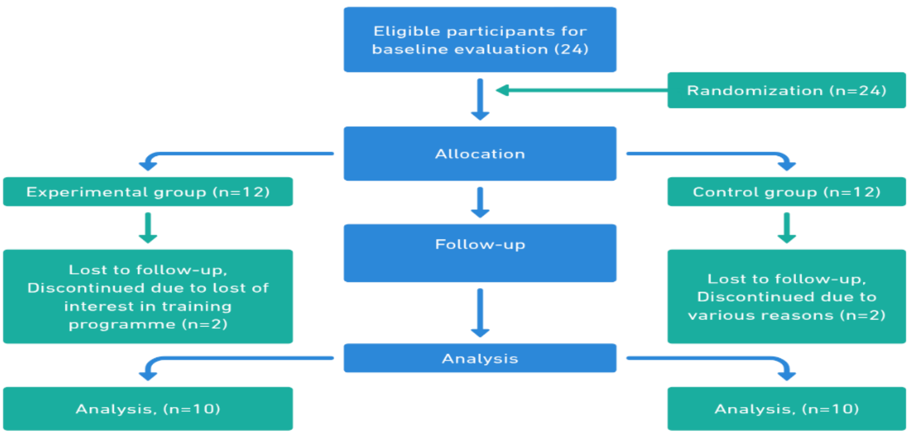
Research Design

As a research design, pre-test and post-test randomized group design was used for the study. The main goal of this design was to assess the degree of change caused by the six-week conditioning training. In this design, the experimental group received conditioning training, while the control group did not receive any conditioning training but maintained their regular day-to-day activities. Further, the test was conducted 72 hours later just after the last training sessions so that the participants were able to provide their best without any undue fatigue, which might lead to inaccurate data.

Participants

For the study, data were gathered through a random sampling technique. In order to estimate the sample size, G*Power software (Version 3.1.9.7, Heinrich Heine University Düsseldorf (HHU), Germany) (Faul et al., 2007) was used, in which effect size was kept as 0.08 ($f = 0.8$), α error probability as 0.05 ($\alpha = 0.05$), and the desired power as 0.80 ($1 - \beta = 0.80$);based on this estimation, the suggested sample size was 15. A sample of 24 (n=24) state-level female badminton players was considered to compensate for the participant's attribution. The age of subjects was from 18 to 25 years, with a mean age of 22.3 ± 1.72, a height of 166.1 ± 2.4 cm, and a weight of 62.1 ± 4.8 kg. Further, the study subjects were divided into two groups: Experimental group (EG, n=12) and controlled group (CG, n=12). The randomization of the subjects into two groups, the experimental group and the control group, was done through a computer-generated number sequence in MS excel; this helps in upholding the integrity of the random distribution process. At the end, 20 participants' data were recorded for the final data analysis process (EG: n=10; CG: n=10). The 4 participants were excluded primarily because they were unable to complete the training program due to various reasons, specifically loss of interest in the training program and time constraints. Inclusion criteria include the following: the participants should have at least 3 years of playing experience in badminton. The participants should be physically fit and free from any injuries or disorders within one year. Exclusion criteria include the person underwent physiotherapy and other health-related medication.

Fig.1 Participants flow chart of the pre-test-post-test intervention study.



Ethics and consent

The study had been thoroughly examined and approved, and its experimental protocol was registered on 18TH January, 2024, with Regd. No. RGU/RS-1283/2023 by the institutional ethical committee of the Rajiv Gandhi University, Arunachal Pradesh, India. The benefits and risks of the study were properly explained to the subjects, and accordingly, their signed consent was obtained before the start of the data collection. They were also informed that they can discontinue or withdraw from the study at any period of time of the study. Further, the study follows the Declaration of Helsinki and also adheres to CONSORT guidelines.

Procedures

Exercise interventions

The intervention program (see details in table 1, 2, and 3) consists of 6 weeks with 3 days per week. Each training session consists of 1 hour and is divided into three phases: a 10 min warm-up, the main exercise program lasting 40 min and cool-down period of 10 min. We also maintained the subject and coach ratio of 5:1 so that the training intervention could remain effective throughout the training program. The warm-up and a cool-down phases comprised low-intensity running or cycling and dynamic stretching. The program is divided into 3 phases, i.e., foundation (weeks 1-2), strength & speed (weeks 3-4), and power & sports-specific (weeks 5-6). Further, the foundation phase is consisting of 50-60% of max effort with moderate intensity; the strength & speed phase consists of 60-70% of max effort (moderate-high intensity); and the power & sport-specific phase consists of 70-85% of max effort with high intensity. The intensity progression was light to high over the six-week program, and each exercise was closely monitored by the conditioning expert. The controlled group didn't take part in any of the mentioned exercises of the program they performed their regular training. The exercise is designed and administered by the two strength and conditioning experts of Rajiv Gandhi University for effective and personalized training.

Table 1. Exemplified conditioning exercise session for first phase i.e., foundation phase taken from first two weeks of the exercise programme

Sequence	Exercise	Sets	Repetitions/Duration	Rest between sets	Rest between exercises
Warm-up	jogging	1	3 min	-	-
	skipping	1	3 min	-	-
	Side shuffles	1	1 min	-	-
	Dynamic stretching	1	30 sec	-	-
	Arm swings	1	20 sec	-	-
	Arm circles	1	20 sec	-	-
	Leg swings	1	20 sec	-	-
Main workout	Shuttle run	1	30 sec	-	60 sec
	Ladder drills	4	30 sec	45 sec	60 sec
	Sidesteps with resistance band	3	12 reps	30 sec	60sec
	Jump rope	3	60 sec	75 sec	60 sec
	Footwork drills	4	30 sec	45 sec	60 sec
	Bodyweight squats	3	15 reps	30 sec	60 sec
	lunges	3	10 reps	30 sec	60 sec
	plank	3	30 sec	45 sec	60 sec
	Push-ups	3	12 reps	30 sec	60 sec
	Russian twists	3	20 reps	30 sec	60 sec
	Side plank	3	20 sec	30 sec	60 sec
Cool-down	Static stretching	1	5min	-	-
	Breathing exercises	1	5 min	-	-

Training intensity (50–60% of HRmax) was monitor using a heart rate monitor (Polar T31, Polar Electro Oy, Kempele, Finland) (Montes & Navalta, 2019).

Table 2. Exemplified conditioning exercise session for second phase i.e., strength & speed phase taken from mid two week of the exercise programme

Sequence	Exercise	Sets	Repetitions/Duration	Rest between sets	Rest between exercises
Warm-up	jogging	1	3 min	-	-
	skipping	1	3 min	-	-
	Side shuffles	1	1 min	-	-
	Dynamic stretching	1	30 sec	-	-
	Arm swings	1	20 sec	-	-
	Arm circles	1	20 sec	-	-
	Leg swings	1	20 sec	-	-
Main workout	Dumbbell squats	3	12 reps	30 sec	60 sec
	Deadlifts (light)	4	12 reps	30 sec	60 sec
	Step-ups (with dumbbells)	3	12 reps	30 sec	60sec
	Push-ups	4	12 reps	45 sec	60 sec
	Plank with shoulder taps	4	30 sec	45 sec	60 sec

	Ladder drills (complex footwork patterns)	5	30 sec	45 sec	60 sec
	Cone drills (figure-8 runs)	4	20 sec	30 sec	60 sec
	Sidestep jumps	3	12 reps	30 sec	60 sec
	Reaction drills (partner drops shuttle)	4	30 sec	45 sec	60 sec
	Box jumps	4	12 reps	30 sec	60 sec
	Skater jumps	4	12 reps	30 sec	60 sec
	Medicine ball slams	4	12 reps	30 sec	60 sec
	Jump squats	4	12 reps	30 sec	60 sec
	Explosive push-ups	3	12 reps	30 sec	60 sec
Cool-down	Static stretching	1	5min	-	-
	Breathing exercises	1	5 min	-	-

Training intensity (60-70 % of HRmax) was monitor using a heart rate monitor (Polar T31, Polar Electro Oy, Kempele, Finland) (Montes & Navalta, 2019).

Table 3. Exemplified conditioning exercise session for first phase i.e., power & sports-specific phase taken from last two weeks of the exercise programme

Sequence	Exercise	Sets	Repetitions/Duration	Rest between sets	Rest between exercises
Warm-up	jogging	1	3 min	-	-
	skipping	1	3 min	-	-
	Side shuffles	1	1 min	-	-
	Dynamic stretching	1	30 sec	-	-
	Jumping jack	1	20 sec	-	-
	High knees	1	20 sec	-	-
	shoulder rotations	1	20 sec	-	-
Main workout	Power cleans	4	10 reps	30 sec	60 sec
	Squat jumps	4	10 reps	30 sec	60 sec
	Deadlifts	4	10 reps	30 sec	60sec
	Medicine ball throws	4	10 reps	30 sec	60 sec
	Push-ups (explosive)	4	10 reps	30 sec	60 sec
	Ladder drills (Quick footwork)	4	20 sec	35 sec	60 sec
	Reaction shuttle drills (partner drops shuttle)	4	20 sec	35 sec	60 sec
	Skipping (high speed)	4	20 sec	35 sec	60 sec
	Lateral footwork drills (side shuffles)	4	20 sec	35 sec	60 sec
	Badminton-specific footwork drills	4	20 sec	35 sec	60 sec
	Shuttle drill with racquet	4	20 sec	35 sec	60 sec
	Lateral quickness drills (shuffling side to side)	4	20 sec	35 sec	60 sec
	Plyometric jumps (mimicking jumps in badminton)	4	10 reps	30 sec	60 sec
	Sprints (court-length	4	20 sec	35 sec	60 sec
Cool-down	Static stretching	1	5min	-	-
	Breathing exercises	1	5 min	-	-

Training intensity (70-80 % of HRmax) was monitor using a heart rate monitor (Polar T31, Polar Electro Oy, Kempele, Finland) (Montes & Navalta, 2019).

Administration of Test and procedure of data collection

In this study, we allocated independent blinded assessors, who were not informed about the participant allocation in various groups, to conduct the assessment. We chose this methodology in order to improve the reliability of our findings. All the test were conducted between 10:00 am and 3:00 pm. The researcher made sure that none of the participants were involved in any tedious physical activity for last 72 hrs. Before the test was administered, the participants were informed and explain in detailed, how to utilize the instruments. The researcher also provides detailed demonstrations of the test items. The participants were given enough trials to become familiar with the tests so that they could complete the tasks without any interruption. Further, all pertinent data were collected from both the control and experimental groups before and after training, i.e., pre-test data and post-test data. During the administration of tests, the following considerations were kept in mind: The researcher ensured that all instruments were applied systematically and ensured that all instruments were used more effectively concerning their variables.

Blood lactate

Blood lactate has been chosen as an important parameter of anaerobic metabolism. Badminton rallies is characterized by explosive motions, high level of acceleration, and maximal intensity strokes which are heavily based on anaerobic energy pathways. Blood lactate levels during on court field tests of around 10.4 mmol L -1 confirm high levels of anaerobic contribution during high-intensity rallies (Valenzuela et al., 2019). Blood lactate was measured by using Lactic acid concentration Instruments:

Lactic analyzer. The lactate scout 4 (SensLab GmbH, Leipzig, Germany) is designed for field and gym use and is ideal to measure lactate levels. Data on blood lactate is collected after the conditioning training through test stripes. The test strips were inserted in the LA analyzer and the reading was taken (Mentzoni et al., 2024).

Blood pressure

Resting blood pressure was measured as an indicator of cardiovascular health and training status. Blood pressure reflects chronic cardiovascular adaptations to training. Studies have reported lower resting blood pressure in higher-level badminton players compared to lower-level players, suggesting favourable cardiovascular adaptation associated with training status (Heller, 2010). Blood pressure was assessed by an instrument called Sphygmomanometer. A digital sphygmomanometer (Omro, Omron healthcare, Kyoto, Japan) often known as a blood pressure cuff, is used to measure blood pressure. Correct upkeep and calibration are necessary for accuracy it is often used to check the blood pressure of a person. To block the flow of blood in your artery, the cuff is put around your arm and inflated. Blood pumped through the arteries causes a rise in pressure, known as systolic pressure, followed by a reduction in pressure as the heart's ventricle prepares for each beat, known as diastolic pressure (P. Zhang et al., 2021).

Vital capacity

Vital capacity was tested using an instruments called spirometer (Spirobank Smart, MIR, Rome, Italy). This device for calculating the amount of air that is inhaled and exhaled by the lungs. A spirometer monitors ventilation or the inflow and outflow of air from the lungs (Ooi et al., 2009). During a spirometry test, subjects were required to breathe into a tube attached to a machine called a spirometer. During the test, the participants were seated. To keep the subjects' nostrils closed, a clip was placed on their nose. Subjects took a deep inhale and exhaled as strongly as they could through the tube for several seconds. It was critical that their lips formed a tight seal around the tube to prevent air from escaping (Graham et al., 2019). To ensure that the results were fairly consistent, at least three trials were conducted. If the three outcomes differed too significantly from one another, the subject was asked to repeat the test. The highest score out of three closely related test outcomes was used as the final result.

VO_2 Max

VO2 max was chosen as one of the outcome variables since it is a maximal aerobic capacity, which is an fundamental part of badminton as badminton matches involve repeated high-intensity with short periods of rest between them. Increased VO2 max enables the ability to recover oxygen intake and elimination of metabolic toxins more quickly between rallies and points (Faude et al., 2007). In order to measure VO_2 Max, Yo-Yo Intermittent Recovery Test Level 1 was used. In this test three markers (cone A, B, C) were placed on a parallel line. The distance from Cone A to cone B is 5m and from cone B to Cone C is 20m. The Participants commence the test at cone B. Upon receiving instructions from the audio player, participants must sprint to cone C (which must be reached prior to the subsequent beep) and promptly return to cone B before the next signal. Upon reaching Cone B, participants are allotted a 10-second recovery interval during which they must jog from Cone B to Cone A and return to Cone B prior to the initiation of the subsequent shuttle. Participants are permitted only two consecutive failed attempts before being pulled from the test. If the individual does not return to cone B from cone C within the designated time, a failure is recorded. If this occurs a second consecutive time, they will be eliminated. After the end of the test, the number of total shuttles were recorded (Krustrup et al., 2003). Further, the number of shuttles were multiple by 40, this will provide the total distance, after than we have to apply this formula: VO2max (mL/kg/min) = Total Distance (m)× 0.0084 + 36.4

Data analysis

In this study, IBM Statistical Package for Social Science (SPSS) version 24 software (version 24.0, Armonk, NY: IBM Corp) were utilized for all statistical analysis. The data were presented as mean and standard deviation. The normality of the data and homogeneity of variance were determined by applying Shapiro-Wilk Test and levene's test respectively. Further, the statistical technique Analysis of Covariance (ANCOVA) was employed in the study to compare post-test performance between groups while adjusting for baseline performance (pre-test scores) as a covariate. Despite random group assignment, minor discrepancies in early performance may occur, potentially confounding the post-test outcomes. Incorporating pre-test scores as a covariate, ANCOVA accounts for baseline discrepancies, guaranteeing that the changes in post-test results are due to the specific conditioning intervention rather than prior performance levels. This modification diminishes error variance, enhances statistical power, and yields a more precise and meaningful assessment of the intervention's impact. Furthermore, the level of significance was set a priori, at $p < 0.05$.

Results

The treatment were given all the participants according to the group allocated. During the training programme no one get injured. Finally the data were collected from 20 participants for further analysis.

The detail of the descriptive Statistics of Physiological Variables were displayed in *Table* .

Table 4. Descriptive Statistics of Physiological Variables (N=20)

Variables	Group	Pre-test mean ± SD	Post-test mean ± SD
Diastolic (Blood Pressure)	Experimental	76.9 ± 4.65	76.6 ± 4.65
	Control	78.1 ± 4.4	77.2 ± 3.91
Systolic (Blood Pressure)	Experimental	119.3 ± 8.23	118.3 ± 7.66
	Control	122.6 ± 3.89	121.1 ± 3.28
Blood Lactate	Experimental	11.14 ± 1.27	8.59 ± 1.07
	Control	11.03 ± 2.9	11.35 ± 2.01
Vital Capacity	Experimental	3.51 ± 0.66	4.17 ± 0.68
	Control	4.18 ± 0.63	4.39 ± 0.61
VO_2 Max	Experimental	49.81 ± 5.21	53.8 ± 4.2
	Control	43.2 ± 3.19	45.26 ± 3.51

Table 5. Ancova Table of Physiological Variables

Variables	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Diastolic (Blood Pressure)	Pre_Diastolic	311.50	1	311.50	124.60	0.000	0.88
	Groups	1.23	1	1.23	0.49	0.492	0.03
	Error	42.50	17	2.50			
	Corrected Total	355.80	19				
Systolic (Blood Pressure)	Pre_Systollic	586.18	1	586.18	256.69	0.000	0.94
	Groups	0.07	1	0.07	0.03	0.861	0.00
	Error	36.66	17	2.16			
	Corrected Total	664.20	19				
	Corrected Total	95.76	19				
Blood Lactate	Pre_ Blood_Lactate	1.68	1	1.68	0.63	0.439	0.04
	Groups	28.22	1	28.08	10.49	0.005	0.38
	Error	56.56	17	3.33			
	Corrected Total	95.76	19				
Vital Capacity	Pre_Vital_Capacity	7.30	1	7.30	342.03	0.000	0.95
	Groups	0.71	1	0.71	33.28	0.000	0.66
	Error	0.36	20	0.02			
	Corrected Total	7.91	19				
VO_2 Max	Pre_Vo2_Max	223.98	1	223.98	81.27	0.000	0.83
	Groups	29.94	1	29.94	10.86	0.004	0.39
	Error	46.85	17	2.76			
	Corrected Total	635.49	19				

* Significant at 0.05 level of significance.

Table 5 represents the test of between-subject effects for the score of the following physiological variables before and after the training intervention and it concluded that pre-test scores Diastolic were significant as the 'p' < 0.05. whereas in the case of post-test scores of Diastolic, it was found insignificant as the 'p' > 0.05 level of significance. The pre-test scores Systolic were significant as the 'p' < 0.05. whereas in the case of post-test scores of Systolic, it was found insignificant as the 'p' > 0.05 level of significance. The pre-test scores for Pre-Activity Blood Lactate were insignificant as the 'p' >

0.05. and in the case of post- test scores of Blood Lactate is significant as the 'p' < 0.05 level of significance. The pre-test scores of Vital Capacity were significant as the 'p' < 0.05. and in the case of post-test scores Vital Capacity is also to be significant as the 'p' < 0.05. The pre-test score VO_2 Max was significant as the 'p' < 0.05. and in the case of post-test scores of VO2 Max is also significant as the 'p' < 0.05. The results show that the impact of the conditioning training had a significant change in the experimental group in some of the physiological variables.

Discussion

This study focuses on the impact of 6-week conditioning training on the physiological variables of the badminton player. The findings of the discussion are as follows:

The present study shows that there was a significant differences in both diastolic and systolic blood pressure between groups were exhibited in pre-test ($p < 0.05$), but it became statistically insignificant after the six-week intervention ($p > 0.05$). This homogenization of cardiovascular function suggests an effective conditioning program that involves significant autonomic remodelling and vascular structural adaptation among all participants. The cardiovascular changes which is found in this study is related to aerobic training mechanisms. The use of the structured conditioning programs causes a decrease in the resting sympathetic tone predetermining the reduced systolic and diastolic blood pressure (Valenzuela et al., 2019). Normalization of differences of blood pressure in groups might indicate better sensitivity of baroreflex and increased capacity of endothelial functions, characteristic changes to regular aerobic exercise. These vascular adaptations help provide more efficient delivery of the blood stream during exercise, decrease peripheral resistance, and decrease cardiac afterload. This insignificant change may be likely due to the BP if it's already within the normal range. Studies indicate that persons with normal blood pressure demonstrate negligible alterations in response to exercise treatments, in contrast to those with increased or hypertensive levels (Berge et al., 2015). Another plausible reason for the no significant change may be due to the limited duration period for measurable changes in blood pressure, especially if the training intensity or volume was insufficient. In general, improvements in cardiovascular markers like blood pressure often require longer training periods (8-12 weeks) or more intense conditioning (Cornelissen & Smart, 2013). Further, results from Cheng et al., (2021) showed no statistically significant changes in resting heart rate and blood pressure after ischemic preconditioning interventions in badminton players ($p > 0.05$), with the mean blood pressure in systolic blood pressure 12.30 mmHg ± 1.15 mmHg for males and 11.16 mmHg ± 1.47 mmHg for females. The lack of notable modifications in their study differs from the current results and could be explained because of differences in intervention type, duration, and initial cardiovascular fitness levels.

This study reveals that there was a insighnificant difference in the pre-activity blood lactate ($p > 0.05$) and after intervention there was a significant differences at post-test ($p < 0.05$). This pattern is indicative that the six-week conditioning program produced differential metabolic adaptations among the participants, which indicating a greater lactate clearance capacity, or oxidative enzyme activity, or substrate utilization patterns that were altered by the conditioning training program.The significant result observed in the present study, where blood lactate levels demonstrated a marked increase after high-intensity rallies in badminton, can be attributed to the intermittent nature of the sport. A study explored how physical conditioning affects blood lactate removal after intense exercise. It found that a six-week training program significantly improved the body's ability to clear lactate during recovery. The changes found in the pre-activity blood lactate levels can be related to a number of interrelated physiological mechanisms. First, aerobic training increases the mitochondrial density and oxidative enzymes in the skeletal muscle that improves the ability to oxidise lactate and keep it out of the muscles (Zhao et al., 2024). Second, conditioning programs improve the density and efficiency of monocarboxylate transporters (MCT1 and MCT4) which permit shuttling of lactate between glycolytic and oxidative muscle fibers and muscle and blood(Coles et al., 2004). Third, the increased capillarization after training increases the elimination of lactate from the working muscles into the bloodstream and then to the oxidative tissues (heart, liver and inactive muscles) (Benítez-Muñoz & Cupeiro, 2025). Another study revealed that sprint interval or endurance training methods significantly improved maximal lactate steady-state power, demonstrating the enhanced ability to process lactate due to the conditioning programs (Hommel et al., 2019). The variation in lactate accumulation may also be influenced by factors such as agility and the frequent change of direction in badminton, which emphasizes both aerobic and anaerobic pathways differently compared to continuous activities (Edel et al., 2023).

In this study, we found that vital capacity showed a significant difference during pre-test and post-test ($p < .05$). This tells us that vital capacity was a discriminating variable during training period. Since there was still a difference after training period between, it may be because of genetic endowment, long-term training history, or anthropometric characteristics, rather than a parameter that changes rapidly in response to short-term training interventions. The recent literature on badminton specific training interventions has shown limited direct information on vital capacity adaptations. Sukadiono et al., (2022)found significant improvements in vital capacity following a training program. These results can help explain the plausible mechanism behind the change in vital capacity observed within this study. Vital capacity, which measures the maximum amount of air a person can exhale after a deep inhalation, is closely linked to lung function and overall respiratory health. Improvements in aerobic capacity, as indicated by Yuniana., (2020) suggest enhanced efficiency of the cardiovascular and respiratory systems, which is crucial for oxygen delivery during physical activity. Furthermore, conditioning training boosts respiratory muscle strength by challenging the diaphragm and intercostal muscles, leading to increased lung capacity. This may likely have improved oxygen utilization, enhancing lung ventilation and efficiency. Additionally, it may have caused adaptations in both heart and lung function, improving oxygen absorption and reducing strain on the respiratory system, resulting in enhanced vital capacity. The consistent significance of differences in vital capacity in the present study, in the absence of evidence of convergence between groups, suggests that this parameter might be of some use in identifying athletes with greater respiratory capacity, which might confer some benefits during the prolonged, high-intensity efforts required in competitive badminton.

The significant finding that was observed most commonly in this study was the differences in VO_2 max at pre-test and post-test ($p < 0.05$). This suggests that VO_2 max continued to be a factor that separated participants after the completion of the intervention. This could mean that the intervention either continued or promoted the differences that already existed between subjects or that VO_2 max is something that does not change greatly and is affected by genetics and training background. At the peripheral level, training causes mitochondrial biogenesis, angiogenesis, and increased activity of oxidative enzymes, contributing to an improved ability to extract/utilize delivered oxygen(Ma et al., 2025). Joummy et al., (2020) found significant increases in maximal oxygen consumption after 10 weeks of high-intensity intermittent functional training among youth badminton players ($F (1,14) = 4.663$, $p = 0.049$). Additionally, Wee & Chan., (2017) found VO_2 max significant improvements ($p = 0.001$) after only four weeks of high intensity intermittent badminton multi-shuttle feeding training among collegiate players. Ghosh et al., (1993) demonstrated that players who underwent the conditioning program showed significant improvements in their VO2 max, a key indicator of aerobic fitness, after six weeks. VO2 max, or maximal oxygen uptake, measures the body's ability to utilize oxygen during intense exercise, and its improvement is directly linked to enhanced cardiovascular endurance. In the context of badminton, this means that players with a higher VO2 max can sustain high-intensity rallies for longer periods without experiencing fatigue as quickly (Sudarma et al., 2024). Additionally, the study suggested by Haller et al., (2022) that by focusing on aerobic conditioning training, with a higher VO2 max, players can handle the high oxygen demands of the game, especially during intense moments that require rapid footwork and powerful smashes. After eight weeks of sprint interval training. Liu et al., (2021) observed significant improvements in aerobic performance capacity of elite badminton players. Ariani et al., (2022)revealed significant VO_2 max improvements in young badminton players when trained using both continuous and competitive circuit training models (sig 0.000 for both groups). This finding underscores the importance of incorporating aerobic conditioning into badminton training, as it directly impacts both stamina and overall performance.

Limitations

Lifestyle, previous playing experience, day-to-day activities, and mode of selection of players are considered limitations. Training age, skill levels, and fitness of a player were not considered in this study. Atmospheric changes, humidity, and geographical conditions such as meteorological factors during the period of testing could not be controlled and their possible influence on selected variables is also regarded as a limitation. No special motivational techniques were used to encourage the subjects to do their best during the test.

Recommendations

It is crucial to consider the environmental conditions in which the players are training, such as temperature, altitude, and humidity, as these factors can significantly impact their physical performance and recovery. Each athlete has unique capabilities, fitness levels, and physical limitations. A well-structured training program should be personalized to align with the players' current fitness levels and capacity to handle physical stress, ensuring they improve steadily without overtraining or risking injury. The intensity, volume, and type of training should differ based on the competitive level of the athlete. Age and gender play a significant role in determining the training needs of athletes. Coaches and trainers must regularly evaluate each player's "training age" as it reflects their ability to handle advanced training protocols. Assessing an athlete’s maximum load and intensity helps coaches design training sessions that challenge the athlete without pushing them beyond their limits.

Conclusions

This study shows that there was a significant improvement in Physiological variable such as in blood lactate, vital capacity and vo_2 Max in experimental group after going through 6 weeks of conditioning training. The result also implies that in some Physiological variables such as Systolic & Diastolic Blood Pressure, there was no significant difference was found. Practitioner may use this training programme to improve the physiological performance among the trainees.

Practitioner, coaches and athletes may use this training programme to improve the physiological performance among the athletes. Future research may consider analyzing athletes from varying participation levels, including both badminton players and other sports participants. The study can be replicated with different subject groups to enhance generalizability. Alternative conditioning training methods could be explored in future investigations. Further studies could focus on different variables not included in the current research to gain a broader understanding of the topic.

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References

Ariani, L. P. T. A., Sudiana, I. K., & Kusuma, K. C. A. (2022). Continuous and competitive circuit training: Methods to increase vo2max on young badminton player. *Journal Sport Area*, *7*(2), 236–245. https://doi.org/10.25299/sportarea.2022.vol7(2).9423

Balaji, P., Suresh, C., Sanjaykumar, S., Kalmykova, Y., Grygus, I., Lobo, J., & Setiawan, E. (2025). Strength training protocols tailored for badminton players: A pilot study. *Fizjoterapia Polska*, *25*(1), 383–388. https://doi.org/10.56984/8ZG007D4HBJ

Benítez-Muñoz, J. A., & Cupeiro, R. (2025). Factors Influencing Blood Lactate Concentration During Exercise: A Narrative Review With a Lactate Shuttle Perspective. *Acta Physiologica*, *241*(12), e70131. https://doi.org/10.1111/apha.70131

Berge, H. M., Isern, C. B., & Berge, E. (2015). Blood pressure and hypertension in athletes: A systematic review. *British Journal of Sports Medicine*, *49*(11), 716–723. https://doi.org/10.1136/bjsports-2014-093976

Cheng, C.-F., Kuo, Y.-H., Hsu, W.-C., Chen, C., & Pan, C.-H. (2021). Local and Remote Ischemic Preconditioning Improves Sprint Interval Exercise Performance in Team Sport Athletes. *International Journal of Environmental Research and Public Health*, *18*(20), 10653. https://doi.org/10.3390/ijerph182010653

Coles, L., Litt, J., Hatta, H., & Bonen, A. (2004). Exercise rapidly increases expression of the monocarboxylate transporters MCT1 and MCT4 in rat muscle. *The Journal of Physiology*, *561*(1), 253–261. https://doi.org/10.1113/jphysiol.2004.073478

Cornelissen, V. A., & Smart, N. A. (2013). Exercise Training for Blood Pressure: A Systematic Review and Meta-analysis. *Journal of the American Heart Association*, *2*(1), e004473. https://doi.org/10.1161/JAHA.112.004473

Edel, A., Vuong, J.-L., Kaufmann, S., Hoos, O., Wiewelhove, T., & Ferrauti, A. (2024). Metabolic profile in elite badminton match play and training drills. *European Journal of Sport Science*, *24*(11), 1639–1652. https://doi.org/10.1002/ejsc.12196

Edel, A., Weis, J.-L., Ferrauti, A., & Wiewelhove, T. (2023). Training drills in high performance badminton—Effects of interval duration on internal and external loads. *Frontiers in Physiology*, *14*, 1189688. https://doi.org/10.3389/fphys.2023.1189688

Faude, O., Meyer, T., Rosenberger, F., Fries, M., Huber, G., & Kindermann, W. (2007). Physiological characteristics of badminton match play. *European Journal of Applied Physiology*, *100*(4), 479–485. https://doi.org/10.1007/s00421-007-0441-8

Faul, F., Erdfelder, E., E, L., & Buchner. (2007). *G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behavior Research Methods, 39, 175-191.* https://www.psychologie.hhu.de/fileadmin/redaktion/Fakultaeten/Mathematisch-Naturwissenschaftliche_Fakultaet/Psychologie/AAP/gpower/GPower3-BRM-Paper.pdf

Gasibat, Q., Abdullah, B., Samsudin, S., Alexe, D. I., Alexe, C. I., & Tohănean, D. I. (2023). Gender-Specific Patterns of Muscle Imbalance in Elite Badminton Players: A Comprehensive Exploration. *Sports*, *11*(9), 164. https://doi.org/10.3390/sports11090164

Ghosh, A. K., Goswami, A., & Ahuja, A. (1993). Evaluation of a sports specific training programme in badminton players. *The Indian Journal of Medical Research*, *98*, 232–236.

Graham, B. L., Steenbruggen, I., Miller, M. R., Barjaktarevic, I. Z., Cooper, B. G., Hall, G. L., Hallstrand, T. S., Kaminsky, D. A., McCarthy, K., McCormack, M. C., Oropez, C. E., Rosenfeld, M., Stanojevic, S., Swanney, M. P., & Thompson, B. R. (2019). Standardization of Spirometry 2019 Update. An Official American Thoracic Society and European Respiratory Society Technical Statement. *American Journal of Respiratory and Critical Care Medicine*, *200*(8), e70–e88. https://doi.org/10.1164/rccm.201908-1590ST

Green, R., West, A. T., & Willems, M. E. T. (2023). Notational Analysis and Physiological and Metabolic Responses of Male Junior Badminton Match Play. *Sports*, *11*(2), 35. https://doi.org/10.3390/sports11020035

Haller, N., Stoeggl, T., Strepp, T., Blumkaitis, J., Schmuttermair, A., Kilzer, F., & Wiesinger, H.-P. (2022). High-Intensity Interval Training In Elite Athletes. A Meta-Analysis Of Effects On VO 2max: 1122. *Medicine & Science in Sports & Exercise*, *54*(9S), 272–272. https://doi.org/10.1249/01.mss.0000878432.17738.98

Heller, J. (2010). Physiological profiles of elite badminton players: Aspects of age and gender. *British Journal of Sports Medicine*, *44*(Suppl 1), i17.1-i17. https://doi.org/10.1136/bjsm.2010.078725.51

Hommel, J., Öhmichen, S., Rudolph, U. M., Hauser, T., & Schulz, H. (2019). Effects of six-week sprint interval or endurance trainingon calculated power in maximal lactate steady state. *Biology of Sport*, *36*(1), 47–54. https://doi.org/10.5114/biolsport.2018.78906

Joummy, A., Suppiah, P., & Samsir, M. (2020). The Effect of High-Intensity Intermittent Functional Training Towards The Aerobic Fitness of Youth Badminton Players. *Malaysian Journal of Movement, Health & Exercise*, *9*(1), 149. https://doi.org/10.4103/2600-9404.323194

Krustrup, P., Mohr, M., Amstrup, T., Rysgaard, T., Johansen, J., Steensberg, A., Pedersen, P. K., & Bangsbo, J. (2003). The Yo-Yo Intermittent Recovery Test: Physiological Response, Reliability, and Validity: *Medicine & Science in Sports & Exercise*, *35*(4), 697–705. https://doi.org/10.1249/01.MSS.0000058441.94520.32

Liu, H., Leng, B., Li, Q., Liu, Y., Bao, D., & Cui, Y. (2021). The Effect of Eight-Week Sprint Interval Training on Aerobic Performance of Elite Badminton Players. *International Journal of Environmental Research and Public Health*, *18*(2), 638. https://doi.org/10.3390/ijerph18020638

Ma, S., Xue, W., Soh, K. G., Liu, H., Xu, F., Sun, M., Li, J., Shi, X., & Wang, X. (2025). Effects of physical training programs on healthy badminton players' performance: A systematic review and meta-analysis. *BMC Sports Science, Medicine and Rehabilitation*, *17*(1), 189. https://doi.org/10.1186/s13102-025-01199-y

Mendez-Villanueva, A., Fernandez-Fernandez, J., & Bishop, D. (2007). Exercise-induced homeostatic perturbations provoked by singles tennis match play with reference to development of fatigue. *British Journal of Sports Medicine*, *41*(11), 717–722; discussion 722. https://doi.org/10.1136/bjsm.2007.037259

Mentzoni, F., Skaugen, M., Eythorsdottir, I., Roterud, S., Johansen, E. S., & Losnegard, T. (2024). Precision and accuracy of four handheld blood lactate analyzers across low to high exercise intensities. *European Journal of Applied Physiology*, *124*(12), 3781–3788. https://doi.org/10.1007/s00421-024-05572-6

Montes, J., & Navalta, J. W. (2019). Reliability of the Polar T31 Uncoded Heart Rate Monitor in Free Motion and Treadmill Activities. *International Journal of Exercise Science*, *12*(4), 69–76. https://doi.org/10.70252/JCQF3272

Ooi, C. H., Tan, A., Ahmad, A., Kwong, K. W., Sompong, R., Mohd Ghazali, K. A., Liew, S. L., Chai, W. J., & Thompson, M. W. (2009). Physiological characteristics of elite and sub-elite badminton players. *Journal of Sports Sciences*, *27*(14), 1591–1599. https://doi.org/10.1080/02640410903352907

Souza, E. O., Ugrinowitsch, C., Tricoli, V., Roschel, H., Lowery, R. P., Aihara, A. Y., Leão, A. R. S., & Wilson, J. M. (2014). Early adaptations to six weeks of non-periodized and periodized strength training regimens in recreational males. *Journal of Sports Science & Medicine*, *13*(3), 604–609.

Sudarma, M., Asmawi, M., Lubis, J., . J., Humaid, H., & . S. (2024). Impact of VO2 Max Capacity And Application of Training Methods on the Effectiveness of Endurance Ability. *KnE Social Sciences*. https://doi.org/10.18502/kss.v9i31.17606

Sukadiono, S., Zahrah, S. F., Nasrullah, D., Supatmi, S., & Fitriyani, V. R. (2022). The effect of physical exercise on vital lung capacity in Tapak Suci athletes. *Jurnal Keolahragaan*, *10*(2), 166–174. https://doi.org/10.21831/jk.v10i2.52392

Tai, C.-C., Chen, Y.-L., Kalfirt, L., Masodsai, K., Su, C.-T., & Yang, A.-L. (2022). Differences between Elite Male and Female Badminton Athletes Regarding Heart Rate Variability, Arterial Stiffness, and Aerobic Capacity. *International Journal of Environmental Research and Public Health*, *19*(6), 3206. https://doi.org/10.3390/ijerph19063206

Valenzuela, P. L., Sánchez-Martínez, G., Torrontegi, E., Vázquez-Carrión, J., González, M., Montalvo, Z., & Millet, G. P. (2019). Acute Responses to On-Court Repeated-Sprint Training Performed With Blood Flow Restriction Versus Systemic Hypoxia in Elite Badminton Athletes. *International Journal of Sports Physiology and Performance*, *14*(9), 1280–1287. https://doi.org/10.1123/ijspp.2018-0878

Wang, T., Yee Guan, N., Amri, S., Kamalden, T. F., & Gao, Z. (2025). Effects of resistance training on performance in competitive badminton players: A systematic review. *Frontiers in Physiology*, *16*, 1548869. https://doi.org/10.3389/fphys.2025.1548869

Wee, E. H., & Chan, K. Q. (2017). Effects of High Intensity Intermittent Badminton Multi-Shuttle Feeding Training on Aerobic and Anaerobic Capacity, Leg Strength Qualities and Agility. *In Proceedings of the 5th International Congress on Sport Sciences Research and Technology Support*, 39–47. https://doi.org/10.5220/0006501000390047

Yilmaz, N. (2022). *Investigation of the effect of acute badminton training on selected biomotoric parameters*.

Yuniana, R. (2020). Effect of aerobic and load exercises on body fat and lung vital capacity. *MEDIKORA*, *19*(2), 82–97. https://doi.org/10.21831/medikora.v19i2.34740

Zhang, P., Li, X., Fang, Z., Lu, Y., Cui, J., Du, X., & Hu, R. (2021). Smartphone application-supported validation of three automatic devices for self-measurement of blood pressure according to the European Society of Hypertension International Protocol revision 2010: The Omron HEM-7120, Yuwell YE680A and Cofoe KF-65B. *Blood Pressure Monitoring*, *26*(6), 435–440. https://doi.org/10.1097/MBP.0000000000000547

Zhang, Z., Xie, L., Ji, H., Chen, L., Gao, C., He, J., Lu, M., Yang, Q., Sun, J., & Li, D. (2024). Effects of different work-to-rest ratios of high-intensity interval training on physical performance and physiological responses in male college judo athletes. *Journal of Exercise Science & Fitness*, *22*(3), 245–253. https://doi.org/10.1016/j.jesf.2024.03.009

Zhao, D., Liu, H., Yang, W., Ho, I. M. K., Poon, E. T.-C., Su, Y., Guo, Y., Huang, Y., & Li, Q. (2024). *Effects of Low-Volume Court-Based Sprint Interval Training on Anaerobic Capacity and Sport-Specific Performance in Competitive Tennis Players*. In Review. https://doi.org/10.21203/rs.3.rs-4372803/v1

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