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EFFECT OF UNI-BILATERAL, CROSS FIT AND MUD TRAINING ON VO2 MAX AND RESTING HEART RATE ON FEMALE INDIGENOUS TEAM PLAYER

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Abstract

Aim – Effect of cross fit, uni-bilateral and mud training on vo2 max and resting heart rate on female indigenous team player**.**

Methods: Eighty female indigenous team players from of Kasturba Gandhi Balika Vidyalaya Shahjahanpur Uttar Pradesh, were selected at random to participate as subjects. The ages of the participants fell in between 10 and 14 years. The review was designed with a pre-and post-test random collection strategy in which eighty subjects were divided into four equal groups. There were randomly assigned to one of four groups: Experimental Group-I (N=20; CrossFit). The Experimental Group-II (N=20, uni-bilateral group). The Experimental Group-III (N=20; Mud group) 12-minute run designed by Kenneth Cooper. Vo2max = (22.351 x distance in kilometers) - 11.288 and Pulse Oximeter was used to access vo2 max and resting heart rate. The 12-week training program for CrossFit, uni-bilateral and mud training were tailored with specific sets, repetitions, and intensity levels.

Results: Statistically significant mean differences in VO_2 max among several groups: between the CrossFit training and control groups; uni-bilateral exercise and control groups; mud training and control groups. The corresponding mean differences—1.44, 1.36 and 1.84—exceeded the critical confidence interval value of 1.31. significant mean differences in resting pulse rate among several groups: between the training and control groups; uni-bilateral exercise and mud training; uni-bilateral exercise and control groups; mud training and control groups. The corresponding mean differences—2.67, 1.25 1.87 and 3.12—exceeded the critical confidence interval value of 1.17.

Conclusions: The study demonstrates that interventions involving CrossFit training, uni-bilateral exercise, and mud training significantly improved VO_2 max and resting heart rate among female indigenous team game players.

Keywords: Uni-bilateral, CrossFit, mud training

INTRODUCTION

India is one of the largest country in the world in both area and population. India is also one of the few countries that have retained the popularity of their indigenous games among its people. Such traditional games include pehlwani, kabaddi, silambam, yoga, thayam, aadu puli aatam, parama padam, carrom, Kho-Kho, gili danda, ettu kodu, langdi, lagori, ainthu kallu, pallanguzhi, malyutam.

Cross fit is recognized as one of the fastest growing high-intensity functional training modes in the world. Cross fit strength and conditioning program is used to optimize physical competence in ten fitness domains: (1) cardiovascular/respiratory endurance, (2) stamina, (3) strength, (4) flexibility, (5) power, (6) speed, (7) coordination, (8) agility, (9) balance, and (10)accuracy. Cross fit training is usually performed with high-intensity, functional movements called "workout of the day" (WOD). In these training sessions, high-intensity exercises are executed quickly, repetitively, and with little or no recovery time between sets. With the focuson constantly varying functional movements, cross fit training uses the main elements of gymnastics (e.g., handstand and ring exercises), weightlifting exercises (e.g., barbell squats and presses), and cardiovascular activities (e.g., running or rowing) as exercise tasks (Fisker 2016). According to Glassman (2002) who is the founder of cross fit, the methodology that drives cross fit training is entirely empirical. Furthermore, Glassman (2007) described that "meaningful statements about safety, efficacy, and efficiency, the three most important and interdependent facets of any fitness program, can be supported only by measurable, observable,repeatable facts, i.e., data". Cross fit is also considered an option for high-intensity interval training (HIIT).

"Mud is also useful in reducing swelling and pain and eases stiff joints. For centuries, people around the world

have used mud as a medicinal and beauty remedy. Mudacts as a natural exfoliate and means to draw toxins out of the body, to increase blood flow to certain areas of the body, and to relax muscles" (Deyo, Von Korff, and Duhrkoop, 2015). Mud training is a brilliant way to spice up athletes fitness. Mud training is a way of running, tackling obstacles, testing your fitness and mental resolve.

Speed is determined not only by how fast an individual can run (or cycle, swim, etc.) but also by their own velocity (how quickly they can accelerate from a static position), maximum possible speed of movement, and speed maintenance (minimizing deceleration). Speed necessitates good strength and power, but excess body weight and air resistance can also stymie performance. Speed is determined not only by how fast an individual can run (or cycle, swim, etc.) but also by their own velocity (how quickly they can accelerate from a static position), maximum possible speed of movement, and speed maintenance (minimizing deceleration). Speed necessitates good strength and power, but excess body weight and air resistance can also stymie performance.

Physical fitness is used to denote only the five basic fitness components (muscular strength, muscular endurance, cardiovascular endurance, freedom from obesity and flexibility), whereas motor fitness is a more comprehensive term, which includes all the ten fitness components including additional five motor performance components (power, speed, agility, balance and reaction time), important mainly for success in sports. "Motor fitness refers to the efficiency of basic movements in additional to the physical fitness" (Dos'Santos, 2022). In addition motor fitness in athlete make the sportsperson to learn the complexity of the skill off early and use the tactics of the skill very effectively and efficiently to overpower the opponent's players

Kho-Kho is a traditional Indian sport enjoyed by both school boys and girls. It is a tag game similar to Kabaddi. Kho-Kho is a traditional outdoor sport that dates back to centuries. The game relies heavily on speed and agility as this is a free embodiment type of game where all players can run around freely.

Kho-Kho, which has its roots in the state of Maharashtra (Marathi Kho-Kho); it is a team sport where contact from the opponents is to be avoided. Earlier known as Rathera on account of being played on Indian chariots (raths), the game has emerged as a version of tag, a modified form of 'run-and-chase' in which the purpose is to chase/pursue and touch the opponent. "Kho-Kho at individual level requires the variables of stamina, endurance, strength and agility, and the skills of dodging, feinting and bursts of speed because the game is vigorous and combative in nature. Running, skipping and weight-lifting are the training measures for maintaining endurance and strength required for the sport; the game is complicated and tactical and those with the mesomorphic somatotype and good muscle development and with better anaerobic and aerobic fitness compared to volley ball players, perform well" (Roy, Ashim 2017).

"Kho-Kho is a popular sport in India, especially in rural areas and schools. It is a low-cost and easy-to-play game that requires minimal equipment and space. It is also a game that promotes physical fitness, mental alertness, social skills and cultural values" (Ravindra, Gouda & Virupaksha,2016).

Kho-Kho has a bright future and a huge potential to become one of the leading sports in India and the world. The game has many advantages and attractions, such as its simplicity, excitement, thrill, competitiveness, and cultural significance. "Kho-Kho also has the potential to attract more sponsors, media coverage, and viewership, as it is a fast-paced and entertaining game that can be easily adapted to different formats and platforms" (Roy & Ashim, 2017).

Mud is one of the five elements of nature. It has fine qualities and helps to absorb toxins, improve blood circulation and relax muscles. It also maintains metabolism and has a positive impact on digestion" (Ram Kumar Agarwal ,2022).

"Mud is also useful in reducing swelling and pain and eases stiff joints. For centuries, people around the world have used mud as a medicinal and beauty remedy. Mudacts as a natural exfoliate and means to draw toxins out of the body, to increase blood flow to certain areas of the body, and to relax muscles" (Deyo, Von Korff, and Duhrkoop, 2015).

Speed is determined not only by how fast an individual can run (or cycle, swim, etc.) but also by their own velocity (how quickly they can accelerate from a static position), maximum possible speed of movement, and speed maintenance (minimizing deceleration). Speed necessitates good strength and power, but excess body weight and air resistance can also stymie performance. Speed is determined not only by how fast an individual can run (or cycle, swim, etc.) but also by their own velocity (how quickly they can accelerate from a static position), maximum possible speed of movement, and speed maintenance (minimizing deceleration). Speed necessitates good strength and power, but excess body weight and air resistance can also stymie performance.

Physical fitness is used to denote only the five basic fitness components (muscular strength, muscular endurance, cardiovascular endurance, freedom from obesity and flexibility), whereas motor fitness is a more comprehensive term, which includes all the ten fitness components including additional five motor performance components (power, speed, agility, balance and reaction time), important mainly for success in sports. "Motor fitness refers to the efficiency of basic movements in additional to the physical fitness" (Dos 'Santos, 2022).

A unilateral exercise movement is when each limb works independently of the other to create the desired movement. Unilateral training is any form of movement that trains one limb at a time, rather than both arm or leg simultaneously (Avetisyan, 2022)".

VO2 max, or maximal oxygen uptake, is one factor that can determine a player's capacity to perform sustained exercise and is linked to aerobic endurance. VO2 max refers to the maximum amount of oxygen that an individual can utilize during intense or maximal exercise" (Michaikidis, 2018). It is measured as "milliliters of oxygen used

in one minute per kilogram of body weight." To support high performance during the aforementioned stunts requires good physical condition. One of the components needed is durability. Endurance is the body's capacity to carry out activities for a long time without experiencing fatigue and is characterized by rapid recovery. To determine whether an athlete's endurance is good or not is to measure and see the VO2Max capacity. VO2Max is considered the main indicator for evaluating cardiorespiratory fitness. VO2Max is the main indicator for measuring athlete performance and cardiovascular adaptation to training loads. As a sport that needs good physical condition, the VO2Max needs of players must be known by every coach and player. “The selection of the right training method must be a concern for the coach. To train endurance in this case to improve VO2Max ability, many training methods can be used, training that can be used to improve the Vo2max ability of players include interval training, fartlek, continuous training and SSG” (Sporis & Leko, 2021).

Resting heart rate (RHR) may be defined as, without any external or internal influence, rate of contraction of heart to maintain basal metabolic rate at complete rest. RHR depends on type of sports. Regular physical activity helps to reduce RHR. HR at rest depends on increases in parasympathetic tone or decrease in beta-adrenergic stimulation or change in end diastolic volume in the intrinsic HR mechanisms” (Magri & Piepoli,2022). It is well known that high RHR is associated with increased cardiovascular risk in general populations, possibly due to sympathetic over-activity or elevated blood pressure (BP). Nowadays, RHR along with HRV is considered as a very effective way to prevent serious mistakes in training. A simple inspection of RHR can indicate training adaptation when HRV is trending positively. “An athlete’s resting heart rate may be considered low when compared to the general population. A young, healthy athlete may have a heart rate of 30 to 40 bpm. That’s because exercise strengthens the heart muscle. It allows it to pump a greater amount of blood with each heartbeat. More oxygen is also going to the muscles. This means the heart beats fewer times per minute than it would in a nonathlete. However, an athlete’s heart rate may go up to 180 bpm to 200 bpm during exercise” (Nystoriak & Bhatnagar ,2018).

MATERIALS AND METHODS

Participants

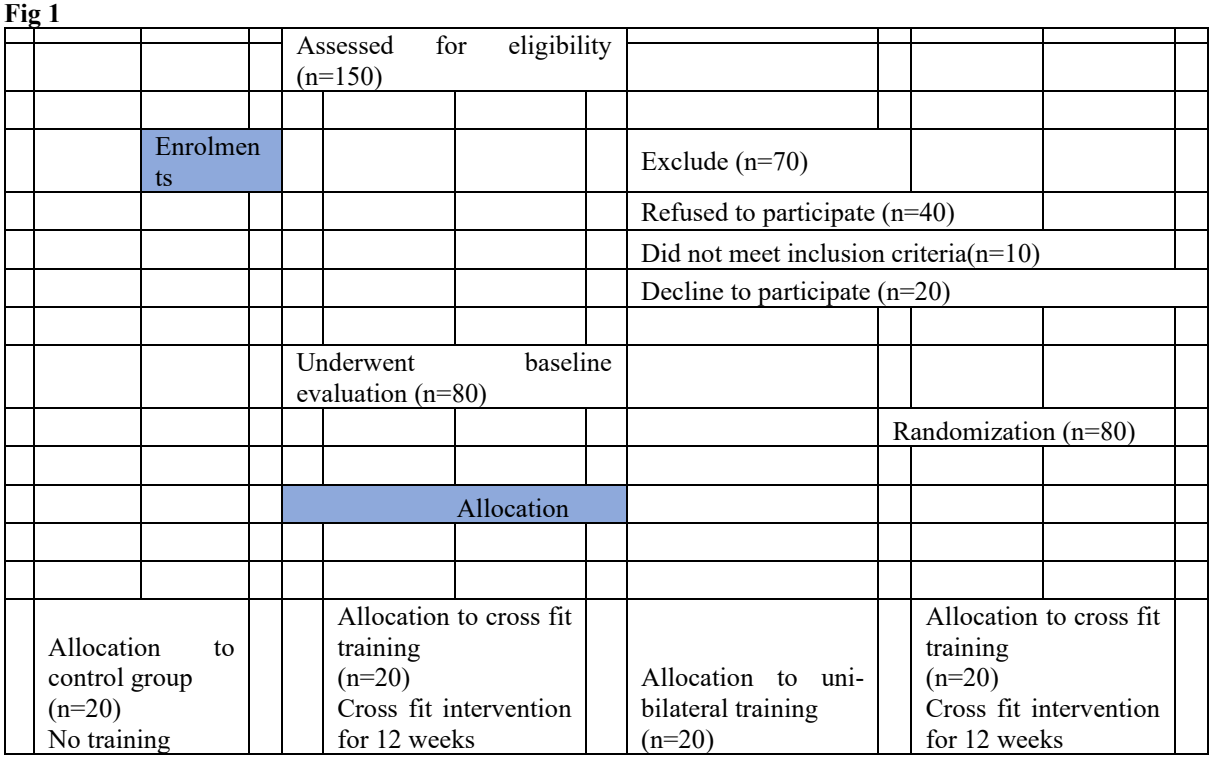
This study used a pre-test and post-test design. The primary objective was to evaluate how Cross fit and mud training affected vo2 max and resting heart rate over 12 weeks. Two measurement points were established:

Pre-test: Baseline measures of VO_2 max ($mL \cdot kg^{-1} \cdot min^{-1}$) and resting heart rate (beat per minute) were recorded before the intervention.

Post-test: VO_2 max ($mL \cdot kg^{-1} \cdot min^{-1}$) and resting heart rate (beat per minute) were measured after the 12-week intervention.

This randomized controlled trial investigated the effects of CrossFit, uni-bilateral and mud training on vo2 max and resting heart rate on female indigenous team players. The study enrolled 80 participants, aged 10- 14 years of Kasturba Gandhi Balika Vidyalaya Shahjahanpur Uttar Pradesh (the age of sportsperson will be calculated through the Aadhaar Card) chosen for the study. There are 15 blocks in Shahjahanpur district and each block has one Kasturba Gandhi Balika Vidyalaya. From each block minimum 10 players were selected by purposive sampling cum random sampling. Participants were randomly assigned (Figure 1) to one of three groups: control, CrossFit, uni-bilateral mud training, with 30 individuals per group, using a lottery method (See Figure 1).

Fig 1



									Cross fit intervention for 12 weeks							
					Analysis											
	Analysed (n=20)				Analysed (n=20)				Analysed (n=20)				Analysed (n=20)			

Sample size calculation

The sample size was determined using G*Power software version 3.1.9.2 (Kang, 2021). The calculation was based on a ANCOVA with four groups, assuming a medium effect size (f=0.50), an alpha level of 0.05, and a desired power of 0.80. To account for potential dropouts and ensure adequate power for subgroup analyses, the researchers increased the sample size by approximately 20%, resulting in a total target sample of 60 participants.

Inclusion and exclusion criteria

Inclusion criteria required participants to understand and follow instructions in the local language and to be willing to participate for the full study duration.

Exclusion criteria included Presence of any chronic illness or condition contraindicating intense physical exercise. Athletes currently engaged in CrossFit, uni-lateral, or mud training programs.

Procedure

The intervention programs spanned 12 weeks, comprising three weekly sessions, each lasting 60 minutes. Training volume, including sessions, sets, repetitions, and duration, was kept consistent between the training. The passive control group did not engage in any prescribed exercise during the study. The training interventions were meticulously designed and administered by expert trainers from the Fitness Centre of the Kasturba Gandhi Balika Vidyalaya. We maintained a participant-to-coach ratio of 1:5 to ensure personalized attention and effective training. Each training session was structured into three phases: a 10-minute warm-up, the main exercise program, and a cool-down period. Pre-Mobility Session (03min): Pre-mobility of all the major joints is highly required. Warm-Up (07 min): Jog, Walking Butt Kick, Walking High Knee, Arms Extended Rotation, 10m Sprint × 3, Cool Down (05 min): Hamstring Stretch, Calf Stretch, Crossed Leg Toe Touch, Torso Twist. Adjustments to load, repetitions, and rest periods can be made based on individual fitness levels. Proper technique and form should be prioritized to avoid injuries.

Training Protocol

(GROUP-1) CROSSFIT EXERCISE GROUP

Table - 1

Duration (Weeks)	Phases	Exercises (Performed in a Circuit)	Sets	Repetitions	Recovery Between Sets	Intensity
1 & 2	Phase 1	1. Jump Squat 2. Butterfly Sit-ups 3. Triceps Dips 4. Burpee 5. Lunge hoops 6.Sit-ups	2	08 - 12	120 Seconds	70-80%
3 & 4	Phase 1	1. Jump Squat 2. Butterfly Sit-ups 3. Triceps Dips 4. Burpee 5. Lunge hoops 6.Sit-ups	2	08 - 12	120 Seconds	70-80%
5 & 6	Phase 2	1. Jump Squat 2. Butterfly Sit-ups 3. Triceps Dips 4. Burpee 5. Lunge hoops 6.Sit-ups	2	12 - 15	90 Seconds	70-80%
7 & 8		1. Jump Squat 2. Butterfly Sit-ups	3	12 - 15	90 Seconds	75-85%

Duration (Weeks)	Phases	Exercises (Performed in a Circuit)	Sets	Repetitions	Recovery Between Sets	Intensity
	Phase 2	3. Triceps Dips 4. Burpee 5. Lunge hoops 6.Sit-ups				
9 & 10	Phase 3	1. Jump Squat 2. Butterfly Sit-ups 3. Triceps Dips 4. Burpee 5. Lunge hoops 6.Sit-ups	3	15 - 18	60 Seconds	75-85%
11 & 12	Phase 3	1. Jump Squat 2. Butterfly Sit-ups 3. Triceps Dips 4. Burpee 5. Lunge hoops 6.Sit-ups	3	15 - 18	60 Seconds	75-85%

(GROUP-2) UNI-BILATERAL EXERCISE GROUP
Table - 2

Duration (Weeks)	Phases	Exercises (Unilateral + Bilateral)	Sets	Repetitions	Hold Time	Recovery Between Sets	Intensity
1 & 2	Phase 1	Unilateral: 1.Side Lunge 2.Forward Lunge 3 Backward Lunge Bilateral: 1.Glute Bridge 2.Calf-Raise 3.Good Morning	2	08 - 12	30 Seconds	120 Seconds	70-80%
3 & 4	Phase 1	Unilateral: 1.Side Lunge 2.Forward Lunge 3.Backward Lunge Bilateral: 1.Glute Bridge 2.Calf-Raise 3.Good Morning	2	08 - 12	30 Seconds	120 Seconds	70-80%
5 & 6	Phase 2	Unilateral: 1.Side Lunge 2.Forward Lunge 3.Backward Lunge Bilateral: 1.Glute Bridge 2.Calf-Raise 3.Good Morning	2	12 - 15	45 Seconds	120 Seconds	70-80%
7 & 8	Phase 2	Unilateral: 1.Side Lunge 2.Forward Lunge 3.Backward Lunge Bilateral: 1.Glute Bridge 2.Calf-Raise 3.Good Morning	3	12 - 15	45 Seconds	90 Seconds	75-85%

Duration (Weeks)	Phases	Exercises (Unilateral + Bilateral)	Sets	Repetitions	Hold Time	Recovery Between Sets	Intensity
9 & 10	Phase 3	Unilateral: 1.Side Lunge 2.Forward Lunge 3.Backward Lunge Bilateral: 1.Glute Bridge 2.Calf-Raise 3.Good Morning	3	15 - 18	60 Seconds	90 Seconds	75-85%
11 & 12	Phase 3	Unilateral: 1.Side Lunge 2.Forward Lunge 3.Backward Lunge Bilateral: 1.Glute Bridge 2.Calf-Raise 3.Good Morning	3	15 - 18	60 Seconds	90 Seconds	75-85%

(GROUP-3) MUD TRAINING EXERCISE GROUP
Table - 3

Duration (Weeks)	Phases	Exercises (Mud-Based)	Sets	Repetitions	Recovery Between Sets	Intensity
1 & 2	Phase 1	1.High Knee 2.Standing Rear Leg Raise- Right Leg 3.Standing Rear Leg Raise- Left Leg 4.Standing Side-ward Leg Raise - Right Leg 5.Standing Side-ward Leg Raise - Left Leg 6.Vertical Jump	2	05-08	120 Seconds	70-80%
3 & 4	Phase 1	1.High Knee 2.Standing Rear Leg Raise- Right Leg 3.Standing Rear Leg Raise- Left Leg 4.Standing Side-ward Leg Raise - Right Leg 5.Standing Side-ward Leg Raise - Left Leg 6.Vertical Jump	2	05-08	120 Seconds	70-80%
5 & 6	Phase 2	1.High Knee 2.Standing Rear Leg Raise- Right Leg 3.Standing Rear Leg Raise- Left Leg 4.Standing Side-ward Leg Raise - Right Leg 5.Standing Side-ward Leg Raise - Left Leg 6.Vertical Jump	2	08 - 10	120 Seconds	75-85%
7 & 8	Phase 2	1.High Knee 2.Standing Rear Leg Raise- Right Leg 3.Standing Rear Leg Raise- Left Leg 4.Standing Side-ward Leg Raise - Right Leg 5.Standing Side-ward Leg Raise - Left Leg 6.Vertical Jump	3	08 - 10	90 Seconds	75-85%
9 & 10	Phase 3	1.High Knee 2.Standing Rear Leg Raise- Right Leg 3.Standing Rear Leg Raise- Left Leg 4.Standing Side-ward Leg Raise - Right Leg 5.Standing Side-ward Leg Raise - Left Leg 6.Vertical Jump	3	10 - 12	90 Seconds	75-85%
11 & 12	Phase 3	1.High Knee 2.Standing Rear Leg Raise - Right Leg 3.Standing Rear Leg Raise - Left Leg 4.Standing Side-ward Leg Raise - Right Leg 5.Standing Side-ward Leg Raise - Left Leg 6.Vertical Jump	3	10 - 12	90 Seconds	75-85%

Testing

The assessment method used in our study was non-blinded, meaning assessors were aware of the participants' group assignments. This approach was chosen to facilitate logistics and align with the specific features of each intervention. We carefully applied standardized assessment procedures to all groups to improve the credibility of our results, guaranteeing uniformity and impartiality in our assessments. Moreover, the main findings of our research were derived from objective measurements, which naturally reduce the possibility of bias.

Data collection and analysis

Data were collected at baseline, and all outcome measures were assessed pre- and post-intervention by trained research assistants who were blinded to group allocation. Data analysis was conducted using SPSS version 25.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were calculated for all variables, while between-group differences were analyzed using one-way ANCOVA for continuous variables followed by post hoc Scheffe's test. Statistical significance was set at $p<0.05$.

RESULTS

Analysis of VO_2 max

The descriptive analysis, including the means, standard deviations, percentage of improvement, mean differences, and t-ratios of the collected VO_2 max data for the experimental and control groups, is presented in Table IV (A).

Table – IV (A) Descriptive Analysis of the data on VO_2 max of Experimental and Control Groups (Unit of Measurement – (Milliliter/kilogram/minute)

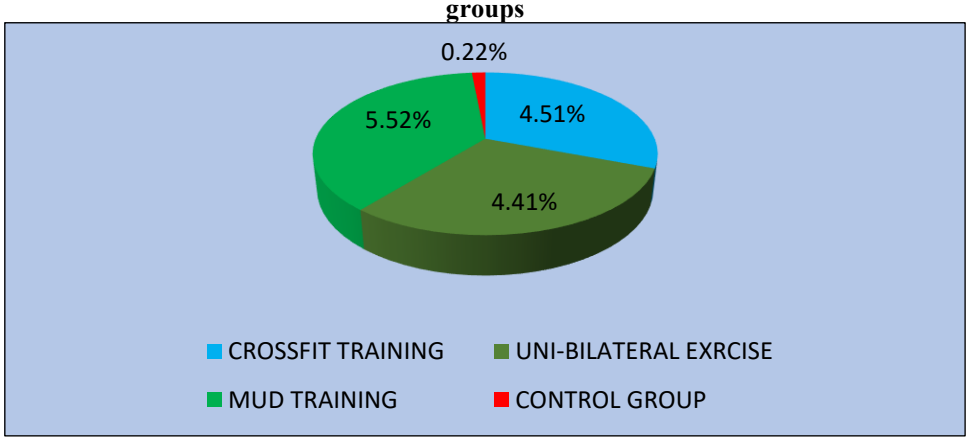
Training	Pre-test		Post-test		M.D	% of changes	't' ratio
	Mean	S. D	Mean	S. D			
CROSSFIT TRAINING	35.64	2.05	37.26	2.02	1.61	4.51 %	7.22*
UNI-BILATERAL EXRCISE	35.36	2.46	36.92	2.62	1.56	4.41 %	2.83*
MUD TRAINING	35.65	2.38	37.61	2.13	6.7	5.52 %	7.30*
CONTROL GROUP	35.87	1.95	35.95	2.08	0.08	0.22 %	0.55

Table t-ratio at 0.05 level of confidence for1 and 19 (df) = 2.093

The calculated t-ratios of 7.22, 2.83, and 7.30 for the CrossFit training, uni-bilateral exercise, and mud training, respectively, exceed the critical t-value of 2.093 at the 0.05 level of significance with degrees of freedom (df) = 1, 19. These results indicate a statistically significant difference between the pre-test and post-test VO_2 max scores in these experimental groups. In contrast, the t-ratio for the control group was 0.55, which is below the critical value, suggesting that the difference observed was not statistically significant.

The intervention outcomes showed improvements in VO_2 max as follows: a 4.51% increase in the CrossFit training, 5.52% in the mud training, and only a 0.22% change in the control group. Figure I illustrate the percentage changes in VO_2 max across all four groups.

Figure – 2 Pie Diagram showing the Percentage of Changes on VO_2 max of Experimental and Control groups



VO_2 max data from the four groups were statistically analyzed using ANCOVA, and the results are presented in Table IV (B).

Table – I (B) Analysis of Covariance on VO_2 max of Experimental and Control groups

	CROSSFIT TRAINING	UNI-BILATERAL EXRCISE	MUD TRAINING	CONTROL GROUP	SOV	SOS	df	M.S	f-ratio
Adjusted Post-test					BG	38.55	3	12.85	6.34*

Mean	37.22	37.14	37.62	35.78	**W G**	152.09	75	2.03	

*Significant at 0.05 level of confidence.

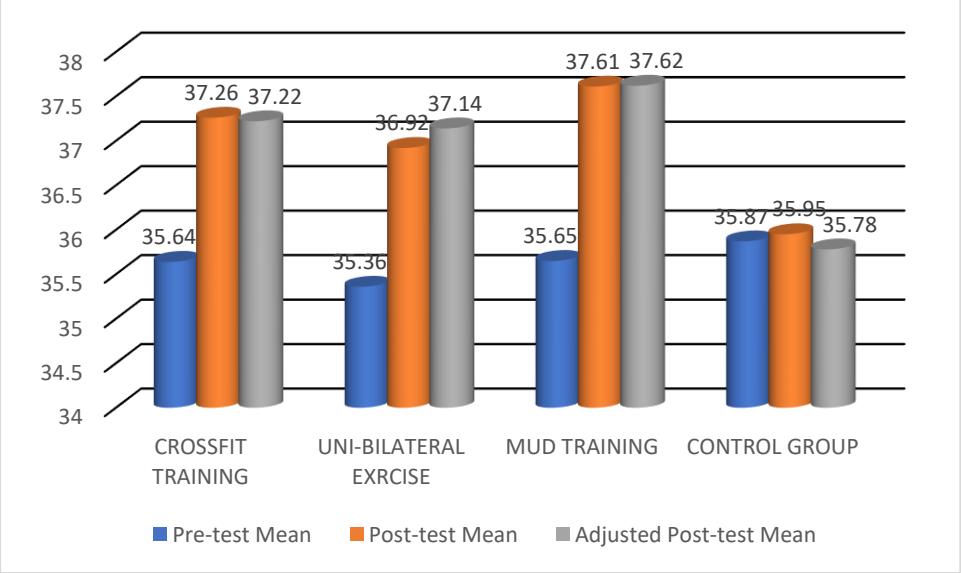
(The table value required for significance with df3 and 75 is 2.73)
The adjusted post-test mean values for VO_2 max were 37.22 for the CrossFit training, 37.14 for the uni-bilateral exercise, 37.62 for the mud training, and 35.78 for the control group. The analysis of covariance yielded an 'F' ratio of 6.34, which exceeded the critical value of 2.73 at the 0.05 level of significance with degrees of freedom 3 and 75. This indicates a statistically significant difference among the adjusted post-test means of the four groups. Consequently, it was concluded that significant differences exist in VO_2 max across the CrossFit training, uni-bilateral exercise, mud training, and control groups. To determine the specific group differences, Scheffé's post hoc test was conducted, and the pairwise comparison results are presented in Table IV (C).

Table – IV (C) Scheffe's Post hoc Test for the differences among Adjusted Post-test Paired Means of Experimental and Control groups on VO_2 max

CROSSFIT TRAINING	UNI-BILATERAL EXRCISE	MUD TRAINING	CONTROL GROUP	M.D	C.I
37.22	37.14	-	-	0.08	1.31
37.22	-	37.62	-	0.40	
37.22	-	-	35.78	1.44*	
-	37.14	37.62	-	0.48	
-	37.14	-	35.78	1.36*	
-	-	37.62	35.78	1.84*	

*Significant at 0.05 level
As presented in Table IV (C), the Scheffe's post hoc analysis revealed statistically significant mean differences in VO_2 max among several groups: between the CrossFit training and control groups; uni-bilateral exercise and control groups; mud training and control groups. The corresponding mean differences—1.44, 1.36 and 1.84—exceeded the critical confidence interval value of 1.31, indicating statistical significance.
In contrast, the mean differences between the CrossFit training and uni-bilateral exercise (0.08), between the CrossFit training and mud training (0.40), and between the uni-bilateral exercise and mud training (0.48) were below the confidence interval threshold, suggesting no significant difference.
These findings indicate that interventions involving CrossFit training, uni-bilateral exercise, and mud training significantly improved VO_2 max among female indigenous team game players. Furthermore, the mud training was more effective than the other groups in enhancing VO_2 max. However, no significant differences were observed between experimental groups.
The pre-test, post-test, and adjusted post-test mean values of VO_2 max for the experimental and control groups are illustrated in Figure II.

Figure – III Bar Diagram Showing the Mean Values on VO_2 max of Experimental and Control groups



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Analysis of Resting Pulse rate (bpm)

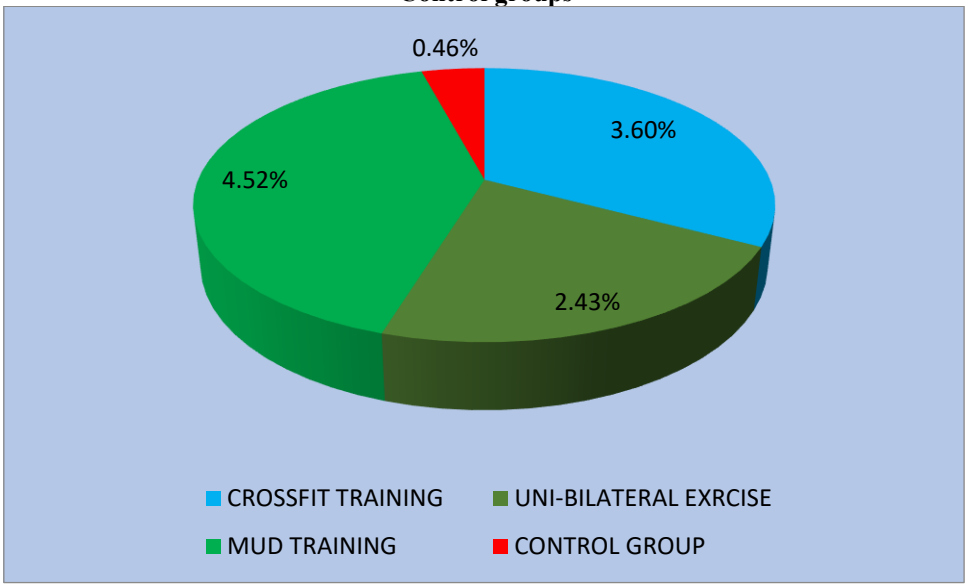
The descriptive analysis, including the means, standard deviations, percentage of improvement, mean differences, and t-ratios of the collected resting pulse rate data for the experimental and control groups, is presented in Table V (A).

Table – V (A) Descriptive Analysis of the data on Resting Pulse rate of Experimental and Control Groups (Unit of Measurement – bpm)

Training	Pre-test		Post-test		M.D	% of changes	't' ratio
	Mean	S. D	Mean	S. D			
CROSSFIT TRAINING	65.30	3.51	62.95	2.95	2.35	3.60 %	9.65*
UNI-BILATERAL EXRCISE	65.60	3.87	64.00	3.74	1.60	2.43 %	8.72*
MUD TRAINING	66.40	3.76	63.40	2.13	3.00	4.52 %	5.53*
CONTROL GROUP	65.40	3.53	65.70	3.09	0.30	0.46 %	1.67

Table t-ratio at 0.05 level of confidence for1 and 19 (df) = 2.093
The calculated t-ratios of 9.65, 8.72, and 5.53 for the CrossFit training, uni-bilateral exercise, and mud training, respectively, exceed the critical t-value of 2.093 at the 0.05 level of significance with degrees of freedom (df) = 1, 19. These results indicate a statistically significant difference between the pre-test and post-test resting pulse rate scores in these experimental groups. In contrast, the t-ratio for the control group was 1.67, which is below the critical value, suggesting that the difference observed was not statistically significant.
The intervention outcomes showed improvements in resting pulse rate as follows: a 3.60% increase in the CrossFit training, 2.43% in the uni-bilateral exercise, 4.52% in the mud training, and only a 0.46% change in the control group. Figure III illustrates the percentage changes in resting pulse rate across all four groups.

Figure – IV Pie Diagram showing the Percentage of Changes on Resting Pulse Rate of Experimental and Control groups



Resting pulse rate data from the four groups were statistically analyzed using ANCOVA, and the results are presented in Table IV (E).

Table – V(B) Analysis of Covariance on Resting Pulse Rate of Experimental and Control groups

	CROSSFIT TRAINING	UNI-BILATERAL EXRCISE	MUD TRAINING	CONTROL GROUP	SOV	SOS	df	M.S	f-ratio
Adjusted Post-test Mean	63.26	64.06	62.81	65.93	BG	113.26	3	37.76	22.45*
					WG	126.11	75	1.68	

*Significant at 0.05 level of confidence.
(The table value required for significance with df3 and 75 is 2.73)

The adjusted post-test mean values for resting pulse rate were 63.26 for the CrossFit training, 64.06 for the uni-bilateral exercise, 62.81 for the mud training, and 65.93 for the control group. The analysis of covariance yielded an 'F' ratio of 22.45, which exceeded the critical value of 2.73 at the 0.05 level of significance with degrees of freedom 3 and 75. This indicates a statistically significant difference among the adjusted post-test means of the four groups. Consequently, it was concluded that significant differences exist in resting pulse rate across the CrossFit training, uni-bilateral exercise, mud training, and control groups. To determine the specific group differences, Scheffé's post hoc test was conducted, and the pairwise comparison results are presented in Table IV (F).

Table – V (C) Scheffe's Post hoc Test for the differences among Adjusted Post-test Paired Means of Experimental and Control groups on Resting Pulse Rate

CROSSFIT TRAINING	UNI-BILATERAL EXRCISE	MUD TRAINING	CONTROL GROUP	M.D	C.I
63.26	64.06	-	-	0.80	1.17
63.26	-	62.81	-	0.45	
63.26	-	-	65.93	2.67*	
-	64.06	62.81	-	1.25*	
-	64.06	-	65.93	1.87*	
-	-	62.81	65.93	3.12*	

*Significant at 0.05 level

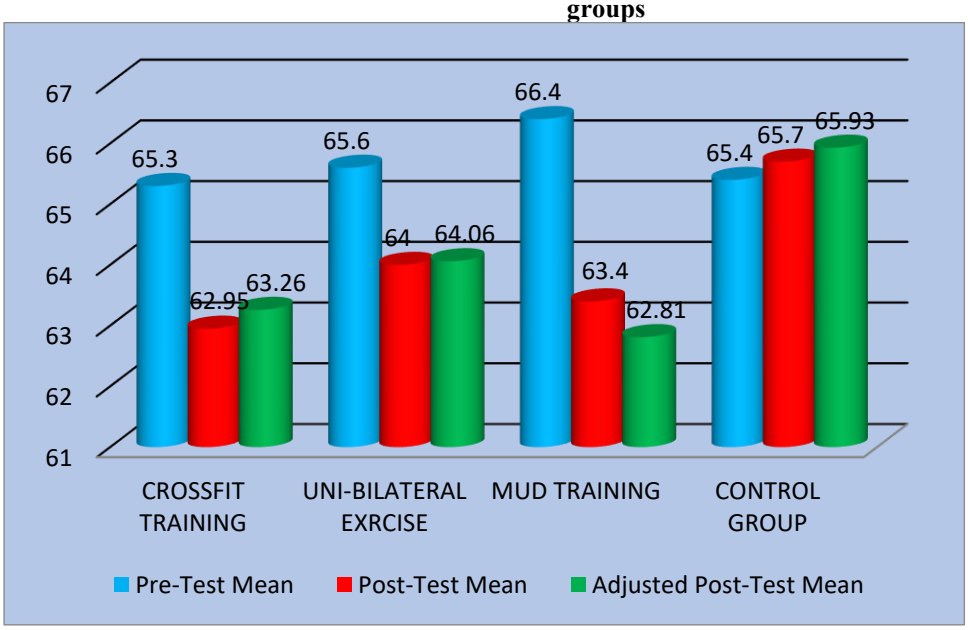
As presented in Table IV (C), the Scheffe's post hoc analysis revealed statistically significant mean differences in resting pulse rate among several groups: between the CrossFit training and control groups; uni-bilateral exercise and mud training; uni-bilateral exercise and control groups; mud training and control groups. The corresponding mean differences—2.67, 1.25 1.87 and 3.12—exceeded the critical confidence interval value of 1.17, indicating statistical significance.

In contrast, the mean differences between the CrossFit training and uni-bilateral exercise (0.80), and between the CrossFit training and mud training (0.45), were below the confidence interval threshold, suggesting no significant difference.

These findings indicate that interventions involving CrossFit training, uni-bilateral exercise, and mud training significantly improved resting pulse rate among female indigenous team game players. Furthermore, the mud training was more effective than the other groups in enhancing resting pulse rate. However, no significant differences were observed between CrossFit and uni-bilateral; and CrossFit and mud training.

The pre-test, post-test, and adjusted post-test mean values of Resting pulse rate for the experimental and control groups are illustrated in Figure IV.

Figure – V Bar Diagram Showing the Mean Values on Resting Pulse Rate of Experimental and Control groups



DISCUSSION

Vo2 Max

The findings clearly indicate that CrossFit training, uni-bilateral exercises, and mud training are highly effective in enhancing selected VO2 max and resting pulse rate, among female indigenous team game players.

These results are strongly supported by evidence from previous research studies. **Xiang (2023)** conducted a study to investigate the impact of CrossFit training on the athletic performance of basketball players. The findings demonstrated that incorporating CrossFit-based training significantly enhanced physical fitness and overall sports performance, suggesting its applicability in routine training regimens.

The data confirms that **all three experimental trainings** significantly improved VO_2 max, with **mud training showing the greatest effect**. This aligns with previous studies like Ramirez-Campillo (2015).

Resting heart rate –

This study evaluated a 6-week CrossFit program in twelve recreationally active adults. Measures included VO_2 max, anaerobic capacity, power, performance, resting heart rate, resting blood pressure, body composition, and subjective recovery efforts. **Goins, J. M. (2014).**

The analysis indicates that **all three interventions significantly reduced resting heart rate**, with **mud training again proving most effective**. This suggests improved cardiovascular efficiency and parasympathetic tone. These results support the hypothesis that diverse physical training forms (especially those with terrain resistance like mud training) enhance autonomic control in young athletes. The findings also correlate with studies cited (e.g., Kashef et al., 2022)

CONCLUSION

In conclusion, this study provides valuable and novel insights into the comparative effect of CrossFit, uni-bilateral and mud training on vo2 max and resting heart rate among female indigenous team players. all three groups have the potential to improve vo2 max and resting heart rate. The study demonstrates that interventions involving CrossFit training, uni-bilateral exercise, and mud training significantly improved VO_2 max among female indigenous team game players. Furthermore, the mud training was more effective than the other groups in enhancing VO_2 max. These findings indicate that interventions involving CrossFit training, uni-bilateral exercise, and mud training significantly improved resting pulse rate among female indigenous team game players. Furthermore, the mud training was more effective than the other groups in enhancing resting pulse rate. However, no significant differences were observed between CrossFit and uni-bilateral; and CrossFit and mud training.

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