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Effects of High-Intensity Interval Training on VO_2 Max and Resting Heart Rate in Kho-Kho Players Across Mud and Mat Playing Surfaces

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Abstract: The game Kho-Kho uses natural principles to boost players' preliminary skills using the principles of functional development. Taking part in an active game encourages a competitive spirit in young people. Movement is an important part of the game, and it requires a lot of endurance and strength to keep up with the pace. A 12-week high-intensity interval training (HIIT) was conducted with 45 participants to explore the effects of HIIT on VO_2 Max and Resting heart rate. Treatment Group I represented as HIIT Mud Surface, group II acted as the HIIT Mat Surface, and Group III control group (CG). All the forty-five subjects were instated for pre- and post-tests on VO_2 Max and Resting heart rate. Experimental groups have undergone HIIT 3 days per week for a period of twelve weeks. None of the training the CG acquired was to carry out their daily tasks. Before and after training, the resting heart rate and VO_2 Max were assessed. The result from the 'F' test inferred that the 12-week HIIT treatment produced identical changes in VO_2 max and resting heart rate of inter-collegiate women Kho-Kho players. Further, the findings verified that HIIT is an effective practice to bring forth the required alterations over VO_2 max and resting heart rate of inter-collegiate women Kho-Kho players.

Keywords: High-Intensity Interval Training (HIIT), Mud Surface, Mat Surface, VO_2 Max, Resting Heart Rate

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Introduction

The benefit of interval training is that it enables a good number of participants to practice simultaneously. Running repeatedly at predetermined intervals and recovering with gentle jogging in between is known as interval training. An athlete's intensity increases with the amount of effort they do in a specific period (Gibala, 2007). All that intensity is the result of neuromuscular activation. The workout and sport-specific assessment of intensity is made. There are numerous techniques to quantify the intensity at which a sportsperson works.

Exercises that vary from low to high intensity are included in interval training, and it requires an interval or period of rest between every repetition of exercises. Interval training typically comprises workouts that progress in intensity from low to high, broken up by rest intervals (MacInnis and Gibala, 2017). Kho-Kho, which is largely practiced in rural as well as urban locations, is one of the most famous historical sports in India. It was originally known as Rathera and originated in Maharashtra. It was historically performed on "raths," or chariots. Although the exact origins of Kho-Kho remain unclear, many historians posit that it evolved from a game called 'run chase,' which involves pursuing and touching opponents. It is easy, less expensive, and fun, just like all Indian games, but it does require strength, speed, stamina, physical fitness, and a great degree of skill (Gullett *et al*., 1989). This reproduction is a little exciting with its dodging, feinting, and controlled speed bursts.The ultimate goal of Kho-Kho is to trap by running after; that is, to chase rather than just run. Being a top player in Kho-Kho requires a combination of intelligence, physical fitness, quick reflexes, and neuromuscular coordination (Gibala *et al*., 2012). They need quick reflexes, nimble movements, and an acute sense of movement to read their opponent's thoughts from their posture and approach. The viewers experience increased tension in proportion to the talent and quickness of both attackers and defenders (Billat, 2001). Since speed is the essence of this game, the brief nine minutes of recreation are packed with exuberance, cheers, and fierce competition. The runner needs endurance to extend with dexterity and with specific recreation skills to get away from the catcher. The sport involves both mud and mat, and anaerobic and cardiac features technically express speed to chase the runner (Sharma, 2004).

As a result, just like other national customs, the history and unique features of Kho-Kho games are fascinating and significant. It is a game where having a strong aerobic base is crucial to becoming a great Kho-Kho player (Wisløff *et al*., 2009). The purpose of this study is to determine how twelve weeks of HIIT affect the mud and mat surface of female inter-collegiate Kho-Kho athletes.

Materials and Methods

To achieve the purpose of the study through purposive sampling 45 inter-collegiate women Kho-Kho players in the age group of 20- 24 years were from Ernakulam, Kerala, India. The subjects were assigned into three equal groups, corresponding to fifteen each, videlicet HIIT training Mud group (n = 15), HIIT training Mat group (n = 15), and Control group (n = 15). Training was given to the experimental groups 3 days per week for a training period of 12 weeks (Praveen, 2022). Players who freely agreed to get involved in this study were considered and included in this study. The control group was not given any kind of training except their routine. The estimated VO_2 maximum was assessed by a Beep test unit of dimension in Lit/kg/Ml. Resting heart rate was assessed by a Bio monitor test unit of dimension in beats per minute. The parameters were measured at dawn and after 12 weeks of high-intensity interval training. The intensity was increased formerly in two weeks based on the variation of the exercises.

Training Programme

The training program lasted for 60 min for sessions in a day, 3 days a week for a period of twelve weeks duration. These 60 min included warm up for 10 min, 40 min of high-intensity interval training (Mud and Mat), and warm down for 10 min.

Statistical Analysis

The means and standard deviations of high-intensity interval training groups were calculated for Vo_2 max and resting heart rate for the pre- as well as post-tests. Statistical significance was set to a priority at $p< 0.05$. All statistical tests were calculated using the IBM SPSS.

Table 1: Unadjusted and covariate-adjusted descriptive statistics for VO_2 max

Groups		Before treatment		After treatment unadjusted		After treatment adjusted	
	n	Mean	SD	Mean	SD	Mean	SE
HIIT on Mud Surface	15	42.3840	1.08070	43.3830	.98957	43.444	0.12
HIIT on Mat Surface	15	42.5280	1.25615	45.6430	1.45639	45.576	0.12
Control Group	15	42.4450	1.30119	42.65	1.72389	42.50	0.12

Table 2: Analysis of Covariance by treatment with pretreatment VO_2 max of Experimental and Control Groups

Source	Type III Sum of Squares	df	Mean Squares	F	Sig	Partial Eta Squared
VO_2 max	48.384	2	24.192	27.926	0.001	0.56
Groups	66.858	1	66.858	77.177	0.001	0.45
Error	48.512	42				
a. R Squared = 0.477 (Adjusted R Squared = 0.449)						

Results and Discussion

The unadjusted and covariate-adjusted descriptive statics for VO_2 max are presented across groups (Table 1). HIIT mud surface group, HIIT mat surface group and control group treatment each considered for 45 participants.

After treatment the mean of VO_2 max for the HIIT mud surface group increased from 42.38 to 43.38 and after adjusting for covariates, it remained high at 43.44. The standard deviation (SD) for the VO_2 max decreased slightly from 1.08 to 0.98 after treatment indicating the more stable measures.

For the HIIT mat surface group, the mean VO_2 max increased from 42.52 to 45.64 unadjusted, and the adjusted mean remained at 45.57. Similar to the HIIT mud surface group, the SD decreased after treatment, suggesting increased precision in the measurement.

In contrast, the control group showed minimal change in meanVO_2 max from 42.44 to 42.65 unadjusted, and the adjusted mean was 42.50. The SD remained constant after adjustment.

The findings suggest both training groups experienced improvements in VO_2 max after treatment with adjustment accounting for potential covariates. The control group however, exhibited marginal changes; the standard error of the mean provides an estimated variability of the sampled means with lower values indicating percussion in the estimation of the population mean.

The Table 2 presents the results of the analysis of covariance (ANCOVA) and examines the impact of different treatments on VO_2 max, with pretreatment VO_2 max serving as a covariate. The analysis reveals significant effects of both the VO_2 max pre-test and treatment groups, the VO_2 max pre-test (a covariate) contributes significantly to the model, with a large Type III sum of square 48.38 a high F statics 27.92 and p-value of 0.001, this indicates the pretreatment VO_2 max has a

Table 3: Pair-wise computation for VO_2 max in training groups within and between and control

I Group	J Group	Mean difference	95% confidence interval for difference		p
			Lower Bound	Upper Bound	
HIIT on Mud Surface	**HIIT on Mat Surface**	-2.132*	-2.722	-1.541	0.0001
	Control Group	-0.587	-1.177	0.003	0.051
HIIT on Mat Surface	**HIIT on Mud Surface**	2.132*	1.541	2.722	0.0001
	Control Group	1.545*	0.955	2.134	0.0001
Control Group	**HIIT on Mat Surface**	0.587	-0.003	1.177	0.051
	HIIT on Mud Surface	-1.545*	-2.134	-0.955	0.0001

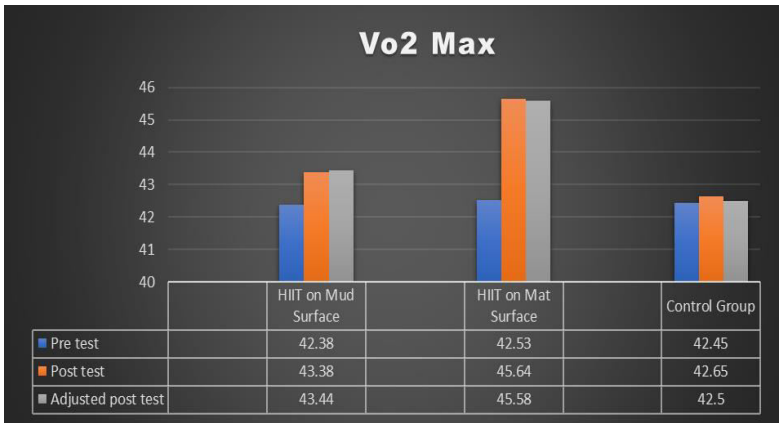

Fig. 1: The mean value on VO_2 max of women Kho-Kho players on experimental groups and control group.

substantial influence on the dependent variable (VO_2 max).

Similarly, the treatment groups show a significant effect, as evidenced by the type III sum of squares 66.86, F statistics 77.18 and p-value 0.001. The partial eta squared values of both the Vo_2 max pre-test 0.56 and groups 0.45 suggest the proportion of the variability in VO_2 max is explained by these factors.

The error term, representing unexplained variability has a relatively small mean square of 66.86 indicating that the model explains variance in VO_2 max while the adjusted r-squared value considers the number of predictors in the model, suggesting a high level of explanatory power.

In summary, the results that both pretreatment VO_2 max and treatment groups significantly contribute to the observed variability in VO_2 max providing valuable insights into the effects of different treatments while controlling for the pre-treatment differences.

Table 3 and Figure 1 presents a pair-wise comparison of the VO_2 max in the HIIT mud and mat groups with the control group mean difference (I-J) along with 95% confidence intervals.

In Table 4, the unadjusted and covariate-adjusted descriptive statics for resting pulse rate are presented across groups. HIIT mud surface group, HIIT mat surface group and control group treatment each considered for 45 participants. After treatment, the mean resting heart rate for the HIIT mud surface group decreased from 76.34 to 73.54 and after adjusting for covariates, it

Table 4: Unadjusted and covariate-adjusted descriptive statistics for Resting pulse rate

Groups		Before treatment		After treatment unadjusted		After treatment adjusted	
	N	Mean	SD	Mean	SD	Mean	SE
HIIT on Mud Surface	15	76.34	0.83	73.54	0.78	73.54	0.78
HIIT on Mat Surface	15	75.99	1.09	71.97	1.11	71.97	1.11
Control Group	15	76.08	1.16	76.58	0.99	76.72	0.99

Table 5: Analysis of Covariance by treatment with pretreatment resting pulse rate of experimental and control groups

Source	Type III Sum of Squares	df	Mean Squares	F	Sig	Partial Eta Squared
Resting Pulse Rate	19.474	1	12.56	17.00	0.001	0.78
Groups	12.979	2	15.34	20.76	0.001	0.64
Error	41.363	42				
R Squared = 0.477 (Adjusted R Squared = 0.449)						

remained high at 73.54. The standard deviation SD for the resting pulse rate decreased slightly from 0.83 to 0.78 After treatment indicating the more stable measures.

For the HIIT mat surface group, the mean resting pulse rate decreased from 75.99 to 71.97 unadjusted, and the adjusted mean remained the same at 71.97 (Table 4). Similar to the HIIT mud surface group, the SD decreased after treatment, suggesting increased precision in the measurement.

In contrast, the control group showed minimal changes in mean resting pulse rate from 76.08 to 76.58 unadjusted, and the adjusted mean was 76.72. The SD remained constant after adjustment.

The findings suggest both training groups experienced improvements in resting pulse rate after treatment, with adjustments accounting for potential covariates. The control group exhibited marginal changes; the standard error of the mean provides an estimate of the variability of the sampled means. with lower values indicating percussion in the estimation of the population mean.

Table 5 presents the results of the analysis of covariance (ANCOVA) and examines the impact of different treatments on resting pulse rate, with pretreatment resting pulse rate serving as a covariate. The analysis reveals significant effects of both the resting pulse rate pre-test and treatment groups, the resting pulse rate pre-test (a covariate) contributes significantly to the model, with a large Type III sum of square 19.47 a high F statics 12.98 and p-value of 0.001, this indicates the pretreatment resting pulse rate has a substantial influence on the dependent variable (resting pulse rate).

Similarly, the treatment groups show a significant effect, as evidenced by the type III mean of squares 12.56 F statistics 15.34 and p value 0.001, the partial eta squared values of both the resting pulse rate pre-test 0.78 and groups 0.64 suggest a proportion of the variability in resting pulse rate is explained by these factors.

The error term, representing unexplained variability has a relatively small mean square of 15.34 indicating that the model explains variance

Table 6: Pair wise computation for resting pulse rate in training groups within and between and control

I Group	J Group	Mean difference	95% confidence interval for difference		p
			Lower Bound	Upper Bound	
HIIT on Mud Surface	HIIT on Mat Surface	1.409*	0.859	1.958	0.0001
	Control Group	0.748*	0.201	1.296	0.008
HIIT on Mat Surface	HIIT on Mud Surface	-1.409*	-1.958	-0.859	0.0001
	Control Group	-0.660*	-1.205	-0.115	0.018
Control Group	HIIT on Mat Surface	-.748*	-1.296	-0.201	0.008
	HIIT on Mud Surface	0.660*	0.115	1.205	0.018

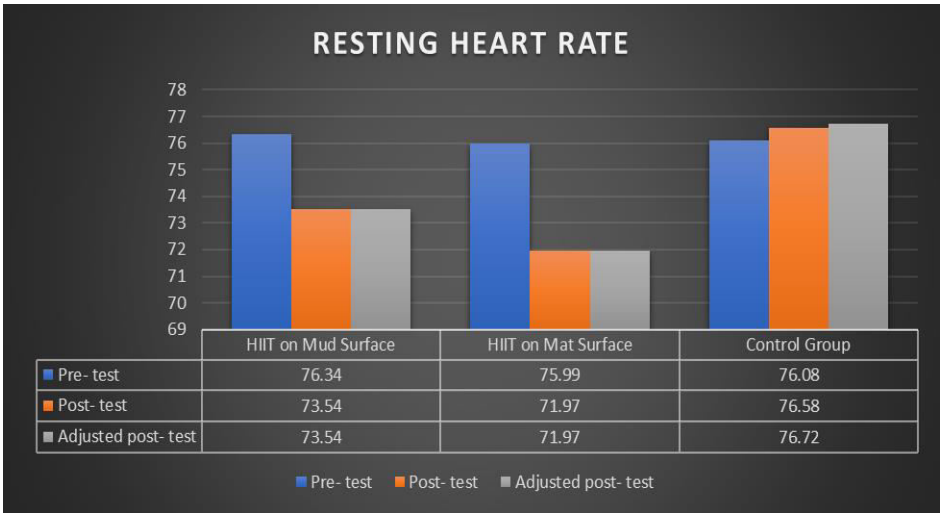

Fig. 2: The mean value on resting heart rate of women Kho-Kho players in experimental groups and control group.

in resting pulse rate. The adjusted r-squared value considers the number of predictors in the model, suggesting a high level of explanatory power.

In summary, the results that both pre-treatment resting pulse rate and treatment groups significantly contribute to the observed variability in resting pulse rate providing valuable insights into the effects of different treatments while controlling for pre-treatment differences.

Table 6 and Figure 2 present the pair-wise comparison of the resting pulse rate in the training groups HIIT mud and mat group within the control group. mean difference (I-J) along with 95% confidence intervals and p values are reported.

Interval training involves a program of repeated bouts of exercise interspersed with periods of rest or low-intensity activity. The duration of rest intervals should be sufficient for athletes to partially recover but not fully, to maintain a high level of intensity (Shiraev and Barclay, 2012). Intensity in interval training is determined by the amount of work performed per unit of time and is influenced by neuromuscular activation, which varies depending on the exercise and sport (Das *et al.*,

2019).

The game of Kho-Kho requires players to exhibit both speed and agility, as well as strategic decision-making skills (Jothi *et al*., 2011). Positive outcomes observed in Kho-Kho players can be attributed to their adherence to training programs, which contribute to improved performance and motor skills development (Raghuwanshi, 2019). Kho-Kho is a sport that requires minimal space and equipment, making it accessible for play in various environments, including artificial turf and indoor facilities. Players must make quick decisions during gameplay, enhancing cognitive skills and agility (Paul and Das, 2016).

Research has shown that participation in Kho-Kho leads to significant improvements in aerobic capacity and resting heart rate, indicating enhanced endurance and cardiovascular health (Sharma, 2004). High-intensity interval training has been shown to improve oxygen consumption efficiency when short rest periods are utilized, leading to greater fitness gains (Pate and Durstine, 2004). A study investigating the effects of twelve weeks of high-intensity interval training on VO_2 max and resting heart rate in female Kho-Kho players demonstrated significant improvements in both parameters, highlighting the efficacy of this training method (Laursen and Jenkins, 2002).

The result of this study is veritably encouraging and it demonstrates the benefits of high-intensity interval training. The results support that enhancement in mobility can do 12 weeks of high-intensity interval training. The study is delimited to 45 women inter-collegiate students from Ernakulam, Kerala, India. Their socioeconomic status was not taken into consideration.

Conclusion

From the results of the study the following conclusions were drawn. Women Kho-Kho player's high-intensity interval training form rehearsed with a different surface.

- Grounded on the result of the study it was concluded that the 12 weeks of high-intensity interval training (Mud and Mat surfaces) have significantly changed the VO_2 max and resting heart rate of women Kho-Kho players.
- It was concluded that the 12 weeks of high-intensity interval training with Mud surfaces improved VO_2 max and resting heart rate better than the high-intensity interval training with Mat surfaces of women Kho-Kho players.
- It is concluded that high-intensity interval training needs to be incorporated into the training protocol to enhance the overall performance of Kho-Kho sports.

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