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Effect of Plyometric Training and High-Intensity Interval Training (HIIT) on Power and Agility Among Under 23 Cricket Batsmen: A Randomized Controlled Trial

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Abstract:

Background: This study aims to compare the effectiveness of plyometric vs high-intensity interval training, on selected fitness variables in cricket batsmen.

Methods: Thirty-six male subjects were assigned to: a plyometric group (n=12, 12 regular training sessions, 2 sessions per week, each lasting for 30 minutes); an HIIT group (n=12, 12 regular training sessions, 2 sessions per week, each lasting for 30 minutes). The outcome measures included tests were seated medicine ball throw test, Illinois agility test, and one-minute push-up test.

Results: The plyometric group showed an improvement in seated medicine ball throw ($p<0.05$, $\Delta=1.28$), Illinois agility test ($p<0.05$, $\Delta=5$), and one-minute push-up test ($p<0.05$, $\Delta=11$) after 12 sessions of training. The HIIT group showed an improvement in seated medicine ball throw ($p<0.05$, $\Delta=0.93$), Illinois agility test ($p<0.05$, $\Delta=4.47$), and one-minute push-up test ($p<0.05$, $\Delta=9.91$) after 12 sessions of training. The control group showed an improvement in seated medicine ball throw ($p<0.05$, $\Delta=0.008$), Illinois agility test ($p>0.05$, $\Delta=0.2$), and one-minute push-up test ($p<0.05$, $\Delta=5.08$) after 12 sessions of training.

Conclusion: The results of this study concluded that both the plyometric and HIIT groups were better than the control group but there is no statistically significant difference between plyometric and HIIT groups on improving power and agility.

Keywords: Batsman, Cricket Sport, High-Intensity Interval Training, Male, Plyometric Exercise, Seated medicine ball throw

Introduction:

Cricket is a non-contact sport, played in a twenty-two-yard pitch. During the play, players participate in a wide range of physical activities such as running, throwing, batting, bowling, catching, jumping, and diving [1].

Internationally, three formats of cricket are played at the elite level: test, one-day and twenty20. All players bat and field, while only some players bowl and one person keeps wicket [7].

Cricket is a well-liked team sport played across the globe. There are different game styles from lengthy multi-day tests to quick twenty20 matches. With varying physiological demands during each format, batsmen play a crucial part in all of the game types. Investigation of the physiological demands imposed

during cricket batting has historically been neglected with much of the research focusing on bowling responses and batting technique [6].

In cricket and its various formats, the actual physical demand has expanded, requiring the player to possess more agility, flexibility, and strength. In this sport, the ability to change direction quickly, running between the wickets, and catching and tossing the ball requires agility [2].

Cricket is a sport where agility is essential for a player to excel. Despite the widespread popularity of cricket, there is a limited amount of research that focuses on measuring the agility of cricketers. Agility in this context is also connected to other physical qualities that can be developed, such as strength, power, and balance. Good agility requires a complete mixture of speed, balance, power and co-ordination [2].

In cricket, power is equally necessary, an increase in upper body strength is particularly important when executing powerful cricket strokes. Accurately timed and forceful cricket strokes offer batsmen the greatest likelihood of achieving boundaries. (Taliep MS et. al, 2015) The contractile component of the actin and myosin cross bridges with the sarcomere plays an important role in motor control and force development during plyometrics. Plyometric movements utilize the pre-stretch of the muscle-tendon unit, which aligns with the physiological length-tension curve, to enhance the muscle fibers' capacity for generating greater tension and force output [4].

Biomechanically "priming" the muscle is supported by Elftman's research. Elftman's proposal suggests that muscle force production follows a predictable hierarchical pattern. This orderly format is that eccentric muscle contractions create the most force, followed by isometric contractions and then concentric contractions [4].

Maximal eccentric muscle actions produce 10-40 percent more force compared to concentric contractions. The reason it generates more force is that during the eccentric muscle action, the SEC and PEC are being stretched which generates more force resulting in an increase in the power produced by the muscle [4].

HIIT is a form of timed interval training that alternates periods (e.g., 20-seconds) of high-intensity effort with rest intervals (e.g., 10-second), repeated several times [5].

HIIT is a type of interval training exercise. It involves multiple rounds alternating between several minutes of high-intensity exercises, which elevate the heart rate to at least 80% of its maximum, and brief intervals of lower-intensity activity. The blood supply to the muscles increases as a result of increase in the heart rate, which provides more amount of oxygen to the muscles improving their ability to work more efficiently. Improved muscle efficacy provides better physical fitness [17].

Methods:

Participants: A randomized control trial was performed on 36 cricket players selected from Local cricket academy in Bhubaneswar, Odisha. Ethical clearance was obtained from the Institutional ethical committee of prior to the commencement of the study. The participants selected were within the age group of 18-23 years and had at least 3 years of batting experience were included in the study. The purposive sampling method was used for sampling. The players having any kind of recent injury, female cricket batters, or PARQ score less than 7 were excluded from the study.

Sample size calculation: The sample size was calculated using G-Power software using A priori power analysis with effect size (0.65), alpha (0.05), power (0.90), of Illinois agility test. (Scanlan AT et.al, 2016) (Aloui G et.al, 2022)

Materials used were stopwatch (mobile application), rope for rope training, wooden box (40 cm), kettlebell (6 kg), marking cones, measuring tape, adjustable hurdles (40 cm) and medicine ball (4 kg).

Procedure: An experimental study was undertaken at Jagruti Cricket Academy, Bhubaneswar. 36 participants were randomly included based on the inclusion and exclusion criteria mentioned earlier. Brief demographic data of all the participants was obtained, written consent was taken from all the participants, and the experimental protocol was explained with its benefits and harms. The study duration was 6 weeks which included 12 sessions of experimental protocol. 36 Participants, who cleared the Physical activity readiness questionnaire (PARQ), and the inclusion criteria were randomly divided to Plyometric Group, High Intensity Interval Group, and Control Group. Group A underwent plyometric exercises, Group B underwent High Intensity Interval Training (HIIT), twice a week for 6 consecutive weeks, with their regular training, and Group C (control group) did not undergo any additional training protocol apart from their regular training regime. Power and Agility were assessed for all the subjects using primary outcome measures, Seated Medicine Ball Throw Test (SMBT), Illinois Agility Test (IAT) respectively, and secondary outcome measure One-minute Push-ups Test (1-MPT) prior to the commencement of the training protocol and after 6 weeks. No adverse events were observed during the training sessions.

- **Plyometric Training (PT):** The plyometric training included 3 exercises which were performed prior to the cricketing drills, twice a week for 6 consecutive weeks. The exercise protocol is explained in the TABLE 1.
- **High Intensity Interval Training (HIIT):** The HIIT protocol also included 3 exercises which were performed prior to the cricketing drills, twice a week for 6 consecutive weeks. The exercise protocol is explained in the TABLE 1.

Plyometric Training Protocol:

1. 40 cm - Box jump - 30 repetitions x 5 sets
2. Full arc arm rotation with elbow off the table - 10 repetitions x 5 sets with 6kg kettlebell
3. Two hand rotation from side - 10 repetitions x 5 sets with 6kg kettlebell

(Dosage: 6 weeks, 2 days/week, 30 minutes/day, 15-20 seconds rest in between sets, and 1-minute rest between exercises)

High-Intensity Interval Training:

1. Seated rope training - 15 seconds exercise and 5 seconds rest x 6 repetitions x 5 sets
2. Shuttle sprints - 10 seconds sprint and 5 seconds rest x 6 repetitions x 5 sets
3. 40 cm Hurdle jumps - 6 jumps followed by 5 seconds sprint and 10 seconds rest x 5 sets

(Dosage: 6 weeks, 2 days/week, 30 minutes/day, 15-20 seconds rest between sets, and 1-minute rest between exercises)

TABLE 1: Dosage and list of exercises

Outcome Measures:

Primary Outcome Measures:

1. **Seated Medicine Ball Throw Test:** The seated medicine ball throw test **(ICC=0.96)** (Davies et.al, 2008) is used to measure the power of the upper extremities with and is performed with athlete sitting on floor with both the knees extended and back supported by the wall. Usually 4kg medicine ball is used for the test, but there are variations in this test which allow the examiner to use 1kg, 2kg, or 3kg

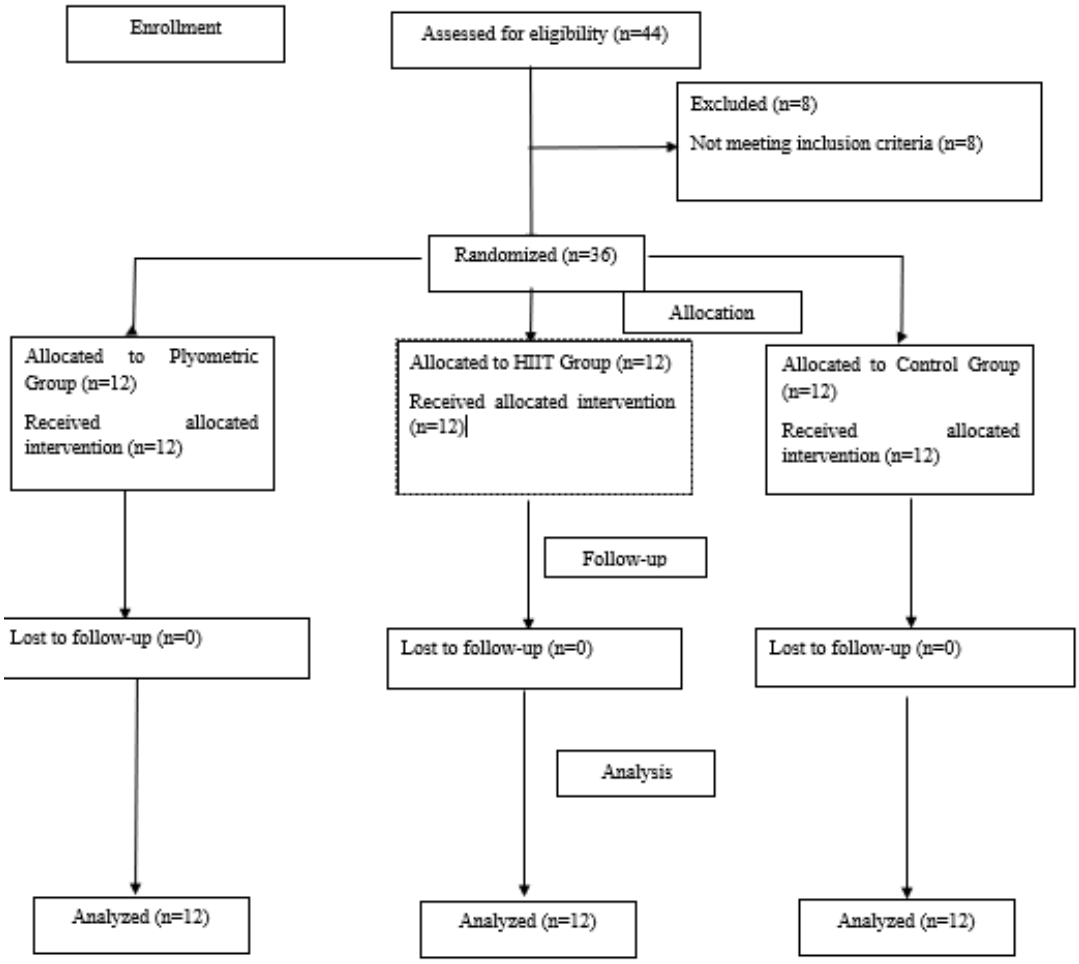
medicine ball depending upon the targetted population. The ball is held with the hands by the side of the body and parallel to the ground. The athlete is asked to throw the ball as far as possible by keeping his back in constant touch with the wall. The distance from the wall to the dropping point of the ball is measured.

2. **Illinois Agility Test:** Illinois agility test **(ICC=0.96, SEM=0.19 seconds)** (Salimi, Z., & Ferguson-Pell, M. W. 2020) is performed athletes assuming a prone position with their hands by their shoulders, they should face the starting line. Once the runner hears the command "Go," the stopwatch starts, and they must run as fast as they can to sprint 10 meters ahead, 10 meters back, and then up and down a four-cone slalom course. The timing is halted at the finishing cone when the athlete completes a final 10 meters of up and back running.

Secondary Outcome Measure:

1. **One-minute push-up test:** The aim of one-minute push-up test **(ICC=0.987)** (Diehl et.al) is to perform as many push-ups as athlete can in one minute. The starting position is with the arms straight, elbows locked, body straight, hands placed slightly wider than shoulder-width apart with fingers pointing forward and both feet on the floor. From the starting position, on the command ‘go,’ start the push-up by bending elbows and lowering your body until the shoulders drop below the level of the elbows, then return to the starting position.

Consort Flow Chart:



Statistical analyses:

Statistical analysis was performed using IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp. Normality of the data was found using Shapiro-Wilk test. Descriptive analysis was done using mean and standard deviation while performing interferential statistics. The interferential statistics that is the Paired t-test was used for time factor analysis within the group and One-way ANOVA was used for the group factor analysis. The level of significance (p-value) kept at ≤0.05.

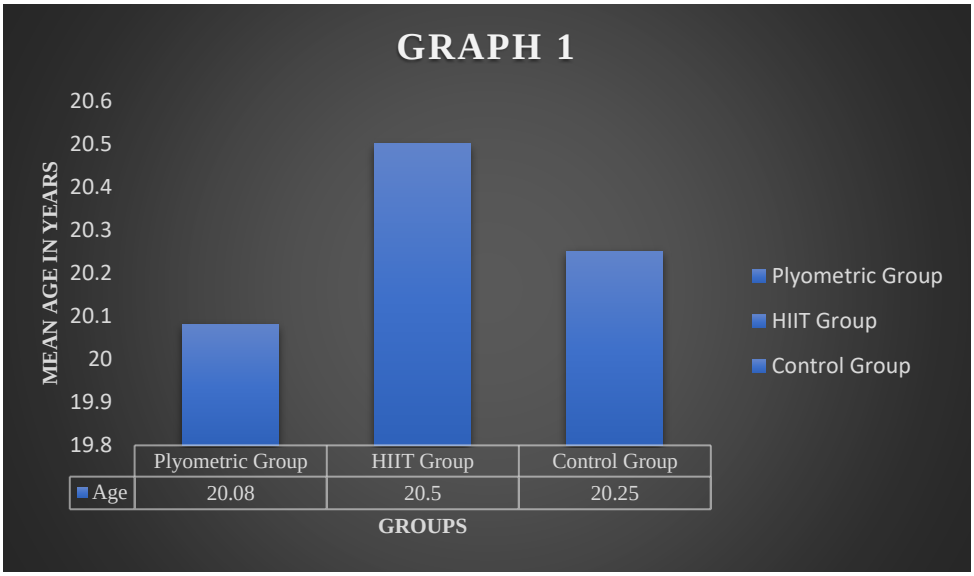
Results

The current study included 36 participants aged 18 to 23 years. The baseline data are shown in **TABLE 1**. A comparison of the pre-intervention Seated Medicine Ball Throw Test (SMBT), Illinois Agility Test (IAT), and One-minute Push-ups Test (1-MPT) among the three groups revealed no statistically significant difference in the pre-intervention data (**p>0.05**).

- **GRAPH 1 illustrates the age distribution among groups.**

FACTORS	Plyometric Group	HIIT Group	Control Group	p Value
Age	20.08	20.5	20.25	p>0.05
SMBT	1.83	1.88	1.9	p>0.05
IAT	22.49	22.11	22.74	p>0.05
1-MPT	26.5	27.25	27.08	p>0.05

Table 1: Demographic data and pre-intervention data



- In a within-group comparison of the pre- and post-intervention of the Seated Medicine Ball Throw Test (SMBT), the plyometric, HIIT, and Control groups shown gains in power and agility with (**p<0.05**), (**TABLE 2** and **GRAPH 2**).

Groups	Pre	Post	Mean Difference	p Value
Plyometric Group	1.83	3.12	1.28	p<0.05
HIIT Group	1.88	2.82	0.93	p<0.05

Control Group	1.9	1.98	0.08	p<0.05

Table 2: Seated Medicine Ball Throw Test within Group Comparison

- Within-group comparison of pre-and post-intervention of the Illinois Agility Test (IAT) in Group A, and Group B (**TABLE 3** and **GRAPH 3**) demonstrated improvement in the agility with the (**p<0.05**), which is statistically significant. Control group showed no statistically significant difference in the Illinois Agility Test with (**p>0.05**).

Groups	Pre	Post	Mean Difference	p Value
Plyometric Group	22.49	17.49	5	p<0.05
HIIT Group	22.11	17.64	4.47	p<0.05
Control Group	22.74	22.54	0.2	p>0.05

Table 3: Illinois Agility Test within Group Comparison

- **TABLE 4** and **GRAPH 4** show that, there was a statistically significant improvement in power and agility within plyometric, HIIT, and Control groups when comparing their pre- and post-intervention scores on the One-minute Push-ups Test (1-MPT).

Groups	Pre	Post	Mean Difference	p Value
Plyometric Group	26.5	37.5	11	p<0.05
HIIT Group	27.25	37.16	9.91	p<0.05
Control Group	27.08	32.16	5.08	p<0.05

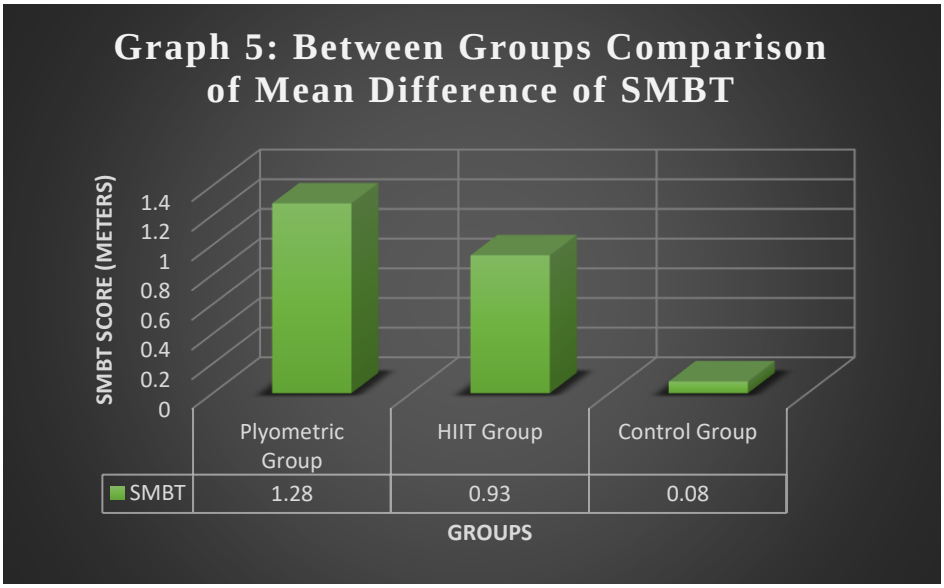
Table 4: One-Minute Push-up Test within Group Comparison

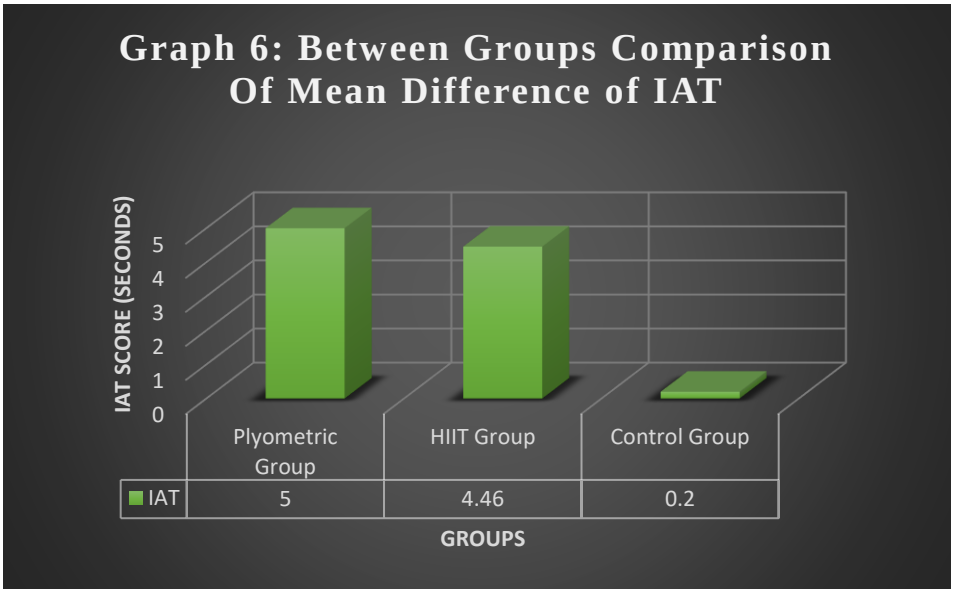
Outcome Measure	Groups	Baseline Mean	Post Mean	Mean Difference	Between Group ANOVA		MCID
					F Value	p Value	
Seated Medicine Ball Throw Test	Plyometric Group	1.83	**3.12***	**1.28***	39.84	**p<0.05***	0.41
	HIIT Group	1.88	2.82	0.93			
	Control Group	1.9	1.98	0.08			
Illinois Agility Test	Plyometric Group	22.49	**17.49***	**5***	67.95	**p<0.05***	
	HIIT Group	22.11	17.64	4.47			
	Control Group	22.74	22.54	0.2			
One-Minute Push-ups Test	Plyometric Group	26.5	**37.5***	**11***	12.13	**p<0.05***	2.5
	HIIT Group	27.25	37.16	9.91			
	Control Group	27.08	32.16	5.08			

Table 5: Between Group Analysis Of Mean Differences
***Indicates clinically as well as statistically significant change**

- A comparison of the post-intervention Seated Medicine Ball Throw Test (SMBT), Illinois Agility Test (IAT), and One-minute Push-up Test (1-MPT), with (**p<0.05**), indicates that there is a statistically significant difference in the post-intervention data among the plyometric, HIIT, and control groups.
- Comparison of means of Seated Medicine Ball Throw Test, Illinois Agility Test, and One-minute Push-ups Test among all the 3 groups, i.e plyometric, HIIT, and control groups demonstrated in

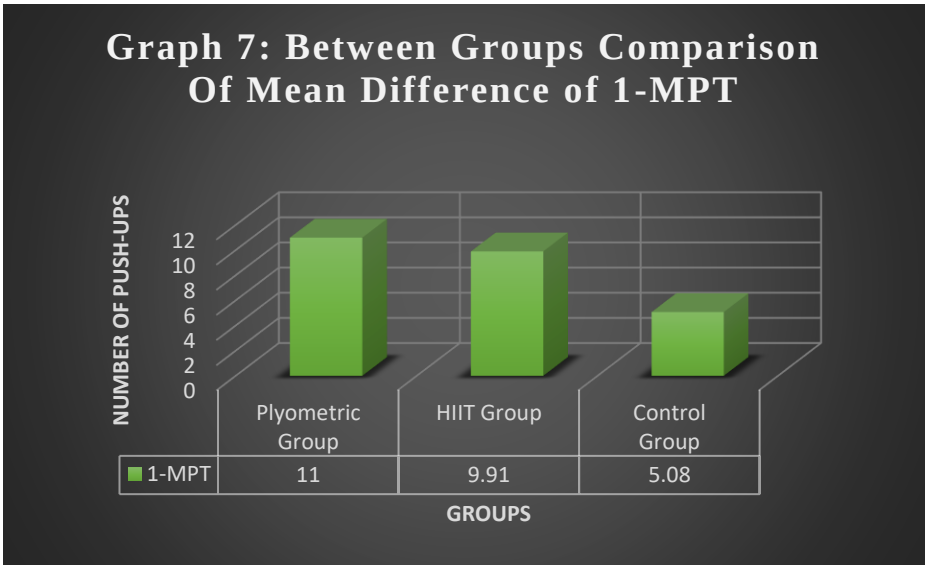
TABLE 5 and **GRAPH 5, GRAPH 6, and GRAPH 7** respectively.





For SMBT	Group A vs Group B	Group B vs Group C	Group A vs Group C
Mean Difference	0.349	0.853	1.202
Cohens D	0.8647	2.3285	6.2385
C.I	(-0.117 , 0.816)	(0.434 , 1.271)	(0.966 , 1.437)
p Value	p>0.05	p<0.05	p<0.05

Table 6 - Pair-wise comparison of SMBT



- The pairwise comparison of seated medicine ball throw test, Illinois agility test, and one-minute push-up test between groups, shown in , **TABLE 7, TABLE 8, and TABLE 9** respectively, indicates that plyometric and HIIT training groups have improved the power and agility compared to the control group. These tables also indicate that there is no statistically significant difference between plyometric and HIIT groups on improving SMBT, IAT, and 1-MPT.

For IAT	Group A vs Group B	Group B vs Group C	Group A vs Group C
Mean Difference	0.544	4.262	4.807
Cohens D	0.4065	4.0101	5.6084
C.I	(-0.794 , 1.883)	(3.175 , 5.35)	(3.751 , 5.862)
p Value	p>0.05	p<0.05	p<0.05

Table 7 - Pair-wise comparison of IAT

For 1-MPT	Group A vs Group B	Group B vs Group C	Group A vs Group C
Mean Difference	1.083	4.833	5.917
Cohens D	0.3121	1.5293	2.2064
C.I	(-3.757 , 5.924)	(1.313 , 8.353)	(2.901 , 8.932)
p Value	p>0.05	p<0.05	p<0.05

Table 8 - Pair-wise comparison of 1-MPT

- Based on these within- and between-groups comparisons, all three groups showed improvement in the power and agility assessed by using the seated medicine ball throw test, the Illinois agility test, and the one-minute push-ups test, but plyometrics training resulted in greater improvements compared to the other 2 groups, which was clinically and statistically significant, and Group C did not show statistically significant improvement in the Illinois Agility Test for Agility.

Discussion:

The aim of the current study was to compare the plyometric and high-intensity interval training on improving power and agility among cricket batsmen. The power and agility were measured using seated medicine ball throw test, Illinois agility test, and One-minute push-up test; pre- and post-intervention. The participants selected were within the age group of 18-23 years and had at least 3 years of batting experience.

The results of this study revealed that the power and agility measured using primary outcome measures-SMBT and IAT; and secondary outcome measure-1-MPT; improved in all 3 groups i.e plyometric, HIIT, and control groups, but statistically significant improvements were seen in plyometric training and HIIT groups. The control group did not show statistically significant improvements when compared to plyometric and HIIT groups.

Thus, from the results of this study it can be stated that power and agility can be improved by plyometric and high-intensity interval training in male cricket batsmen. The reason could be neural adaptations such as an increased nerve conduction velocity, improved intermuscular coordination, enhanced motor unit recruitment strategy, increased excitability of the Hoffman reflex, as well as changes in muscle size, architecture, or mechanical characteristics of the muscle-tendon complex, and changes in single-fiber mechanics. (Goran Markovic et.al, 2010)

In a study, conducted in 2018 on effects of HIIT with various intervals on repeated sprint ability (RSA), counter movement jump (CMJ), and 10 meter sprint in elite handball players. It was found that the high intensity interval training improved the RSA, CMJ, and 10-m Sprint. The result of which indicates that HIIT can improve power and agility. The rationale for the improvements was, boost in aerobic fitness and muscle buffer capacity that may promote faster rate of phosphocreatine re-synthesis. (Sergio Carballeira et. al, 2018)

A study conducted by Harvard et al in 2020 on effects of plyometric training on change of direction in experienced soccer players. The conclusion of the study supported the current study in terms of improvement in change of direction followed by plyometric training, which was due to increased proprioceptive inputs and muscle power. (Harvard G. et. al, 2020)

A systematic review and meta-analysis was done in the year 2021 by Elena et al on effects on plyometric training on vertical jump, linear sprint, and change of direction in female soccer players which concluded that plyometric training was useful in improving the power and agility, which supports the current study. The rationale for improvement was improved stretch-shortening cycle of the muscle-fibres and increased strength and power production. (Pardos-Mainer et. al, 2021)

Several previous studies have suggested that PT can enhance sprinting ability just because it is based on the use of the SSC (de Villarreal et. Al, 2008). The greatest benefits of PT for sprint performance are dependent on the velocity of muscle action employed in training (Rimmer and Sleivert, 2000). Therefore, it has been suggested that greatest effects of PT on sprinting performance occur in the acceleration phase. (Slimani M. et. Al, 2016)

Some researchers suggest that PT is more effective in improving performance due to the ability of subjects to use the elastic and neural benefits of the SSC. (de Villarreal et. Al, 2008; Markovic and Mikulic, 2010) Overall, improvements in agility after PT can be attributed to neural adaptation, specifically to increased intermuscular coordination. (Markovic and Mikulic, 2010)

Anaerobic glycolytic and ATP-PCr systems, which are responsible for performing brief activities (2–15 seconds), such as throwing and sprinting, are trained throughout the training protocol in both the HIIT and

plyometric groups. This is the reason for the improvement in power and agility outcomes following the training period in both plyometric and HIIT group. (Markovic and Mikulic, 2010)

The results of the current study indicate that there was no statistically significant difference ($p>0.05$) in SMBT between the plyometric and HIIT groups, with a Cohen's d effect size of 0.8647. However, statistically significant differences were observed ($p<0.05$) in SMBT between the HIIT and control groups, as well as between the plyometric and control groups, with effect sizes of 2.3285 and 6.2385, respectively. According to the findings of the current study, there was no statistically significant distinction ($p>0.05$) in IAT between the plyometric and HIIT groups, accompanied by a Cohen's d effect size of 0.4065. Nevertheless, notable differences were evident ($p<0.05$) in IAT between the HIIT and control groups, as well as between the plyometric and control groups, demonstrating effect sizes of 4.0101 and 5.6084, respectively.

Based on the results of the current study, there was no statistically significant difference ($p>0.05$) in 1-MPT between the plyometric and HIIT groups, with a Cohen's d effect size of 0.3121. However, significant differences were observed ($p<0.05$) in 1-MPT between the HIIT and control groups, as well as between the plyometric and control groups, with effect sizes of 1.5293 and 2.2064, respectively.

Thus, based on the findings and statistical analyses of this study, significant improvements ($p<0.05$) in power and agility were observed in both the plyometric and HIIT groups compared to the control group. However, there was no statistically significant difference ($p>0.05$) detected between the plyometric and HIIT groups when compared to each other.

Conclusion:

To conclude, this study demonstrated that the plyometric and HIIT training are individually better than the regular training regime on improving power and agility of cricket batsmen. But, when compared to each other the plyometric and HIIT training groups showed no significant difference on improving power and agility which were measured by using SMBT, IAT, and 1-MPT. The study concludes that both Plyometric and HIIT training are effective methods for enhancing the power and agility of cricket batsmen. However, neither method proved superior to the other, indicating that both training protocols are equally beneficial.

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