EFFECTS OF POST ACTIVATION PERFORMANCE ENHANCEMENT INDUCED BY ACTIVATION OF OBLIQUE SLING ON EXPLOSIVE POWER AGILITY PERFORMANCE IN COMPETITIVE ATHLETES

By

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Under the guidance of

Prof. Dr. A. Joseph Oliver Raj

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Abhinav Bindra Sports Medicine & Research Institute

Bhubaneswar, Odisha

2022 - 2024

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation/thesis entitled **"Effects of Post-Activation Performance Enhancement Induced by Activation of Oblique Sling on Explosive Power and Agility Performance in Competitive Athletes"** is a bona fide and genuine research work carried out by me under the guidance of Prof. Joseph Oliver Raj, Dean, ABSMARI.

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LIST OF ABBREVIATIONS USED

AOS	Anterior oblique sling
BOMBT	Backward overhead medicine ball throw test
COMB	Combined anterior and posterior oblique sling activation
FOMBT	Forward overhead medicine ball throw test
POS	Posterior Oblique Sing
T-TEST	Agility T-test

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ABSTRACT

Purpose: This study aimed to increase the upper body's explosive power and lower body's agility by activating the anterior and posterior oblique slings via the Post Activation Performance enhancement (PAPE) mechanism.

Methods: Thirty participants were recruited based on the inclusion and exclusion criteria in the study, with ten individuals randomly assigned to each of three activation protocols: anterior oblique sling activation, posterior oblique sling activation, and combined activation. The activation protocols were administered in a sequential order, with a 7-day washout period between each phase. To evaluate the effects on power and agility, the study employed the forward medicine ball throw test, backward medicine ball throw test, and t-test as outcome measures.

Results: The forward medicine ball throw test, backward medicine ball throw test, and t-test revealed statistically significant differences in power and agility following activation of the anterior oblique sling, posterior oblique sling, and combined activation techniques, each exhibiting significance at $p<0.05$. Furthermore, comparative analysis of these activation techniques, based on scores from the forward medicine ball throw test, backward medicine ball throw test, and t-test, indicated that all three activation methods produced statistically significant differences among each other ($p<0.05$).

Conclusion: The findings of this study indicate that activation of the anterior oblique sling, posterior oblique sling, and their combined activation all contributed to enhancements in power and agility. However, the combined activation technique produced superior results in both power and agility compared to the individual activation methods.

Keywords: Anterior Oblique Sling Activation (AOS), backward medicine ball throw (BOMBT), combined activation, forward medicine ball throw (FOMBT), Posterior Oblique Sling Activation (POS)

INTRODUCTION

In both athletic and clinical settings, practitioners aim to achieve both acute and chronic improvements in physical function. Chronic improvement results from long term implementation of training and treatment strategies, often utilizing exercise periodization techniques (bompa and haff, 1994). Athletes, in particular, seek methods to enhance their performance, even if only for brief periods. Acute improvements, achieved through various physical and physiological strategies during or immediately before training session or sporting competition. One commonly employed approach is the pre-competition warm-ups, which is believed to enhance neuromuscular performance through both non-temperature-related effects (increase in BF, elevation of base line oxygen consumption and physiological effects) and temperature related [3] Likewise it is possible that additional conditional activity may also influence neuromuscular performance [4], possibly above and beyond that of warm-up [5].

Additionally, recent research has introduced the concept of post activation performance enhancement (PAPE), formerly known as post activation potentiation (PAP) [6]. This phenomenon involves an increase in voluntary force production or exercise performance following prior muscle activity. According to Blazevich and Babault [5], PAPE may result from mechanisms similar to those observed in warm-ups, such as change in muscle temperature and intramuscular fluid accumulation or neural mechanism. PAPE specifically refers to acute enhancement of explosive neuromuscular capacity triggered by conditioning activities performed at maximal or submaximal intensity, with

effects typically observed 3-10 minutes [5] after the condition activity and lasting for 6-20 minutes [7].

In 1988, Serge Grakovetsky introduced the “The Spinal Engine” theory, proposing that the human spine, through its rotation and the associated musculature of the lumbo-pelvic region, is fundamental to human movement. Grakovestsky’s theory suggest that even quadruple amputees might be able to walk by leveraging the bones at the base of their pelvis, emphasizing the spine’s central role in locomotion. Building on this concept, Andry Veelming and Thomas Myers later proposed the significance of “anatomy sling”, which are interconnected muscular and fascial chains that contribute to efficient dynamic movements. They argued that these slings are crucial for optimizing movement efficiently and stability [8], with serving primarily to amplify the motion generated by the core musculature. Together, these theories underscore the importance of the spine and trunk musculature in driving and coordinating movements, shifting the focus from the limbs to the core as the primary source of movement initiation and efficiency.

Anterior oblique sling system	**Posterior oblique sling system**
1. External oblique 2. Internal oblique 3. Adductor 4. Adductor-abdominal fascia	1. Latissimus dorsi 2. Gluteus maximus 3. Thoraco-lumbar fascia. 4. Hamstring [17]

Research suggested that, the core serves as an anchor for the limbs especially upper limbs due to its size and capacity to become rigid [9,10,11]. In most of the athletic situations, hip musculature generates majority of power. The power is transferred upward through the linkage to the arms through a stiffened core [9,11,12] suggesting that stiffness is the essential pre-cursor to stability and the efficient transfer of forces together with being one of the keys to injury prevention.[8]

How does these systems enhance limb speed and stiffness in throwing? A right-handed pitcher “wind-up” the throw bringing the left leg up and balancing on the right leg, slightly flexing the right hip and knee. This position loads the posterior oblique sling musculature from right foot to left shoulder. As the cocking phase begin using the posterior oblique to generate the forward momentum. During the early cocking phase, the anterior sling musculature is loaded, as the right arm and left leg are extended and abducted. During late cocking phase, the left foot is planted into the ground to decelerate the hip’s forward momentum, whereas the right hip continues its forward movement. This also loads the elastic component of linkage to store some elastic energy which is unleased during acceleration phase. The key to acceleration phase is the core so that the maximum power can be transferred between the hip and the shoulder.[13]

During a game, the ability to rapidly change velocity and direction is a key factor for the outcome of many technical actions [14,15]. According to the agility’s deterministic model proposed by Shepperd and Young [16], the player is required to suddenly adapt his own movement to that of his opponent and the current situation. While many researches have concluded that agility helps

in performance enhancement by directly contributing to an athlete's ability to perform effectively. For an instance, a volleyball player must quickly adjust their positioning to execute spikes or blocks. Agility also have many cognitive benefits by enhancing cognitive functions such as memory, focus, and decision-making that are crucial for athletes to make quick judgements during play.

NEED OF THE STUDY

1. Muscle activation is required prior to any strength-based competition. Finding more effective and sports-specific warm-up regimens can help players perform better. Sport-specific PAPE conditioned activity may be a preferable alternative for athletes.

2. Upper body power is critical for many explosive, short-duration sports. Athletes can gain a performance edge by using effective and up-to-date Post-Activation Performance Enhancement (PAPE) techniques to boost their upper body power for immediate gains in these high intensity events.

3. Lower-body PAPE has been the primary focus of many studies. Thus, there is a dearth of study on the upper body.

4. For the purpose of improving performance, more attention needs to be paid to the oblique sling, which is mostly made up of global muscles and aids in the transfer of tensile strain from the upper to the lower body.

AIM OF THE STUDY

To increase the upper body's explosive power and lower body's agility by activating the anterior and posterior oblique slings via the PAPE mechanism.

OBJECTIVE OF THE STUDY

1. To find out effect of PAPE on upper limb explosive power by oblique sling activation through AOS, POS and combined AOS & POS.
2. To find out the effect of PAPE on agility by oblique sling activation through AOS, POS and combined AOS & POS.
3. To find out the best protocol among AOS, POS; combined AOS & POS.

HYPOTHESES

Null Hypotheses:

H01 - There will be no significant increase in Upper limb Explosive power using AOS, POS; combined AOS & POS.

H02 - There will be no significant increase in Agility using AOS, POS; combined AOS & POS.

H03 - There will be no significant difference between AOS, POS; combined AOS & POS.

Alternate Hypotheses:

H11 - There will be significant increase in Upper limb Explosive power using AOS, POS; combined AOS & POS.

H12 - There will be significant increase in Agility using AOS, POS; combined AOS & POS.

H13 - There will be significant difference between AOS, POS; combined AOS & POS.

REVIEW OF LITERATURE

1. Mitchell James Finlay et al 2021 conducted a study on the “Upper-Body Post-activation Performance: A Systematic Review with Meta-analysis and Recommendation for Future Research” in UK. This review concluded that several upper-body movement specific conditioning activities could be used in pre-competition warm-ups to acutely enhance performances.

2. Gianmmarco Ciocca et al 2021 conducted a study “Effect of Post-activation Performance Enhancement (PAPE) Induced by a Plyometric Protocol on Deceleration Performance” in Austria. They concluded that PAPE evoked a significant improvement in player’s deceleration performance at 2nd min from its execution.

3. Alejandro Escobar Hincapie et al conducted a study “Unilateral and Bilateral Post-activation Performance Enhancement on Jump Performance and Agility” in Spain. 17 participants (12 male and 5 female) were selected with mean age of 25±1.6 years with mean strength and power training experience of 7.6±2.3 years were randomized into either unilateral squat group (UT) or the bilateral squat group (BT). They found that PAPE protocols show performance benefits in agility tests, with a large effect size for the unilateral protocol.

4. Wootaek Lim 2021 conducted a study “Tensile Force Transmission from the Upper Trunk to the contralateral Lower Leg throughout the Posterior Oblique Sling System” in Korea. The study concluded that upper portion of the POS passes through thoracolumbar fascia and is connected all the way down to the contralateral hamstrings and calf.

5. Dae-kwan Kang et al 2019 conducted a study “Comparison of Muscle Activities of the Posterior Oblique Sling Muscles among Three Prone Hip Extension Exercises with and without contraction of the Latissimus dorsi” in Korea. The aim was to investigate most effectives ways to activate the POMS (posterior oblique sling muscles). Three different PHE exercises were compared. They found that prone knee and hip internal rotation with extension to 10º with 1-lb dumbbell improve the activities of the POSMs.

6. Juan C. Santana et al in 2015 conducted a study “Anterior and posterior serape: The rotational core” in California. The purpose of this study was to expand a concept surrounding the rotational function and training of body’s core. They concluded that muscles of the serape form a spiralling system, augmented with elastic passive tissue that enhances the efficiency of cycling activities such as throwing.

METHODOLOGY

Participants-

A randomized crossover trail was conducted with 30 competitive athletes involved in overhead throwing activities selected from local clubs in Bhubaneswar. Ethical approval for the study was granted by the Institutional Ethical Committee of Abhinav Bindra Sports Medicine and Research Institute (ABSMARI), Pahal, Bhubaneswar. The protocol ID for approval was ABS-IEC-2023-PHY-015. Participants, aged 18-25 years with a minimum of 2 years of sport experience, were selected through purposive sampling. Athletes with recent injuries or those participating in other training during the intervention week were excluded from the study.

Sample size calculation-

Sample size was calculated in G-Power software using effect size (0.28), alpha (0.05), power (0.95).

Study duration- 8 months

Inclusion Criteria-

1) Age- 18-25
2) Gender- Both Male and Female
3) Competitive athletes involving any kind of throwing activities.
4) Playing sports for at least 2 years.
5) Subjects those who have given consent.

Exclusion Criteria-

1) Any musculoskeletal injury or fracture in the upper and lower limb in the past 6 months.
2) Subjects having any vestibular disorder.
3) Involved in any kind of other training during the week of intervention.

Materials used-

1. Elastic resistance band / Cable
2. Measuring tape
3. Marking Cones (5)
4. Mat
5. Medicine ball of 2kg & 3kg
6. Dumb bells of 1-2kg
7. Stop watch (mobile application)

Outcome Measures:

1. Upper body power- Forward overhead medicine ball throw

   Backward medicine ball throw

2. Agility- T-Test

PROCEDURE

A crossover study was conducted at the local clubs in Bhubaneswar, involving 30 participants who were randomly selected according to the previously specified inclusion and exclusion criteria mentioned earlier.

A 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 3 weeks which included 3 sessions of experimental protocol that is once in a week. 30 participants, who cleared the inclusion criteria were randomly divided into the sequence of AOS, POS, and COMB group with 10 participants in each group.

All the participants underwent a 3-5 min generalised warm-up protocol. After that Group AOS underwent Anterior sling activation exercises, Group POS underwent Posterior sling activation exercises and Group COMB underwent combined AOS and POS activation exercises in a sequence of AOS, POS & COMB.

The upper body's power was assessed for all subjects using primary outcome measures, forward overhead medicine ball throw test (FOMBT), Backward overhead medicine ball throw test (BOMBT) and the lower body's agility was assessed using Illinois agility test before and after the activation.

A 7 days of rest was given to the participants as a wash-out period to nullify the carryover effect.

In the second week the sequence was changed to POS, COMB and AOS such that participants who under AOS Activation in the first week, now received POS Activation, POS activation participants now underwent COMB

Activation and COMB Activation participants in the first week underwent AOS activation this week. The pre and post value was taken for the outcome measures.

Again after 7 days of rest the sequence was again changed into COMB, AOS and POS and the pre and post were taken for the outcome measures.

There were no adverse events during the training sessions recorded.

- **AOS ACTIVATION-**
  - The AOS activation included 6 exercises which were performed just prior to the throwing activities once a week. The exercise protocol is explained in the TABLE 1.

- **POS ACTIVATION-**
  - The POS activation include 6 exercises which were performed just prior to the sporting activities once a week. The exercise protocol is explained in the TABLE 1.

- **COMB ACTIVATION-**

  The Combined AOS and POS activation included the exercises from both AOS and POS which were performed prior to the sporting activities. The exercise protocol is explained in the TABLE 1.

Anterior sling activation protocol (AOS):

1. Push with elastic band – 10 repetitions x 2 sets
2. Push with lunge – 10 repetitions x 2 sets
3. Wood chopping (high to low) – 10 repetition x 2 sets
4. Single leg stands with contralateral knee drive and arm drive- 10 repetition x 2 sets
5. Sprint thrust- 10 repetition x 2 sets
6. Dynamic oblique crunches- 10 repetitions x 2 sets

Posterior sling activation protocol (POS):

1. Pull with elastic band – 10 repetitions x 2 sets
2. Bend to extend with rotation-10 repetitions x 2 sets
3. Wood chopping (low to high)- 10 repetitions x 2 sets
4. 4.Single leg stand with contralateral knee drive and arm drive –10 repetitions x 2sets
5. Sprint hip thrust-10 repetitions x 2 sets
6. Bird dog quadruped-10 repetitions x 2 sets
7. Prone hip with IR and extension of arm 1-lb dub bell- 10 repetitions x 2sets.

Combined AOS and POS activation (COMB):

1. 6 exercises from AOS Protocol + 6 exercise from POS protocol – 5 repetitions x 2sets

(Dosage: 3 weeks, 1day/week, 30 mins/day, 15-20 seconds rest in between sets and 30 seconds rest in between exercises)

TABLE 1: list and dosage of exercise

Outcome Measures:

1. **Forward overhead medicine ball throw test-**

The forward overhead medicine ball throw test is used to measure upper body strength and explosive power.

The participants were made to stand at a line with feet side by side and slightly apart, facing the direction to throw.

The ball was held with hands on the side and slightly behind the center. The ball was brought back behind the head, then thrown vigorously forward as far as possible.

The participants were permitted to step forward over the line after the ball was released to maximize the throw distance.

Three attempts were allowed and the distance for each throw was measured from the starting position nearest to the foot to where the ball lands. The best result of the three throws was used as the final score.

Key points- A 2kg and 3kg medicine ball were used for women and men respectively.

2. **Backward overhead medicine ball throw test-**

The test is used to measure core strength and total body power.The participants were made to stand in a line facing the direction away from the throw with their heels at the start line.

The starting position was with the ball in both hands, held above the head with arms extended.

Keeping the arms extended the participants were allowed to swing the ball between their legs. Then in one motion the ball was flung up and back over the head.

The subjects were permitted to fall backward over the line after the ball is released.

Three attempts were allowed. The distance from the starting line to where the ball first lands were recorded. The best result of three throws was used as the final score.

3. Agility T-test –

For the test, the cones set up was done in a T-shape, with the middle cone 10 meter from the start, and the left and right cones at 5 meters from the middle cone.

Then the subjects were asked to start at cone A. On the command, they sprint forward to cone B and touch it with their right hand. Then they shuffle to the left to cone C touching it with their left hand. Next, they shuffle to the right to cone D, touching it with their right hand. The stopwatch is stopped as they cross the start line.

The trial doesn't count if the subject crosses their feet while shuffling, fails to touch the cones, or doesn't face forward.

STATISTICAL ANALYSIS

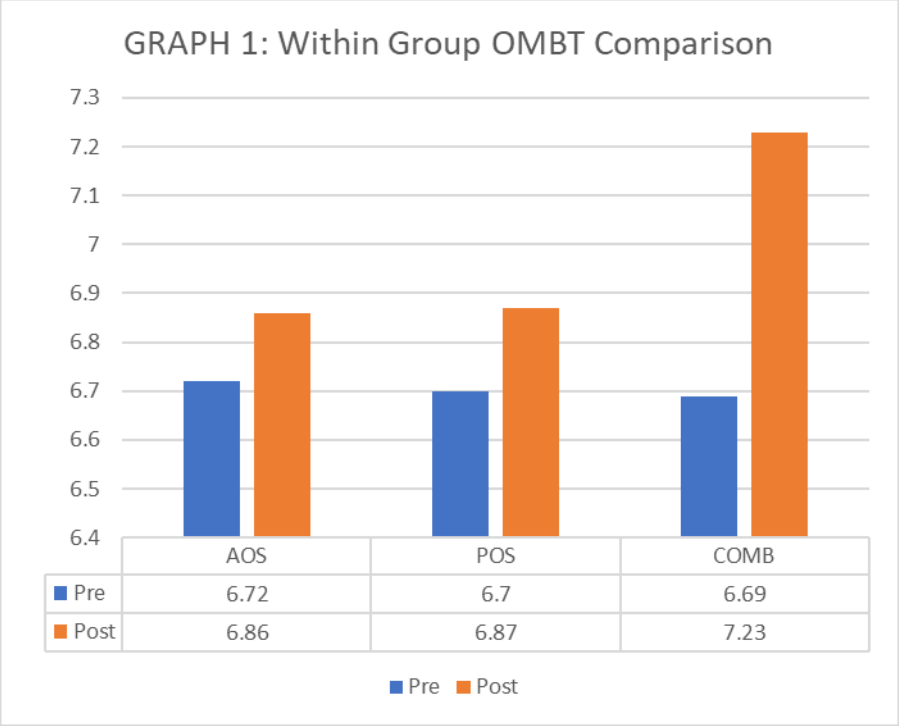
Statistical analysis was performed using SPSS statistical package of social sciences version 25. The normality of the data was found using Shapiro-Wilk test. Descriptive analysis was done using mean and standard deviation. The interferential statistics that is the Paired t-test was used for time factor 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 30 participants aged 18 to 25 years. A within-group comparison of the pre and post-intervention Forward Overhead Medicine Ball Throw Test (FOMBT) among the three groups (AOS, POS & COMB) shows statistically significant gain in explosive power. (**p<0.05**),

Groups	Pre	Post	Mean Difference	P-value
AOS	6.72	6.68	0.14	<0.05
POS	6.7	6.87	0.16	<0.05
COMB	6.69	7.23	0.54	<0.05

TABLE 2: Within Group Comparison of FOMBT

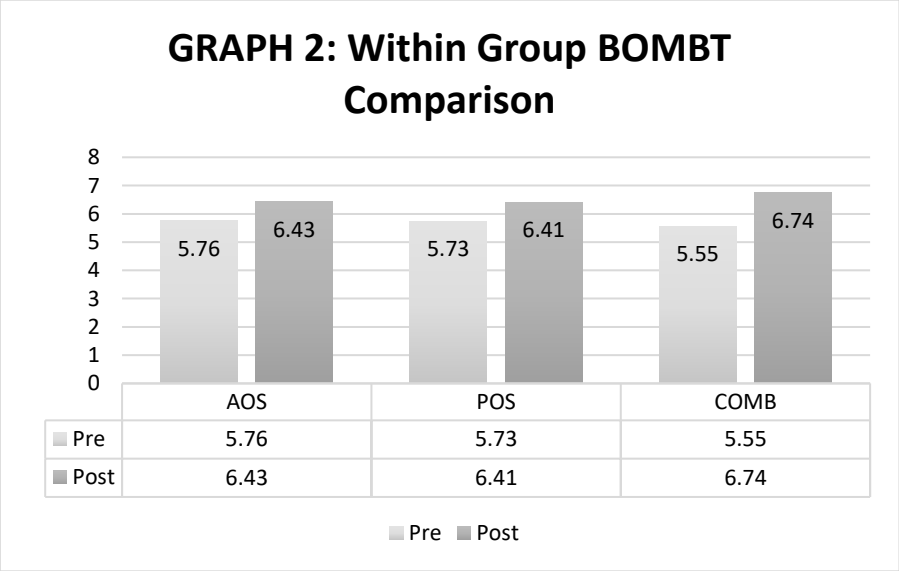


(**TABLE 2 and GRAPH 1**).

- A within group comparison of the pre and post-intervention Backward Overhead Medicine Ball Throw Test (BOMBT) of the three group (AOS, POS & COMB) shows a statistically significant gain in power. **(p<0.05), (TABLE 3 & GRAPH 2).**

GROUP	Pre	Post	Mean Difference	p-value
AOS	5.76	6.43	0.66	<0.05
POS	5.73	6.41	0.64	<0.05
COMB	5.55	6.74	1.19	<0.05

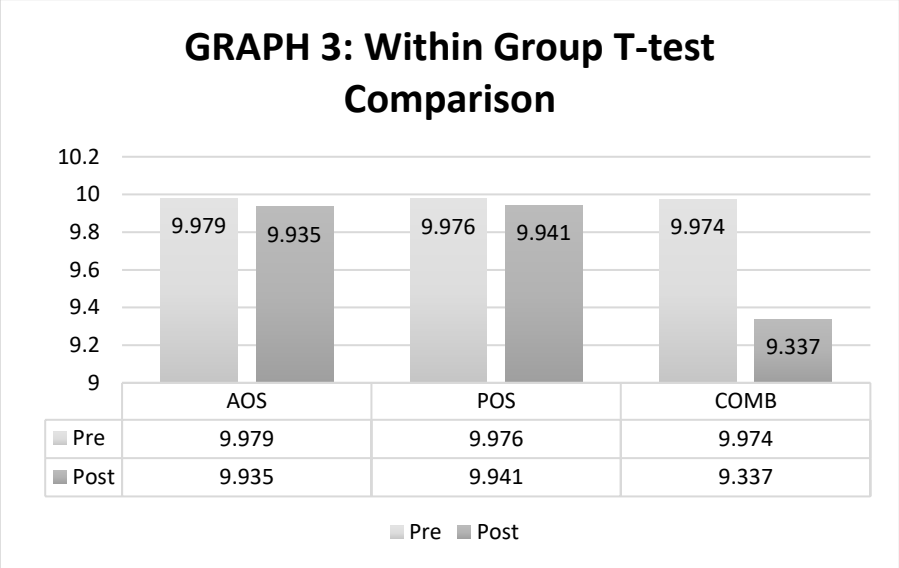
TABLE 3: Within Group Comparison of BOMBT



- A within group comparison of the pre and post-intervention Agility T-test of the three group (AOS, POS & COMB) shows gain in agility. That is statistically significant **(p<0.05), (TABLE 4 & GRAPH 3).**

GROUP	Pre	Post	Mean Difference	P-value
AOS	9.979	9.935	0.043	<0.05
POS	9.976	9.941	0.134	<0.05
COM	9.974	9.337	0.67	<0.05

TABLE 4: Within Group Comparison of Agility T-test



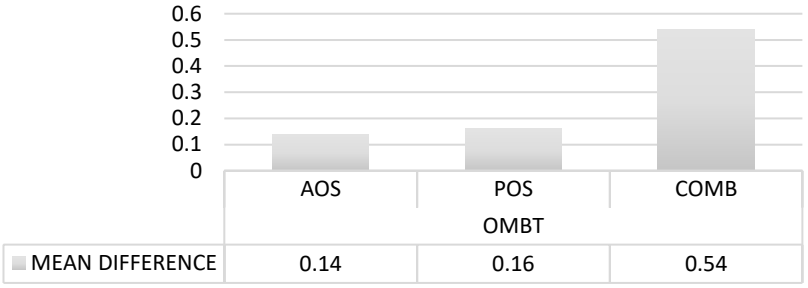
- A comparison of the post-intervention Forward overhead medicine ball throw test (FOMBT), Backward overhead medicine ball throw test (BOMBT), Agility T-test, with (**p<0.05**) indicates that there is a statistically significant difference in the post-intervention data among the AOS, POS and COMB (Combined AOS & POS activation)

- Comparison of means of FOMBT, BOMBT and Agility T-test among all the 3 groups, i.e. AOS, POS and COMB groups demonstrated in **TABLE 5** and **GRAPH 4, GRAPH 5, and GRAPH 6** respectively.

OUTCOME	GROUPS	BASELINE MEAN	POST MEAN	MEAN DIFFERENCE	F-value	P-value
FOMBT	AOS	6.72	6.68	0.14	81.98	<0.05
	POS	6.7	6.87	0.16		
	COMB	6.69	7.23	0.54		
BOMBT	AOS	5.76	6.43	0.66	146.62	<0.05
	POS	5.73	6.41	0.64		
	COMB	5.55	6.74	1.19		
T-TEST	AOS	9.979	9.935	0.043	23.77	<0.05
	POS	9.976	9.941	0.134		
	COMB	9.974	9.337	0.637		

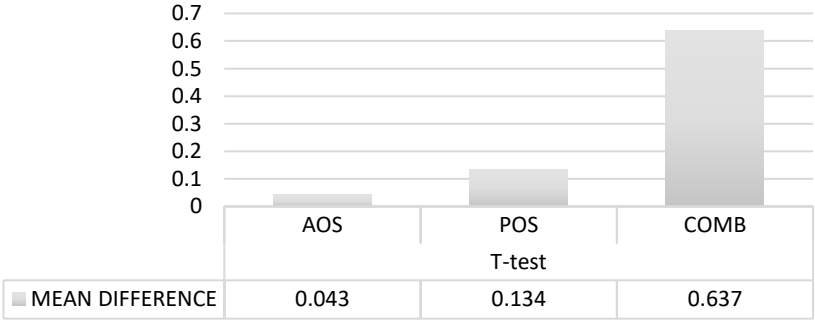
TABLE 5: Between Group Comparison of Outcome Measure

GRAPH 4: BETWEEN GROUP COMPARISON OF MEAN DIFFERENCE IN FOMBT



GRAPH 5: BETWEEN GROUPS COMPARISON OF MEAN DIFFERENCE IN BOMBT SCORES

GRAPH 6: BETWEEN GROUPS COMPARISON OF MEAN DIFFERENCE IN T-TEST SCORES



- The pairwise comparison of FOMBT and BOMBT between groups, shown in, **TABLE 6 and TABLE 7** respectively**,** indicates that the combined activation of AOS and POS have improved explosive power compared to the individual activation of oblique sling. These tables also indicate that there is no statistically significant difference between individual AOS and POS Activation.

For FOMBT	AOS vs POS	POS vs COMB	AOS vs COMB
Mean difference	(-0.007)	(-0.367)	(-0.373)
Cohens d	(-0.01)	(-0.51)	(-0.52)
C.I	(-0.064,0.05)	(-0.466, -0.268)	(-0.455, -0.291)
P-value	>0.05	<0.05	<0.05

TABLE 6: Pair-wise comparison of FOMBT

For BOMBT	AOS vs POS	POS vs COMB	AOS vs COMB
Mean difference	(-0.014)	(-0.33)	(-0.316)
Cohens d	(0.03)	(-0.53)	(-0.5)
C.I	(-0.365,0.338)	(-0.645, -0.014)	(-0.538, -0.094)
P-value	>0.05	<0.05	<0.05

TABLE 7: Pair-wise comparison of BOMBT

- The pairwise comparison of Agility T-test between groups, shown in, **TABLE 8,** indicates that the combined activation of AOS and POS have also improved agility compared to the individual activation of

oblique sling. These tables also indicate that there is no statistically significant difference between individual AOS and POS Activation.

For T-test	AOS vs POS	POS vs COMB	AOS vs COMB
Mean difference	(-0.005)	(-0.604)	(-0.599)
Cohens d	(-0.03)	1.72	1.66
C.I	(-0.027,0.017)	(-0.719, -0.489)	(-0.707, -0.491)
P-value	>0.05	<0.05	<0.05

TABLE 8: Pair-wise comparison of Agility T-test

- Based on these within- and between-groups comparisons, all three groups showed improvement in the power and agility assessed by using the FOMBT, BOMBT and Agility T-test but the COMB Activation (AOS and POS) resulted in greater improvements compared to the individual activation of oblique sling, which was clinically and statistically significant.

DISCUSSION

The objective of this study was to enhance post-activation performance in competitive athletes, focusing specifically on improving explosive power and agility by activating the anterior and posterior oblique sling systems. Explosive power was assessed using the Forward and Backward Overhead Medicine Ball Throw Test [18], for the anterior oblique sling and posterior oblique sling. Agility was evaluated using the Agility T-test [19].

The results of this study demonstrated that activating the anterior oblique sling and posterior oblique sling individually, and both slings in combination led to improvements in explosive power, as assessed by the forward and backward overhead medicine ball throw tests, and in agility, as measured by the Agility T-test. However, the combined activation of the anterior and posterior oblique slings resulted in the most significant enhancements in both explosive power and agility.

The findings reveal that the AOS and POS activation protocols led to more favourable outcomes in the forward and backward overhead medicine ball throw tests. This supports the current study which suggests that activation techniques involving slings can effectively boost muscular performance by enhancing neuromuscular efficiency and force output [20,21]. The observed gains in explosive power are likely due to improved coordination and force transfer resulting from these activation methods.

This study examined the impact of post-activation performance enhancement (PAPE) through oblique sling activation on explosive power and agility in competitive athletes. The results indicate that the combined activation of the

anterior oblique sling (AOS) and posterior oblique sling (POS) substantially improves post-activation performance, as demonstrated by enhanced explosive power and agility metrics. The reason to this could be the tuned stiffness of the core to generate force. [13]. This tuning allows active muscle forces to work with the elastic recoil of other tissues (e.g. ligaments, tendons, and fascia). By activating in spiral pattern, the proximal end of the hip and shoulder muscles are anchored producing faster arm and leg motion across the body, which is an essential component for all rapid reciprocal motions, such as throwing, change in direction, chopping and even single-sided lifting and carrying [8,9,13].

Thus, a universal law of human movement is the product of force multiplied by velocity, or in a rotational sense, twist velocity multiplied by twisting torque. One of this must be low if the other is high [23,24].

Post-activation performance enhancement (PAPE) is characterized by an increase in force production resulting from prior muscle activity. Mechanisms proposed to explain PAPE include elevated plasma catecholamines due to exercise and increased excitability of higher-order motor units. These mechanisms help to elucidate the findings of the current study by providing an explanation for the effects of PAPE [5,6,24].

The observed improvement in agility, as measured by the T-test in this study, aligns with the findings of Mokha et al., who demonstrated that activating the oblique slings has a positive effect on agility. This supports the broader body of research suggesting that effective neuromuscular activation enhances movement efficiency and speed. The combined activation of the anterior and

posterior oblique slings likely enhances dynamic stability and facilitates quicker directional changes, both of which are essential for agility in competitive sports.[22].

These findings have practical implications for athletes and coaches seeking to enhance performance. Integrating oblique sling activation into training programs may serve as a valuable complement to conventional strength and conditioning methods, potentially leading to better athletic outcomes.

Nonetheless, individual differences and specific sport requirements should be considered when applying these techniques.

CONCLUSION

The oblique sling system unifies an understanding of how the body organizes the many parts of the body linkage to create rotational activity and together with PAPE the efficiency of cyclic activity increases together with power and speed that is needed in activities such as throwing. The combined activation of the oblique slings shows a significant improvement in explosive power and agility when compared with individual sling activation.

LIMITATION

1. As the demand of each sports stands different even if it is overhead throwing, the current study had not considered these demands.
2. The level of fatigue was not assessed after the activation.
3. The long-term effect of the activation was not assessed.

FUTURE SCOPE

1. A further study can be conducted in comparison with the traditional warm-up protocols taking the specific sports demands into consideration.

SUMMARY

This study aimed to evaluate the effect of post-activation performance enhancement by activating the oblique sling in improving the explosive power and agility. The study included 30 competitive overhead throwers of age group 18-25 years who went AOS, POS and COMB Activation. The immediate explosive power was measured using FOMBT & BOMBT. Agility T-test was used to measure the agility before and after the activation. The results concluded that the combined activation of the oblique sling shows a significant improvement in explosive power and agility.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

REFERENCES

1. Mitchell James Finlay et.al Upper Body Post-Activation Performance Enhancement for Athletic Performance: A systematic Review with Meta-analysis and Recommendations for future research. Sports Medicine 2022 52:847-871.

2. wootaek Lim. Tensile Force Transmission from upper trunk to the contralateral lower leg throughout the posterior oblique sling system.

3. Bishop D. warm up I. Sports Med. 2003:33(6):483-98.

4. Seitz LB, Haff G. Factors modulating post-activation potentiation of jump, sprint, throw, and upper-body ballistic performances: a systematic review with meta-analysis. Sports Med. 2016:46(2);231-40.

5. Blazevich AJ, Babult N. Post-activation potentiation versus post-activation performance enhancement in humans: historical perspective, underlying mechanisms, and current issues. Front Physiol. 2019. https://doi.org/10.3389/fphys.2019.01359.

6. Cuenca-Fernandez F, Smith IC, Jordan MJ, Macintosh BR, Lopez-Conterras G, et.al Nonlocalized postactivation performance enhancement effects (PAPE) in trained athletes: a pilot study. Appl Physiol Nutr Metab. 2017; 42(10):1122-5.

7.Dobbs, W.C; Tolusso, D.V; Fedewa, M.V.; Esco, effects of post activation potentiation on explosive vertical jump: a systematic review and meta-analysis. J. Strength Cond. Res 2019,33,2009-2018.

8.Myers TW. The functional line. In: Anatomy Trains: Myofascial Meridians for Manual Movement Therapists (2ND ED). London, UK: Elsevier, 2009.pp 131-147.

9. Carr GA. Mechanics of Sport. Champagin.IL: Human Kinetics, 1997. Pp 141.

10. McGill SM. Low Back Disorders: Evidence Based Prevention and Rehabilitation (2ND ed.), 2007.

11.McGill SM. Ultimate Back Fitness and Performance (5th ed.). Waterloo, Canada: Backfitpro, 2014. Pp 111-122.

12. Kirkpatric P. Batting the ball. Amer J Phys 31: 606-613, 1963.

13. Juan C. Santana, Med, CSCSD, FNSCA, McGill, PhD. Anterior and Posterior serape: The Rotational Core. National Strength and Conditioning Association, volume 37, number 5, October 2015.

14. Anis Chaouachi Et.al Agility and change of direction in young soccer players: effect of generic versus specific training, January 2012.

15. Boyle M. New functional training for sports; Human Kinetics, USA 2016: pp 21-26.

16. J M Sheppard et.al J Sports Sci. 2006 sep. Agility literature review classification, training and testing.

17. Dae-kwan Kang, Young-In Hwang, Comparison of muscle activities of the posterior oblique sling among three prone hip extension exercises with and without contraction of the Latissimus dorsi.

18. Barry Stockbrugger et.al J of Strength and Conditioning Research; Validity and Reliability of a Medicine Ball Explosive Power Test.
19. Pauole, Kainoa; Madole, Kent et.al J Strength and Conditioning research; Reliability and Validity of the T-test as a Measure of Agility, Leg-power, and Leg-speed in college-aged Men and Women. Nov.2000.
20. Cormie, P., McGuigan, M. R., & Newton, R. U. (2011). Developing maximal neuromuscular power: Part 1 – Biological basis of maximal power production. Sports Medicine, 41(1), 17-38.
21. Conceição, M. S., Pereira, S., & Silva, A. (2018). The impact of different PAPE protocols on explosive performance in athletes. Journal of Strength and Conditioning Research, 32(4), 1047-1056.
22. Mokha, M., Day, M. L., & Morrow, J. R. (2007). The effects of post-activation potentiation on agility performance in collegiate athletes. International Journal of Sports Science & Coaching, 2(2), 101-109.
23. Santana JC. The serape effect: A kinesiological model for core training. Strength cond. J 25: 73-74, 2003.
24. Santana JC et.al A kinetic and electromyographic comparison of the standing cable press and bench press. J strength cond Res 21: 1271-1279, 2007.
25. Mitchell James et.al Upper-body post-activation performance enhancement for athletic performance: a systematic review with meta-analysis and recommendation for future research. Sports Medicine 2022.
26. Gianmarco Ciocca, Harald Tschan et.al Effects of post-activation performance enhancement (PAPE) induced by a plyometric protocol on deceleration performance. J of human kinetics volume 80/2021.

27. A lejandro Escobar et.al , international j of environment and public health, unilateral and bilateral post-activation performance enhancement on jump performance and agility.

ANNEXURE: 1

CONSENT FORM

I _____, aged ___ years, confirm that I have understood about PAPE and Oblique sling activation procedure and its potential benefits on athletes as explained by Miss. Auroshikha Sahu and is as mentioned in her study which is taking place under the guidance of Prof. Joseph Oliver Raj, Dean, Abhinav Bindra Sports Medicine and Research Institute (ABSMARI).

I understand that my participation is voluntary and I am free to withdraw at any time, without giving any reason.

I understand that confidentiality will be maintained.

I voluntarily agree to and give my consent to be a part of the above-mentioned study.

Signature Date

ANNEXURE:2

ASSESSMENT FORM

Name:

Age/Gender: Group:

Pre- and Post- Intervention data:

FOMBT-

TRIALS	Pre-Intervention	Post-Intervention
Trial 1		
Trial 2		
Trial 3		
Final (Highest) score		

BOMBT-

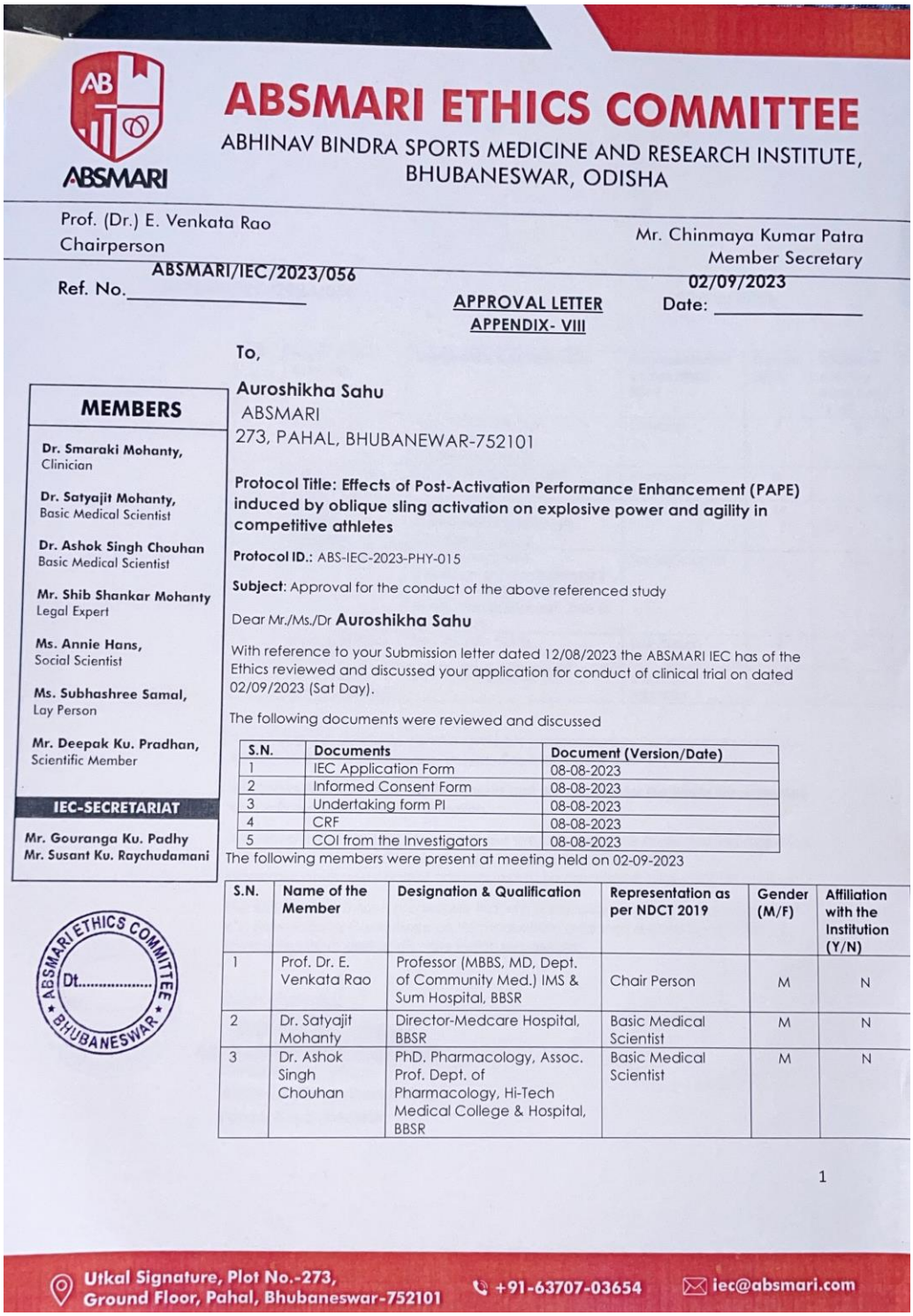
TRIALS	Pre-Intervention	Post-Intervention
Trial 1		
Trial 2		
Trial 3		
Final (Highest) score		

Agility T-Test-

	Pre-Intervention	Post-Intervention
Time (Seconds)		

ANNEXURE: 3

IEC APPROVAL LETTER



ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE, BHUBANESWAR, ODISHA

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2023/056

Date: 02/09/2023

APPROVAL LETTER
APPENDIX- VIII

To,

Auroshikha Sahu
ABSMARI
273, PAHAL, BHUBANEWAR-752101

MEMBERS

Dr. Smaraki Mohanty, Clinician

Dr. Satyajit Mohanty, Basic Medical Scientist

Dr. Ashok Singh Chouhan Basic Medical Scientist

Mr. Shib Shankar Mohanty Legal Expert

Ms. Annie Hans, Social Scientist

Ms. Subhashree Samal, Lay Person

Mr. Deepak Ku. Pradhan, Scientific Member

IEC-SECRETARIAT

Mr. Gouranga Ku. Padhy
Mr. Susant Ku. Raychudamani

Protocol Title: Effects of Post-Activation Performance Enhancement (PAPE) induced by oblique sling activation on explosive power and agility in competitive athletes

Protocol ID.: ABS-IEC-2023-PHY-015

Subject: Approval for the conduct of the above referenced study

Dear Mr./Ms./Dr **Auroshikha Sahu**

With reference to your Submission letter dated 12/08/2023 the ABSMARI IEC has of the Ethics reviewed and discussed your application for conduct of clinical trial on dated 02/09/2023 (Sat Day).

The following documents were reviewed and discussed

S.N.	Documents	Document (Version/Date)
1	IEC Application Form	08-08-2023
2	Informed Consent Form	08-08-2023
3	Undertaking form PI	08-08-2023
4	CRF	08-08-2023
5	COI from the Investigators	08-08-2023

The following members were present at meeting held on 02-09-2023

S.N.	Name of the Member	Designation & Qualification	Representation as per NDCT 2019	Gender (M/F)	Affiliation with the Institution (Y/N)
1	Prof. Dr. E. Venkata Rao	Professor (MBBS, MD, Dept. of Community Med.) IMS & Sum Hospital, BBSR	Chair Person	M	N
2	Dr. Satyajit Mohanty	Director-Medcare Hospital, BBSR	Basic Medical Scientist	M	N
3	Dr. Ashok Singh Chouhan	PhD. Pharmacology, Assoc. Prof. Dept. of Pharmacology, Hi-Tech Medical College & Hospital, BBSR	Basic Medical Scientist	M	N

ABSMARI ETHICS COMMITTEE * BHUBANESWAR * Dt.

1

Utkal Signature, Plot No.-273, Ground Floor, Pahal, Bhubaneswar-752101 +91-63707-03654 iec@absmari.com

ANNEXURE: 4

MASTERCHART

Sr. No.	Name	Age	Gender	Sports	AOS								
					OMBT (meters)			T-test (seconds)			BMBT (meters)		
					Pre	Post	Dfference	Pre	Post	Dfference	Pre	Post	Dfference
1	Sneha Mohanty	20	Female	Badminton	5.46	5.64	0.18	10.12	10.07	0.05	4.95	5.57	0.62
2	Rajesh Patnaik	22	Male	Badminton	6.1	6.31	0.21	9.78	9.72	0.06	5.32	6.06	0.74
3	Pooja Sahu	19	Female	Badminton	5.69	5.88	0.19	10.24	10.13	0.11	6.12	6.65	0.53
4	Alok Das	21	Male	Badminton	6.44	6.52	0.08	9.97	9.9	0.07	5.78	6.45	0.67
5	Swati Behera	18	Female	Badminton	5.85	6.06	0.21	10.49	10.47	0.02	4.88	5.46	0.58
6	Prakash Mishra	23	Male	Badminton	6.66	6.79	0.13	9.68	9.67	0.01	6.57	7.5	0.93
7	Sangita Nayak	24	Female	Badminton	5.74	5.96	0.22	10.36	10.34	0.02	5.41	6.17	0.76
8	Satish Jena	20	Male	Badminton	6.53	6.74	0.21	10.05	10	0.05	6.29	6.81	0.52
9	Ankita Mohapatra	22	Female	Badminton	6.06	6.14	0.08	10.43	10.36	0.07	5.96	6.56	0.6
10	Amit Kumar Parida	19	Male	Badminton	7.07	7.25	0.18	9.83	9.81	0.02	4.72	5.23	0.51
11	Hrashit Jain	25	male	Tennis	6.39	6.51	0.12	9.55	9.49	0.06	6.45	7.34	0.89
12	Deepak Rout	18	Male	Tennis	7.02	7.11	0.09	9.56	9.52	0.04	5.64	6.41	0.77
13	Mitali Mohanty	23	Female	Tennis	6.51	6.68	0.17	10.13	10.08	0.05	6.14	6.79	0.65
14	Rahul Panigrahi	24	Male	Tennis	7.18	7.36	0.18	9.69	9.67	0.02	5.23	5.79	0.56
15	Nandini Sahu	20	Female	Tennis	6.21	6.3	0.09	10.04	9.98	0.06	6.69	7.42	0.73
16	Avinash Dash	22	Male	Tennis	6.89	7.06	0.17	10.25	10.23	0.02	4.8	5.48	0.68
17	Lipi Mishra	19	Female	Tennis	6.98	7.19	0.21	9.85	9.77	0.08	5.89	6.44	0.55
18	Surya Prakash Sahu	21	Male	Tennis	7.27	7.45	0.18	9.61	9.59	0.02	6.33	7.11	0.78
19	Riya Mohanty	18	Female	Tennis	6.63	6.82	0.19	10.22	10.19	0.03	5.53	6.19	0.66
20	Santosh Behera	23	Male	Tennis	7.23	7.45	0.22	9.84	9.79	0.05	6.02	6.86	0.84
21	Sangram Nayak	24	Male	shot put	8.12	8.21	0.09	10.06	10.04	0.02	5.71	6.39	0.68
22	Sangita Panda	20	Female	shot put	8.19	8.34	0.15	10.12	10.09	0.03	6.5	7.03	0.53
23	Rakesh Das	22	Male	shot put	7.34	7.45	0.11	9.54	9.5	0.04	5.47	6.19	0.72
24	Rashmi Patra	19	Female	cricket	8.45	8.49	0.04	10.35	10.31	0.04	6.21	6.76	0.55
25	Anil Samal	21	Male	cricket	7.13	7.21	0.08	9.98	9.95	0.03	5.85	6.52	0.67
26	Niharika Swain	18	Female	cricket	6.45	6.51	0.06	10.44	10.37	0.07	4.77	5.32	0.55
27	Sudeep Mohapatra	23	Male	cricket	6.23	6.32	0.09	9.69	9.66	0.03	6.4	6.98	0.58
28	Madhusmita Pradhan	24	Female	cricket	5.87	6.02	0.15	9.57	9.51	0.06	5.3	6.09	0.79
29	Biswajit Sahu	20	Male	cricket	7.14	7.2	0.06	9.74	9.71	0.03	6.07	6.81	0.74
30	Arpita Mohanty	22	Female	cricket	6.87	7.02	0.14	10.19	10.15	0.04	5.99	6.61	0.62
	MEAN	**21.13333**			**6.723333**	**6.866333**	**0.142667**	**9.979**	**9.935667**	**0.043333**	**5.766333**	**6.433**	**0.666667**
	STANDARD DEVIATION	**2.112905**			**0.735988**	**0.720021**	**0.05589**	**0.296478**	**0.294486**	**0.022793**	**0.578157**	**0.615832**	**0.113634**

Sr. No.	Name	Age	Gender	Sports	POS								
					OMBT (meters)			T-test (seconds)			BMBT (meters)		
					Pre	Post	Dfference	Pre	Post	Dfference	Pre	Post	Dfference
1	Sneha Mohanty	20	Female	Badminton	5.48	5.66	0.18	10.08	10.03	0.05	5.12	6.77	0.72
2	Rajesh Patnaik	22	Male	Badminton	6.15	6.39	0.24	9.75	9.71	0.04	6.05	5.44	0.59
3	Pooja Sahu	19	Female	Badminton	5.72	5.96	0.24	10.2	10.18	0.02	4.85	6.42	0.66
4	Alok Das	21	Male	Badminton	6.45	6.59	0.14	9.94	9.84	0.1	5.76	7.02	0.55
5	Swati Behera	18	Female	Badminton	5.89	6.13	0.24	10.45	10.35	0.1	6.47	6.08	0.77
6	Prakash Mishra	23	Male	Badminton	6.72	6.91	0.19	9.66	9.61	0.05	5.31	6.81	0.53
7	Sangita Nayak	24	Female	Badminton	5.76	5.96	0.2	10.33	10.26	0.07	6.28	5.6	0.68
8	Satish Jena	20	Male	Badminton	6.56	6.71	0.15	10.02	9.96	0.06	4.92	6.56	0.62
9	Ankita Mohapatra	22	Female	Badminton	6.12	6.28	0.16	10.39	10.35	0.04	5.94	7.35	0.73
10	Amit Kumar Parida	19	Male	Badminton	7.12	7.26	0.14	9.78	9.74	0.04	6.62	6.03	0.54
11	Hrashit Jain	25	male	Tennis	6.26	6.41	0.15	9.58	9.56	0.02	5.49	6.86	0.67
12	Deepak Rout	18	Male	Tennis	6.79	6.88	0.09	9.64	9.63	0.01	6.19	6.42	0.75
13	Mitali Mohanty	23	Female	Tennis	6.37	6.59	0.22	10.19	10.17	0.02	5.67	5.42	0.64
14	Rahul Panigrahi	24	Male	Tennis	6.97	7.07	0.1	9.74	9.72	0.02	4.78	6.95	0.6
15	Nandini Sahu	20	Female	Tennis	6.07	6.18	0.11	10.1	10.08	0.02	6.35	5.8	0.57
16	Avinash Dash	22	Male	Tennis	6.69	6.91	0.22	10.31	10.26	0.05	5.23	7.29	0.71
17	Lipi Mishra	19	Female	Tennis	6.78	7	0.22	9.91	9.88	0.03	6.58	5.45	0.65
18	Surya Prakash Sahu	21	Male	Tennis	7.07	7.22	0.15	9.67	9.64	3	4.8	6.88	0.77
19	Riya Mohanty	18	Female	Tennis	6.53	6.71	0.18	10.27	10.21	0.06	6.11	6.56	0.69
20	Santosh Behera	23	Male	Tennis	7.02	7.16	0.14	9.89	9.86	0.03	5.87	5.3	0.56
21	Sangram Nayak	24	Male	shot put	8.21	8.38	0.17	10.03	10.02	0.01	4.74	7.07	0.63
22	Sangita Panda	20	Female	shot put	8.26	8.34	0.08	10.09	10.08	0.01	6.44	6.27	0.72
23	Rakesh Das	22	Male	shot put	7.48	7.66	0.18	9.51	9.47	0.04	5.55	7.22	0.51
24	Rashmi Patra	19	Female	cricket	8.52	8.69	0.17	10.32	10.28	0.04	6.71	6.1	0.68
25	Anil Samal	21	Male	cricket	7.21	7.34	0.13	9.96	9.92	0.04	5.42	6.57	0.55
26	Niharika Swain	18	Female	cricket	6.52	6.67	0.15	10.41	10.39	0.02	6.02	6.74	0.79
27	Sudeep Mohapatra	23	Male	cricket	6.32	6.53	0.21	9.67	9.65	0.02	5.95	5.49	0.5
28	Madhusmita Pradhan	24	Female	cricket	5.96	6.11	0.15	9.54	9.53	0.01	4.99	6.91	0.66
29	Biswajit Sahu	20	Male	cricket	7.23	7.36	0.13	9.71	9.7	0.01	6.25	6.18	0.58
30	Arpita Mohanty	22	Female	cricket	6.98	7.13	0.15	10.16	10.15	0.01	5.6	7.02	0.62
	MEAN	**21.13333**			**6.707**	**6.873**	**0.166**	**9.976667**	**9.941**	**0.134667**	**5.735333**	**6.419333**	**0.641333**
	STANDARD DEVIATION	**2.112905**			**0.740881**	**0.723974**	**0.044069**	**0.287274**	**0.27993**	**0.54172**	**0.612213**	**0.624135**	**0.082284**

Sr. No.	Name	Age	Gender	Sports	AOS+POS (Combined)								
					OMBT (meters)			T-test (seconds)			BMBT (meters)		
					Pre	Post	Dfference	Pre	Post	Dfference	Pre	Post	Dfference
1	Sneha Mohanty	20	Female	Badminton	5.51	5.82	0.31	10.06	9.68	0.38	4.35	5.4	1.05
2	Rajesh Patnaik	22	Male	Badminton	6.18	6.62	0.44	9.71	8.86	0.85	5.67	6.89	1.22
3	Pooja Sahu	19	Female	Badminton	5.76	6.02	0.26	10.14	9.21	0.93	6.12	7	0.88
4	Alok Das	21	Male	Badminton	6.49	6.87	0.38	9.89	9.67	0.22	4.78	6.11	1.33
5	Swati Behera	18	Female	Badminton	5.96	6.57	0.61	10.43	10.08	0.35	5.43	6.62	1.19
6	Prakash Mishra	23	Male	Badminton	6.79	7.4	0.61	9.63	9.05	0.58	6.23	7.18	0.95
7	Sangita Nayak	24	Female	Badminton	5.82	6.16	0.34	10.29	10.13	0.16	4.95	6.43	1.48
8	Satish Jena	20	Male	Badminton	6.61	7.18	0.57	9.98	9.64	0.34	5.89	6.93	1.04
9	Ankita Mohapatra	22	Female	Badminton	6.19	6.55	0.36	10.36	9.48	0.88	6.45	7.74	1.29
10	Amit Kumar Parida	19	Male	Badminton	7.19	7.8	0.61	9.76	9.41	0.35	4.5	5.61	1.11
11	Hrashit Jain	25	male	Tennis	6.32	6.9	0.58	9.57	9.41	0.16	5.12	6.65	1.53
12	Deepak Rout	18	Male	Tennis	6.89	7.43	0.54	9.61	8.71	0.9	6.3	7.15	0.85
13	Mitali Mohanty	23	Female	Tennis	6.45	6.83	0.38	10.16	9.45	0.71	5.67	6.95	1.28
14	Rahul Panigrahi	24	Male	Tennis	7.1	7.51	0.41	9.73	8.93	0.8	4.82	5.98	1.16
15	Nandini Sahu	20	Female	Tennis	6.12	6.93	0.81	10.07	9.28	0.79	6.08	7.43	1.35
16	Avinash Dash	22	Male	Tennis	6.78	7.31	0.53	10.28	9.6	0.68	5.53	6.57	1.04
17	Lipi Mishra	19	Female	Tennis	6.87	7.94	1.07	9.89	9.52	0.37	4.67	5.96	1.29
18	Surya Prakash Sahu	21	Male	Tennis	7.12	7.47	0.35	9.64	9.18	0.46	6.54	7.53	0.99
19	Riya Mohanty	18	Female	Tennis	6.56	7.53	0.97	10.25	9.8	0.45	5.71	6.86	1.15
20	Santosh Behera	23	Male	Tennis	7.11	7.95	0.84	9.87	8.8	1.07	4.4	5.87	1.47
21	Sangram Nayak	24	Male	shot put	8.01	8.32	0.31	10.07	9.86	0.21	5.99	7.29	1.3
22	Sangita Panda	20	Female	shot put	7.97	8.3	0.33	10.14	9.24	0.9	6.24	7.34	1.1
23	Rakesh Das	22	Male	shot put	7.3	7.61	0.31	9.55	8.8	0.75	5.34	6.54	1.2
24	Rashmi Patra	19	Female	cricket	8.4	8.75	0.35	10.38	9.6	0.78	6.11	7.36	1.25
25	Anil Samal	21	Male	cricket	7.07	7.69	0.62	10.02	9.54	0.48	4.56	6.01	1.45
26	Niharika Swain	18	Female	cricket	6.39	6.95	0.56	10.46	9.23	1.23	5.87	6.96	1.09
27	Sudeep Mohapatra	23	Male	cricket	6.17	6.68	0.51	9.72	8.54	1.18	6.49	7.46	0.97
28	Madhusmita Pradhan	24	Female	cricket	5.81	6.85	1.04	9.6	8.74	0.86	4.89	6.23	1.34
29	Biswajit Sahu	20	Male	cricket	7.06	7.62	0.56	9.76	8.88	0.88	5.73	7.25	1.52
30	Arpita Mohanty	22	Female	cricket	6.81	7.63	0.82	10.21	9.79	0.42	6.33	7.17	0.84
	MEAN	**21.13333**			**6.693667**	**7.239667**	**0.546**	**9.974333**	**9.337**	**0.637333**	**5.558667**	**6.749**	**1.190333**
	STANDARD DEVIATION	**2.112905**			**0.685236**	**0.690849**	**0.226314**	**0.285061**	**0.421902**	**0.305388**	**0.694395**	**0.618554**	**0.198172**