THE EFFECT OF POST ACTIVATION PERFORMANCE ENHANCEMENT (PAPE) ON FORCE, VELOCITY, POWER (FVP) PROFILE AND SPRINT PERFORMANCE IN PROFESSIONAL SPRINTERS: RANDOMIZED CROSSOVER CLINICAL TRIAL

By

SHAIKH SHAHALAM

Dissertation Submitted to the
Odisha University of Health Sciences, Bhubaneswar, Odisha

In Partial Fulfillment
Of the requirements for the degree of

MASTER OF PHYSIOTHERAPY (MPT)
In
SPORTS SCIENCES

Under the Guidance of

Dr. Joydip Saha (PT)
Associate Professor, ABSMARI

Abhinav Bindra Sports Medicine and Research Institute
Department of Physiotherapy
Bhubaneswar, Odisha.
2023-2025

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation/thesis entitled **"The Effect Of Post Activation Performance Enhancement (PAPE) On Force, Velocity, Power (FVP) Profile And Sprint Performance In Professional Sprinters: Randomized Crossover Clinical Trial "** is a bonafide and genuine research work carried out by me under the guidance of Dr. Joydip Saha (PT) , Associate Professor, Abhinav Bindra Sports Medicine and Research Institute, Bhubaneswar, Odisha. and there are no conflict of interest associated with this dissertation work.

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Place: **Name: Shaikh Shahalam**

University Reg. No.: 23MP435036

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Seal & Signature of the Guide

Dr. Joydip Saha (PT)

Associate Professor, ABSMARI

Department of Movement Science.

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Date:

Place:

Seal & Signature of the HOD

Dr. Asifuzzaman Shahriyar Ahmed (PT)

Associate Professor, HOD,

Musculoskeletal and Sports, ABSMARI

ENDORSEMENT BY THE PRINCIPAL

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Date:

Place:

Seal & Signature of the Principal

Dr.. Chinmaya Kumar Patra (PT)

Principal, ABSMARI

ODISHA UNIVERSITY OF HEALTH SCIENCES

CERTIFICATE OF ACCEPTANCE

This is to certify that the dissertation entitled **"The Effect Of Post Activation Performance Enhancement (PAPE) On Force, Velocity, Power (FVP) Profile And Sprint Performance In Professional Sprinters: Randomized Crossover Clinical Trial''** carried out by **Mr. Shaikh Shahalam,**, bearing University Registration No. 23MP435036, has been **evaluated and accepted** by me as an **Examiner/ Evaluator**, appointed by the **Odisha University of Health Sciences, Bhubaneswar**, in partial fulfilment of the requirements for the award of the degree of **Master of Physiotherapy (MPT) in sports speciality**.

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I, Shaikh Shahalam of Abhinav Bindra Sports Medicine and Research Institute, Bhubaneswar, Odisha, hereby declare that the Odisha University of Health Sciences and Abhinav Bindra Sports Medicine and Research Institute, Bhubaneswar, Odisha, shall have the rights to preserve, use, and disseminate this dissertation/ thesis in print or electronic format for academic/ research purposes.

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ACKNOWLEDGEMENT

I, at the outset, must thank the Almighty for showering his blessings on me.

I am also immensely grateful to **Dr. Chinmaya Kumar Patra (PT)**, Principal, Abhinav Bindra Sports Medicine and Research Institute, Bhubaneshwar. Your encouragement and belief in my abilities have been a source of motivation and confidence.

I express my deepest gratitude to my guide, **Dr. Joydip Saha (PT)**, Associate Professor, Abhinav Bindra Sports Medicine and Research Institute, Bhubaneshwar. Your unwavering support, expert guidance, and insightful feedback have been instrumental in shaping this research. Your dedication to excellence in academia has inspired me to strive for higher goals in my academic pursuits.

Furthermore, I would like to extend special thanks to **Dr. Joseph Oliver Raj (PT)** for valuable assistance and support throughout this research. Your expertise and constructive criticism have helped me refine my work and explore new dimensions in my study.

I sincerely acknowledge the guidance and support of all the faculty members of the Department of Sports Physiotherapy, whose expertise greatly contributed to the completion of this research. Their collective expertise and encouragement have been instrumental in enhancing the academic quality of this work and in fostering my professional growth.

I also acknowledge, with deep reverence, my heartfelt gratitude to my Mother , **Mrs. Rajia Khatun**, who has always supported me both morally and mentally. I would like to take this opportunity to sincerely thank every athlete, along with their coaches who participated in this study for their kind cooperation and the valuable information they provided. Without their valuable contributions, this work would not have been possible.

In conclusion, this dissertation stands as a testament to the collaborative efforts of the individuals mentioned above, and I am deeply grateful for their contributions to my academic success.

Thank you.

Date :

Place :

Signature of the candidate

Name: Shaikh Shahalam

University Registration No.: 23MP435036

LIST OF ABBREVIATIONS USED

Abbreviation	Full Form
ABSMARI	Abhinav Bindra Sports Medicine and Research Institute
CA	Conditioning Activity
EXP 1	Dynamic Resistance PAPE CA
EXP 2	Plyometric PAPE CA
FVP	Force, Velocity, Power
HZT-F0 (N/kg)	Theoretical Maximal Horizontal Force Production
HZT-V0 (m/s)	Maximal Mechanical Power Output
MPT	Master of Physiotherapy
OUHS	Odisha University of Health Science
PAPE	Post Activation Potentiation Enhancement
SD	Standard Deviation
SPSS	Statistical Package for the Social Science
ST	Sprint Time in Seconds

ABSTRACT

Background and Objective: Athletic performance in sprinting depends on the integration of force, velocity, and power during the acceleration phase. Post-activation performance enhancement (PAPE) has been explored as a way to prime neuromuscular readiness, yet its specific influence on sprint mechanics in trained athletes is not well defined.. This study set out to examine the effects of different PAPE conditioning activities on force–velocity–power profile and 100 m sprint performance.

Methods: A randomized crossover clinical trial was conducted with twenty-four professional athletes (18 men, 6 women; age 18–25 years). Each participant performed both resistance training–based and plyometric conditioning activities in separate sessions, separated by a 72-hour washout period. Sprint performance was measured using 100 m sprint time, and mechanical outputs including horizontal force, sprint velocity, and maximal power were derived using the MySprint application. Pre–post comparisons within each condition and between-group analyses were performed.

Results: All the demographic baseline data such as age, weight, height are statistically significant with $p > 0.05$. Both resistance training and plyometric exercise produced significant within-group improvements in sprint performance(ST: $p=0.000$), horizontal force generation(HZT-F0: $p=0.04$), velocity(HZT-V0: $p=0.02$), and power output (Pmax: $p=0.02$).

Conclusion: Resistance-based and plyometric PAPE activities were equally effective in acutely enhancing sprint performance and FVP characteristics in professional athletes.

Neither approach showed superiority, but both can serve as practical tools in training and warm-up design. These findings suggest immediate performance benefits, with further studies required to assess longer-term adaptations and individual variability.

Keywords: “Acceleration” ; “Athletic Performance” ; “Athletes” ; “Plyometric Exercise” ; “Resistance Training”

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INTRODUCTION

McFarlane [1] characterizes sprinting as a flawless sequence of refined technical execution and coordinated motor skills. Within athletics, the 100-m sprint stands out as the shortest outdoor track event, and those who hold its records are often celebrated as the "world's fastest athletes." Unlike the 200-m and 400-m races, it is run entirely on a straight track, making it particularly suitable for detailed analysis of sprinting mechanics. The objective is straightforward yet highly demanding — to cover the race distance as quickly as possible [2]. At the Olympic Games, this event has become a centerpiece of track and field, highlighting athletes capacity for explosive acceleration and the ability to reach peak velocity in a matter of seconds. Performance in the 100-m sprint is generally divided into three main phases—acceleration, top speed, and deceleration [3, 4].This initial acceleration is not only a key technique but also a primary target for performance enhancement strategies.

This acceleration immediately following the start is regarded as a critical component of performance in the 100-m dash, as the effectiveness of this phase has a direct influence on the athlete's ability to achieve maximum velocity [5, 6]. Within this phase, researchers commonly distinguish between two sub-stages: the initial or starting acceleration, covering the first 0–12 m, and the main acceleration, which extends from 12–35 m [7]. Achieving maximal running speed is largely dependent on the quality of preceding acceleration[8]. Consequently, a sprinter's capacity to generate rapid acceleration within a limited time frame is considered one of the most decisive factors for success in the 100-m event [9, 10]. One such strategy designed to improve this explosive acceleration is referred to as post-activation performance enhancement (PAPE).

Cuenca-Fernández et al. [11] introduced the the principle of post-activation performance enhancement (PAPE) [12–13], which refers to a short-term enhancement in physical performance triggered by a single high-intensity voluntary activity. This principle suggests that such prior activity can lead to measurable gains in strength, speed, or power output [14]. Notably, reductions in sprint times associated with PAPE have been observed most consistently in short-distance races of 40 m or less [15].The physiological basis for this performance boost is rooted in several complex mechanisms.

Beyond the rise in body temperature and its accompanying advantages for neuromuscular and cardiometabolic function [16, 17], potentiation is thought to be driven mainly by phosphorylation occurring in the regulatory light chain of myosin. This adaptation, considered a form of muscle memory, enhances responsiveness to Ca2+, promoting temporary improvements in both maximal force output and the speed of force production[18]. Even so, several mechanisms have been suggested to account for potentiation [19, 20, 21, 22].It is important to distinguish this voluntary performance enhancement from a related physiological phenomenon.

Differentiating between post-activation potentiation (PAP) and post-activation performance enhancement (PAPE) has been the subject of ongoing debate among researchers. PAP is understood as a short-lived physiological effect, usually lasting from a few seconds to several minutes, largely resulting from phosphorylation of the myosin light chain within type II muscle fibers, which produces a heightened muscle twitch response. PAPE, however, represents an increase in voluntary force output that typically emerges a few minutes after activity and endures longer than PAP. Explanations for PAPE commonly involve physiological mechanisms such as increased muscle

temperature, myosin regulatory light chain phosphorylation, and buildup of intracellular fluids [23].Therefore, the term PAPE is more appropriate for describing this voluntary performance enhancement in an athletic context. Thus, the term PAPE is considered a more suitable term compared with the mechanistic label PAP. Given its effects, PAPE has become a valuable tool in the preparation of athletes for explosive events.

Within the domain of sports kinesiology, Post-Activation Performance Enhancement (PAPE) is acknowledged as an important mechanism through which a brief, near-maximal Conditioning Activity (CA) produces beneficial physiological adaptations. Such activities have been shown to induce myosin regulatory light chain phosphorylation, improve the activation of higher-threshold motor units and the reduction of pennation angle during muscle contraction [24]. These mechanisms combine to produce acute gains in performance. Owing to its role in improving efficiency of muscular force generation, PAPE has become widely utilized in sports that rely on explosive strength [25], and its influence is most often measured using sprint and jump tests. Research findings consistently demonstrate that athletes in rugby, football, weightlifting, sprinting, handball, and swimming [26–29] can improve short-distance sprinting ability [26, 30–32] and jumping capacity [33] when PAPE is employed in pre-training or pre-competition warm-up routines. The degree of improvement, however, is largely dependent on the selection of CA[34]. The selection and timing of the conditioning activity are critical to eliciting the desired performance boost.

In the field of athletics, different potentiating methods—such as dynamic resistance training, maximal voluntary isometric contractions, and plyometric exercise—have been employed to improve force and peak power output [35]. This has led to growing

interest in the application of PAPE as a strategy to enhance performance [36–38]. Yet, since the same Conditioning Activity (CA) capable of eliciting PAPE can simultaneously induce fatigue [39, 40], identifying the most effective post-CA interval for achieving performance gains remains a key research concern. Research has begun to establish ideal timings for different types of conditioning activities.

Evidence suggests that 20-m sprint performance can be enhanced through any of the three commonly applied PAP stimuli—squat, plyometric, or isometric exercise—with optimal recovery intervals before competition identified as 4–8 minutes for squat, 8 minutes for plyometric, and 12–16 minutes for isometric interventions [41]. The capacity to generating high muscular power is broadly acknowledged as a critical determinant in both team-oriented and individual sports that rely on sprinting [42]. This capacity is closely tied to rapid force production, which underpins acceleration, speed, change of direction, and overall power, thereby exerting a direct influence on training adaptations and competitive outcomes [43, 44].This power output is fundamentally expressed through an athlete's sprinting capacity.

Consensus exists that Post-Activation Performance Enhancement (PAPE) is considered important for improving strength, sprint speed, and power output [45]. Within this context, sprinting serves as a clear demonstration of horizontal power output, as it requires athletes to produce considerable force that manifests as forward acceleration [46]. To truly understand this power, we must look beyond simple sprint times to the underlying mechanical properties.

The ability to reach maximum speed and acceleration in sprinting is closely linked to the mechanical power which is linked to the forward–backward

component of ground reaction force. Sprint performance (SP) is influenced by several biomechanical factors, but is usually assessed by the time taken to cover a set distance. Relying solely on this time-based measure, however, may oversimplify the mechanical complexities of sprinting and obscure important characteristics of muscular mechanics [37, 38]. To address this, a French group introduced a field method that derives horizontal acceleration from the speed–time curve, enabling calculation of mechanical variables and the development of horizontal force–velocity (HF–V) profiles for sprint accelerations [39, 40]. This method enables the assessment of key estimated metrics such as relative maximum force (HZT-F0, N/kg), relative maximum velocity (HZT-V0, m/s), and relative maximum power (HZT-Pmax, W/kg)[41]. By providing a macroscopic view of sprint mechanics, the HF–V profiling approach offers a more complete understanding of SP dynamics [42, 43]. The definitions and interpretations of these mechanical variables are summarized in Table 1 [44]. This approach for profiling an athlete's force–velocity characteristics is both highly informative and practically accessible.

PROFILING VARIABLE	DEFINITION AND COMPUTATION	PRACTICAL INTERPRETATION
HZT-F0 (N/kg)	Theoretical maximum horizontal force output, extrapolated from the linear sprint force–velocity curve; corresponds to the y-intercept of the relationship.	Represents the peak horizontal force an athlete can apply relative to body mass at the start of sprint acceleration. A higher value indicates greater sprint-specific horizontal force production
HZT-V0 (m/s)	Theoretical maximal sprinting velocity, estimated as the x-intercept of the linear force–velocity curve.	Indicates the athlete's maximal velocity capacity during sprinting, slightly above the measured top speed. It also reflects the runner's ability to maintain horizontal force production under minimal resistance at very high velocities.
HZT-Pmax (W/kg)	Theoretical maximal mechanical power output in the horizontal direction, calculated as Pmax = F0 × V0 / 4, or represented as the peak point of the parabolic force–velocity (F–V) relationship.	Reflects the athlete's maximal power generation per unit body mass in the horizontal direction during sprint acceleration.

Table 1: Definitions and interpretations of these mechanical variable

In 2016, Somazino et al. introduced a practical approach to measure power, force, velocity characteristics, and mechanical effectiveness in sprinting by analyzing the slope of the force–velocity curve, which defines the F–v mechanical profile (SFV) as the balance between an athlete's force and velocity attributes [44]. Evaluating both individual F–V and power–velocity (P–V) relationships, together with the measures of mechanical effectiveness during sprint propulsion,provides valuable information for coaches, strength professionals, and physiotherapists. Sprint performance is strongly associated with HZT-Pmax (W/kg) (Somazino, 2016), and the ability to individually quantify mechanical effectiveness enables the differentiation of physical versus technical determinants of inter- and intra-individual variation in sprint performance. This, in turn, supports the design of more targeted training strategies aimed at enhancing the most relevant mechanical qualities. The practical application of this method makes advanced mechanical analysis feasible outside of a laboratory setting.

Coaches and trainers often lack access to specialized and costly equipment, as well as the expertise needed to interpret raw force data. Consequently, athletes are usually required to undergo laboratory-based testing, which, although precise and valuable for training, is rarely implemented in practice. Hence, the development of a straightforward field-based method for assessing F–V and P–V relationships, along with sprint force application efficiency under realistic conditions, would allow broader application for both training and research purposes.

While PAPE is acknowledged as an approach to temporarily enhance athletic performance, its immediate impact on sprint mechanics, especially the force–velocity–power (FVP) profile, has not been adequately explored.. Much of the existing literature

emphasizes chronic adaptations or generalized performance outcomes, or short distance races and often in non-elite populations, leaving a gap in understanding how PAPE affects professional sprinters and longer distances. Moreover, translation of these effects to competitive measures such as the 100 m sprint is rarely addressed. With the advent of precise tools like the MySprint application, researchers now have the opportunity to examine sprint-specific kinetic variables in greater detail.

Need for the study

There is limited evidence analyzing how PAPE interventions specifically alter the sprint acceleration phase and whether these changes can produce measurable improvements in 100 m sprint performance. Current studies often generalize findings, lack elite athlete representation, and provide little mechanistic insight into sprint-specific adaptations. This creates a pressing need for focused research that examines acute changes in FVP variables—force, velocity, and power—within professional sprinters.

The current investigation seeks to bridge this gap by utilizing dynamic resistance and plyometric dynamic resistance and plyometric conditioning activities as PAPE strategies, assessed using the MySprint application. By quantifying their immediate effects on sprint time and mechanical determinants, this investigation aims to provide evidence directly relevant to elite sport. The outcomes can guide strength and conditioning professionals and physiotherapists in designing individualized warm-up and training protocols, enhancing performance, and supporting injury-prevention strategies in competitive sprinting.

AIM & OBJECTIVE OF THE STUDY

AIM OF THE STUDY

To explore the effect of Post Activation Performance Enhancement (PAPE) on Force, Velocity, Power (FVP) Profile and Sprint Performance in Professional Sprinters

OBJECTIVES OF THE STUDY

1)To investigate the changes in the FVP profile in sprint Acceleration Phase Undergoing Dynamic Resistance PAPE CA using My Sprint Application

2)To investigate the changes in the FVP profile in sprint Acceleration Phase Undergoing Plyometric PAPE CA using My Sprint Application

3)To check difference in the 100m Sprint Performance using sprint time pre and post PAPE CA

HYPOTHESIS OF THE STUDY

HYPOTHESIS:

Null hypothesis :

There will be no significant differences between Dynamic Resistance PAPE CA and Plyometric Exercise PAPE CA in both the FVP profile and sprint performance.

Alternate hypothesis :

There will be Significant differences between Dynamic Resistance PAPE CA and Plyometric Exercise PAPE CA in both the FVP profile and sprint performance

REVIEW OF LITERATURE

METHODOLOGY OF LITERATURE REVIEW:

The articles were explored with appropriate keywords under relevant sections. The literature search was conducted from electronic databases PubMed and Google Scholar. Keywords included were selected for individual section with or without using Boolean operator AND, IN. The databases used were PubMed and Google scholar. The search was then narrowed by adding keywords. Articles other than the English language and human trials were excluded. The narrowed article titles and abstracts were screened. Excluded articles with quality less than 60% in JBI critical appraisal tools. The outcomes of the review are described in the following pages under the relevant section.

- **Section A:** To find the effect of PAPE on sports performance determinants (strength, speed, power).
- **Section B:** To find different sprint profiling methods to analyze the sprint acceleration phase performance.
- **Section C:** To find key mechanical variables of FVP to analyze sprint acceleration performance.
- **Section D:** To find out reliability and validity of My sprint application.
- **Section E**: To find effects of PAPE intervention strategy to improve sprint performance .
- **Section F:** To find effects of PAPE CAs on sprint performance.
- **Section G:** To find out reliability and validity of Photo finish application.

SECTION A

Title - To find the effect of PAPE on sports performance determinants (strength, speed, power)

Objective – This section evaluates the literature to determine if the physiological phenomenon of post-activation potentiation (PAP) is the direct mechanism responsible for observed enhancements in voluntary measures of strength, speed, and power.

Keywords were combined with Boolean terms (AND, IN) to find appropriate articles.

Databases – PubMed

Inclusion – Articles with full text, articles in English language, human trials and articles with JBI guidelines score 60% or more.

ARTICLES INCLUDED IN SECTION A

1) **Blazevich et al. (2019)** [12] Conducted a study to (1) provide an historical perspective of the evolution of PAP research, (2) Critically evaluate the existing literature with respect to the mechanisms that might enhance functional performance or the muscle's contractile response following a conditioning contraction (i.e.,PAP/PAPE) and concluded that, the term post-activation performance enhancement (PAPE) has recently been proposed for use (Cuenca-Fernandez et al., 2017) when a high-intensity voluntary conditioning contraction(s) leads to enhancement in voluntary muscular performance in a subsequent test without confirmatory evidence of classical PAP (i.e., twitch force assessment).

2) **Zimmermann et al. (2020)** [54] Conducted a study to investigate if increases in voluntary performance after a conditioning contraction (CC) are related to the PAP phenomenon and concluded that, the occurrence of PAP does not necessarily mean that the voluntary performance will be improved. Improvement in voluntary performance is sometimes observed when the PAP level reaches extremely high values. Other mechanisms may be more relevant than that for PAP in the manifestation of acute increases in performance following a conditioning contraction.

INFERENCE OF SECTION A

- A critical distinction exists between the observed muscular twitch force enhancement (PAP) and the enhancement of voluntary muscular performance (PAPE), with the latter not necessarily being confirmed by evidence of the former.
- The occurrence of PAP at the muscular level does not automatically or consistently lead to an improvement in voluntary athletic performance.
- Improvements in voluntary performance may only be observed when the level of PAP is extremely high, suggesting it is not the primary mechanism for most performance enhancements.
- Other mechanisms, beyond the classical PAP explanation, are likely more relevant for the acute increases in performance following a conditioning contraction.

SECTION B

Title -To find different sprint profiling methods to analyze the sprint acceleration phase performance

Objective – This section examines the validity and reliability of the Acceleration-Speed Profile (ASP) as a method for analyzing sprint acceleration mechanics in athletic populations.

Keywords were combined with Boolean terms (AND, IN) to find appropriate articles.

Databases – PubMed

Inclusion – Articles with full text, articles in English language, human trials and articles with JBI guidelines score 60% or more.

ARTICLES INCLUDED IN SECTION B

1)**Alonso-Callejo et al. (2024)** [54] Conducted a study To assess the validity and reliability of the acceleration-speed profile (ASP) for measuring the mechanical variables of running kinematics when compared with the force-velocity profile (FVP) obtained by reference systems.(Linear Encoder ,My Sprint APP, GPS device) And concluded that, Collecting acceleration and speed data in specific training and match situations is sufficient to generate an athletic performance profile (ASP) that provides almost the same in- formation as the FVP.From these results, practitioners could implement ASP and the applications of the FVP previously studied, such as resistance training prescription, performance assessment, and return-to-play management.

INFERENCE OF SECTION B

- The Acceleration-Speed Profile (ASP) method demonstrates strong validity and reliability for assessing key mechanical variables of sprint performance, providing results nearly equivalent to those derived from the Force-Velocity Profile (FVP).
- A significant practical advantage of the ASP is its ability to generate a performance profile by utilizing acceleration and speed data collected during athletes' regular training and match situations.
- The methodological simplicity of the ASP allows for its direct implementation by practitioners for critical applications such as prescribing resistance training, conducting performance assessments, and managing athlete return-to-play protocols.

SECTION C

Title - To find key mechanical variables of FVP to analyze sprint acceleration performance

Objective – This section examines the key mechanical variables of the Force-Velocity-Power (FVP) profile that are essential for analyzing and interpreting sprint acceleration performance.

Keywords were combined with Boolean terms (AND, IN) to find appropriate articles.

Databases – PubMed

Inclusion – Articles with full text, articles in English language, human trials and articles with JBI guidelines score 60% or more.

ARTICLES INCLUDED IN SECTION C

1) **Morin et al. (2016)** [43] conducted a study To provide a practical vade mecum to sports practitioners interested in implementing these power-force-velocity–profiling approaches And concluded that, HZT-F0 (N/kg) , HZT-V0 (m/s), HZT-Pmax (W/kg) , RF (%) , RFmax (%) , DRF ,These novel approaches of vertical and horizontal force-velocity-power profiling have the potential to provide sport practitioners simple, cheap, yet accurate methods for more individualized monitoring and training of physical and technical capabilities. These methods can be easily implemented on a regular basis, since they are based on common and sport-specific movements (ballistic push-offs and sprint accelerations) and can therefore be used for long-term monitoring and training processes.

2) **Samozino et al. (2016)** [44] Conducted a study , To validate a simple field method for determining force– and power–velocity relationships and mechanical effectiveness of force application during sprint running and concluded that, The findings support the validity of the proposed simple method, using Anthropometric (body mass, Stature) & Spatiotemporal data (split times), Running velocity measurements, convenient for field use, to determine power, force, velocity properties, and mechanical effectiveness in sprint running.

3).**Hicks et al. (2020)** [55] Conducted a study , To examines the methods used in the field for determining horizontal force-velocity (sprint) profiles. It also includes recommendations for practical training methods to address individual force-velocity characteristics, mechanical effectiveness, thereby optimizing acceleration performance and concluded that, Sprint profiling using the field methods briefly outlined in this review offers an innovative and alternative approach to understand the mechanical determinants of sprint acceleration.

INFERENCE OF SECTION C

- The horizontal Force-Velocity-Power profile provides a comprehensive mechanical model for sprint acceleration, with its key determinants being maximal horizontal force production (HZT-F0 (N/kg)), maximal horizontal velocity (HZT-V0 (m/s) (m/s)), and maximal horizontal power (HZT-Pmax (W/kg)).

- A simple and valid field method exists to determine these FVP variables, requiring only anthropometric data (body mass) and spatiotemporal data (split times or running velocity) collected during a single sprint effort, making it highly practical for practitioners.
- Beyond absolute force and velocity, the mechanical effectiveness of force application (DRF and RFmax) is a critical variable that quantifies how well an athlete applies force into forward motion during each ground contact.
- The analysis of an individual's unique FVP profile offers a foundational framework for prescribing highly individualized and specific training interventions to target identified mechanical deficits, such as a lack of force or a lack of velocity.

SECTION D

Title - To find out reliability and validity of my sprint application.

Objective – This section evaluates the validity and reliability of the My Sprint application as a tool for assessing sprint performance metrics.

Keywords were combined with Boolean terms (AND, IN) to find appropriate articles.

Databases – PubMed

Inclusion – Articles with full text, articles in English language, human trials and articles with JBI guidelines score 60% or more.

ARTICLES INCLUDED IN SECTION D

1)**Silva et al. (2021)** [56] Conducted a study , To (1) identify and summarize studies that have examined the validity of apps for measuring human strength, power, velocity, and change-of-direction, and (2) identify and summarize studies that have examined the reliability of apps for measuring human strength, power, velocity, and change-of-direction And concluded that, My Sprint app showed almost perfect correlations with the radar gun for measures of the power, force, velocity, and mechanical properties of sprint performance

For the My Sprint App, the ICC value of reliability was 1 and CV values were from 0.027–0.14%. the Pearson r values from r = 0.989–0.999.

INFERENCE OF SECTION D

- The My Sprint application demonstrates almost perfect correlation with radar gun measurements when assessing key mechanical properties of sprint performance, including power, force, and velocity.
- High statistical validity is evidenced by Pearson correlation coefficient values ranging from r = 0.989 to 0.999 when compared to the radar gun gold standard.
- The application exhibits exceptional reliability, supported by an intraclass correlation coefficient (ICC) value of 1 and low coefficient of variation (CV) values between 0.027% and 0.14%.

SECTION E

Title - To find effects of PAPE intervention strategy to improve sprint performance

Objective – This section systematically reviews the effects of Postactivation Performance Enhancement (PAPE) intervention strategies on improving sprint performance in athletes.

Keywords were combined with Boolean terms (AND, IN) to find appropriate articles.

Databases – PubMed

Inclusion – Articles with full text, articles in English language, human trials and articles with JBI guidelines score 60% or more.

ARTICLES INCLUDED IN SECTION E

1) **Gautam et al. (2024)** [29] conducted a study, To critically summarize the current evidence on PAPE protocols' effect on Sprint and Change of Direction (COD) performance in Athletes and study the influence of the Type of PAPE protocols, Recovery duration, Volumes, and loads of PAPE protocols and concluded that, PAPE protocols can be incorporated provided the recovery duration is of Moderate duration (3–8mins) or Individualized durations, using multiple sets (2–6), moderate-high loads (>85% 1-RM), type of protocol is Barbell Hip Thrust, Plyometrics or Unilateral biomechanically similar exercises to Running.

INFERENCE OF SECTION E

- The implementation of PAPE protocols can lead to enhancements in sprint performance, provided specific prescription guidelines are followed.
- The optimal recovery duration between the conditioning activity and the subsequent sprint task is identified as a moderate window of 3 to 8 minutes, or alternatively, a duration that is individualized to the athlete.
- Effective protocols utilize multiple sets, typically within a range of 2 to 6 sets, with moderate to high loads exceeding 85% of one-repetition maximum (1-RM).
- The type of conditioning activity is a critical factor, with the most effective exercises being the barbell hip thrust, plyometric exercises, and unilateral movements that are biomechanically similar to the running action.

SECTION F

Title - To find effects of pape CAs on sprint performance

Objective – This section examines the acute effects of various post-activation performance enhancement (PAPE) conditioning activities on sprint performance in athletes.

Keywords were combined with Boolean terms (AND, IN) to find appropriate articles.

Databases – PubMed

Inclusion – Articles with full text, articles in English language, human trials and articles with JBI guidelines score 60% or more.

ARTICLES IN SECTION F

1) **Chen et al. (2023)** (57) conducted a study, To determine whether squats at 85% to 100% 1RM intensity could significantly improve 10-meter and 30-meter sprint ability with an intermittent time of 4-8 minutes, And concluded that, When squats were used as the induction and the load intensity was 85% 1RM~100% 1RM, the sprint ability in 10-meter and 30-meter events could be significantly improved if the intermittent time was 4-8min.

2) **MH et al. (2021)** (58) conducted a study, To investigate the immediate effect of weighted plyometrics exercise on sprint, agility and jump performance And concluded that, Weighted plyometrics exercise have an acute response on sprint, agility and CMJ height following PAP effect developed after plyometrics exercise

3) **Piper et al. (2020)** (31) conducted a study, To determine the effect of different potentiating stimuli on jump and sprint performance in resistance trained, college-aged men and women and concluded that, the Results revealed significantly faster 0–20m sprint times. These findings

indicate that while all PAP stimuli utilized can be effective at improving sprint performance, specific optimal time points may exist.

INFERENCE OF SECTION F

- Performing heavy back squats at intensities between 85% and 100% of one-repetition maximum (1RM) can lead to significant improvements in short-distance sprint ability over both 10-meter and 30-meter distances.
- The efficacy of such high-intensity squat protocols is contingent upon implementing an optimal intermittent recovery period of 4 to 8 minutes between the conditioning activity and the subsequent sprint performance.
- Weighted plyometric exercises serve as an effective conditioning activity, generating a potent PAPE effect that results in acute enhancements in sprint performance.
- While various PAPE stimuli, including heavy resistance and plyometric exercises, are generally effective for improving sprint performance, the specific timing of the performance enhancement may vary, suggesting that optimal time points exist for different protocols.

SECTION G:

Title - To find out reliability and validity of Photo Finish application.

Objective – This section evaluates the validity and reliability of the Photo Finish application as a tool for assessing sprint performance metrics.

Keywords were combined with Boolean terms (AND, IN) to find appropriate articles.

Databases – PubMed

Inclusion – Articles with full text, articles in English language, human trials and articles with JBI guidelines score 60% or more.

ARTICLES IN SECTION G

1) **Marco-Contreras LA, et al. (2024)** [59] conducted a study to analyze the validity and reliability of the Photo Finish® app as a timing tool for sprint performance assessment. The results revealed a high correlation R2=0.986R2=0.986 with gold-standard photocell measurements and an intraclass correlation coefficient (ICC) of 0.999 for repeated measures. These findings indicate that the Photo Finish® app is an accurate and reliable tool for measuring sprint times, suitable for use in sports performance contexts.Marco-Contreras LA, et al. (2024) conducted a study to analyze the validity and reliability of the Photo Finish® app as a timing tool for sprint performance assessment. The results revealed a high correlation R2=0.986R2=0.986 with gold-standard photocell measurements and an intraclass correlation coefficient (ICC) of 0.999 for repeated measures. These findings indicate that the Photo Finish® app is an accurate and reliable tool for measuring sprint times, suitable for use in sports performance contexts.

INFERENCE OF SECTION G

- The Photo Finish® app is a highly valid and reliable tool for measuring sprint performance.
- The app's sprint timing showed an excellent agreement with gold-standard photocell systems, with minimal bias and very strong statistical correlations. Its high consistency across repeated measurements supports its use as a practical, accurate, and accessible timing method in sports performance settings.
- The findings suggest that the app can serve as a convenient alternative to more expensive and complex timing systems without compromising measurement accuracy.

METHODOLOGY & PROCEDURE

- Study design: Randomized Crossover Clinical Trial
- Study population: Professional Sprinters
- Sampling technique: Purposive Sampling
- Sample size: 24
- Study setting: HPCs present at Kalinga Stadium, Bhubaneswar, Odisha.
- Study duration: 1 year
- Ethical clearance: 6 months
- Sample selection, data collection: 4 months
- Statistical analysis, results, discussion: 2 months

INCLUSION CRITERIA

1. Age 18-25 years old
2. Gender male female both
3. Back squat 1RM is greater than or equal to 1.5 times body weight.
4. Resistance trained – 3 days/week for 4 months.

EXCLUSION CRITERIA

1. H/O any injury within past 6months.
2. Not in training period, untrained or recreationally trained
3. Any discomfort due which sprint can be affected

MATERIALS USED

- Barbell & Plates
- Weighted Jacket
- iPhone / iPad
- My Sprint Application
- Stopwatch
- Tripod
- 6 × Cones & 6 × Sticks

OUTCOME MEASURES

Dependent Variables:

A. FVP Variables:

- HZT-F0 (N/kg)
- HZT-V0 (m/s) (m/s)
- HZT-Pmax (W/kg)

B. Sprint Performance

- **100m sprint time (seconds)**

Independent Variables:

A. Dynamic Resistance PAPE CA

B. **Plyometric PAPE CA**

MY SPRINT APPLICATION

The **MySprint application** was used to analyze sprint mechanics and derive the force–velocity–power (FVP) profile from high-speed video recordings of maximal sprint efforts. The app works by registering the time-stamps corresponding to the initiation of the sprint and the athlete's passage across a series of distance markers. In this study, sprints were filmed using an iPhone 6 fixed on a tripod in the frontal plane, placed at the 20 m mark and approximately 8 m from the track, which allowed for full capture of the 40 m sprint.

To correct for video parallax, the six distance markers (5, 10, 15, 20, 30, and 40 m) [47] were placed at slightly adjusted positions, ensuring that the athletes pelvis was brought into alignment with the distance markers when they reached the exact target distances. Two independent observers reviewed each video and identified the initial frame showing the athlete's right thumb lifting off the ground (defining sprint initiation), followed by the frame where the pelvis came into alignment with each marker. These events were then entered into the MySprint application.

The app automatically calculated split times in milliseconds and, by applying the validated mechanical model proposed by **Samozino et al. (2015)**, generated sprint mechanical outputs including horizontal force, velocity, and maximal power. This methodology has been shown to be a reliable and accessible alternative to force plates and radar systems for field-based sprint analysis, while maintaining scientific validity.

FIGURE 1: PROCEDURE OF USING MY SPRINT APPLICATION

PHOTO FINISH APP

The **Photo Finish application** was used to obtain 100 m sprint times in elite-level sprinters. The app operates through motion-detection zones, which automatically identify when an athlete's torso crosses the finish line, displaying sprint speed and time instantaneously.

For this study, participants completed maximal sprints on a standard 400 m outdoor track, starting from a designated line after an auditory cue. Smartphones running the app were mounted on tripods at different heights (1.0–2.0 m) and distances (1.5–2.5 m) from the finish line, aligned in the sagittal plane to ensure accurate torso capture as athletes crossed the line. This arrangement minimized parallax error and allowed for consistent recording regardless of variations in body size or running style.

The system automatically generated sprint times, which were then saved for analysis. To strengthen measurement accuracy, multiple devices recorded simultaneously, permitting assessment of inter-device agreement. Reliability indices reported for this tool include high **intraclass correlation coefficients (ICC > 0.90)**, low **standard error of measurement (SEM)**, and acceptable **minimal detectable change (MDC)** values, supporting its use as a valid and reliable field-based timing system [48].

METHODOLOGY FLOWCHART

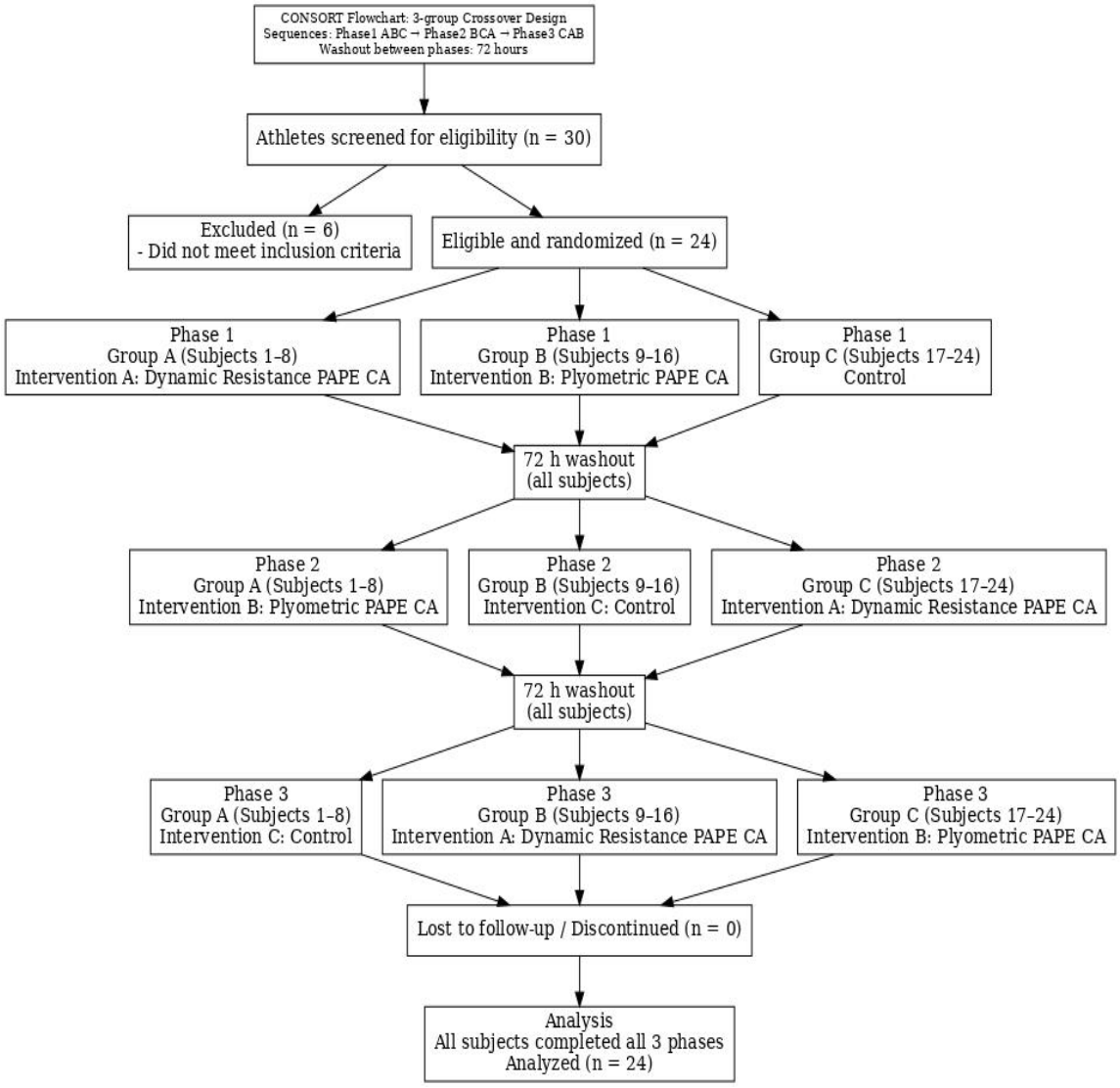


FIGURE 2 : METHODOLOGY FLOWCHART

PROCEDURE

Approval from the IEC of Abhinav Bindra Sports Medicine and Research Institute (Annexure –3) was obtained.

Phase 1

Between May 2025 and June 2025, permission was taken from the head coach, Athletics Project Odisha DSYS; Odisha, Kalinga Stadium for the recruitment of subjects (i.e., professional sprinters).

Phase 2

A total of 30 subjects were accessed out of which 24 subjects were taken as a sample and were randomized and blocked and grouped into 3 groups.

Informed consent was taken (Annexure 1).

Phase 3

Each participant underwent testing across three separate days, with at least 72 hours between sessions to ensure adequate recovery.

Before every session, a pre-test checklist verified the following:

- No engagement in maximal resistance exercise during the preceding 24 hours,
- No heavy meal consumed within 2 hours,
- No caffeine or pre-workout intake within 12 hours, and
- Participant confirmation of sufficient recovery.

During each testing session, participants performed a standardized warm-up (Table 2), after which baseline measures of countermovement jump (CMJ) and a 20 m sprint were recorded. Following this, they undertook one of the three PAP protocols or a control condition.

Day 1 involved participant reporting for baseline measurements of height, weight, one-repetition maximum (1RM) back squat testing, and familiarization with the PAPE conditioning activity (CA).

Baseline data was recorded for individual participants in the format attached in (Annexure 2).

DAY 02, 03, 04, 05 (Testing Days):

Across the remaining three testing days, participants completed— in randomized sequence— one of three PAP protocols (dynamic resistance, plyometric, isometric) or a control session

They began with a standardized warm-up (Table 2), followed by baseline testing of the 100 m sprint.

A window period 4-8 minutes after the assigned stimulus of squat and similarly 8 Min after plyometric and 4 min after walk stimulus Participants were then instructed to complete a 100 m sprint at maximal effort, adhering to the same procedure as during baseline testing.[31].

EXERCISE	SETS/REPS
400m Jog	1×400m
Walking Knee Hugs w/Twist	2×5 each
Walking Toe Touches	2×5 each
Static Calf Stretch	2×20s each
Forward Lunges	2×5 each
Walking Quad Pulls	2×5 each
Glute Bridge	2×10
Body Weight Squat	1×10

TABLE NO 2: STANDARDIZED WARMUP ROUTINE PERFORMED BEFORE EACH TRIAl[31]

PAPE STIMULUS	EXERCISE	INTENSITY	REPS/ DURATION	SETS	REST
DYNAMIC RESISTANCE	BACK SQUAT	87% 1RM	5 REPS	3	3 MIN
PLYOMETRIC	WEIGHTED JUMP	MAX VOLUNTARY +10% BODY WEIGHT	5 REPS	3	3 MIN
CONTROL	WALK	N/A	4 MIN	1	N/A

TABLE 3: POST ACTIVATION PERFORMANCE ENHANCEMENT CA PROTOCOL [31]

FIGURE 3: DYNAMIC RESISTANCE PAPE CA

FIGURE 4: PLYOMETRIC PAPE CA

STATISTICAL ANALYSIS

All variables were first tested for normality using the Shapiro–Wilk test. The demographic variables met the normality assumption (Shapiro–Wilk $p > 0.05$) and are therefore presented as mean ± standard deviation. Outcome measures were examined for distributional assumptions prior to inferential testing. Where normality and sphericity assumptions were satisfied, comparisons across the three experimental conditions were performed using repeated-measures ANOVA; Pairwise post-hoc comparisons were adjusted using the Bonferroni method. All analyses were carried out in IBM SPSS Statistics version 26.0 (Windows 11). Descriptive statistics were calculated by the primary investigator to summarize baseline characteristics. Statistical significance was set at $p < 0.05$.

RESULTS

This investigation followed a randomized crossover clinical trial design and included 24 professional sprinters.Recruitment was carried out using purposive sampling, ensuring that only individuals meeting the predefined inclusion criteria participated. Each participant was exposed to the intervention and control conditions in a crossover manner, with two structured washout periods incorporated to minimize carryover effects between phases.

DEMOGRAPHIC CHARACTERISTICS

A total of 24 participants were recruited for the present study, comprising 18 males and 6 females (Graph 4) .All the participants were professional sprinters who met the eligibility criteria and consented to take part in the trial. had homogeneous age group (Graph 1), height and weight were checked prior to the study to check the baseline of the data (Table 4)

The Shapiro–Wilk test results indicated that all demographic variables showed p-values greater than 0.05, confirming that the data were normally distributed. The detailed demographic parameters are presented in Table 4..

TABLE 4: DEMOGRAPHIC CHARACTERISTICS OF PARTICIPANTS OF THE STUDY POPULATION FOR (N=24). (SHAPIRO-WILK TEST)

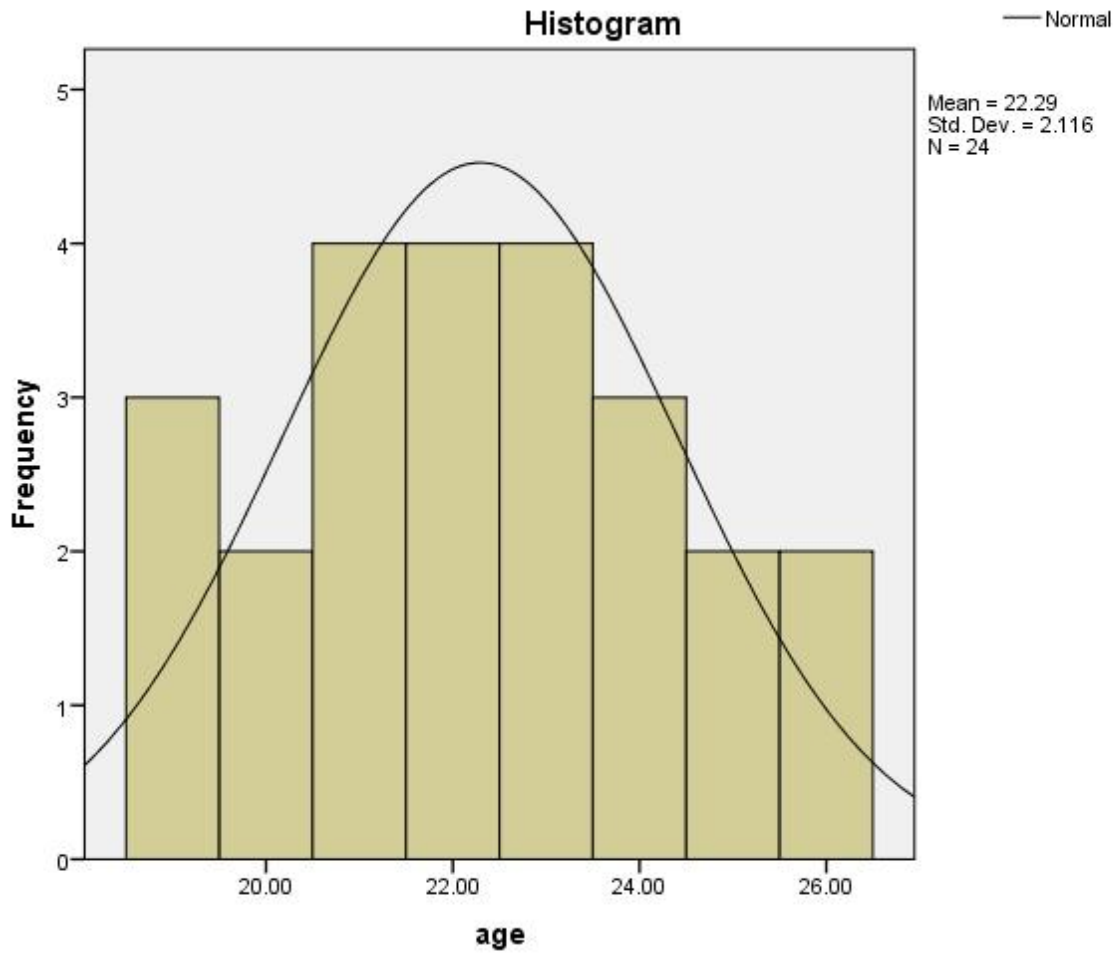
SL. No.	Demographic Details	Mean	SD	p-value
1.	Age (year)	22.2917	2.11576	.337
2.	Height (cm)	1.7042	.07107	.479
3.	Weight (kg)	68.0833	10.28260	.477

Abbreviation:SD: Standard Deviation

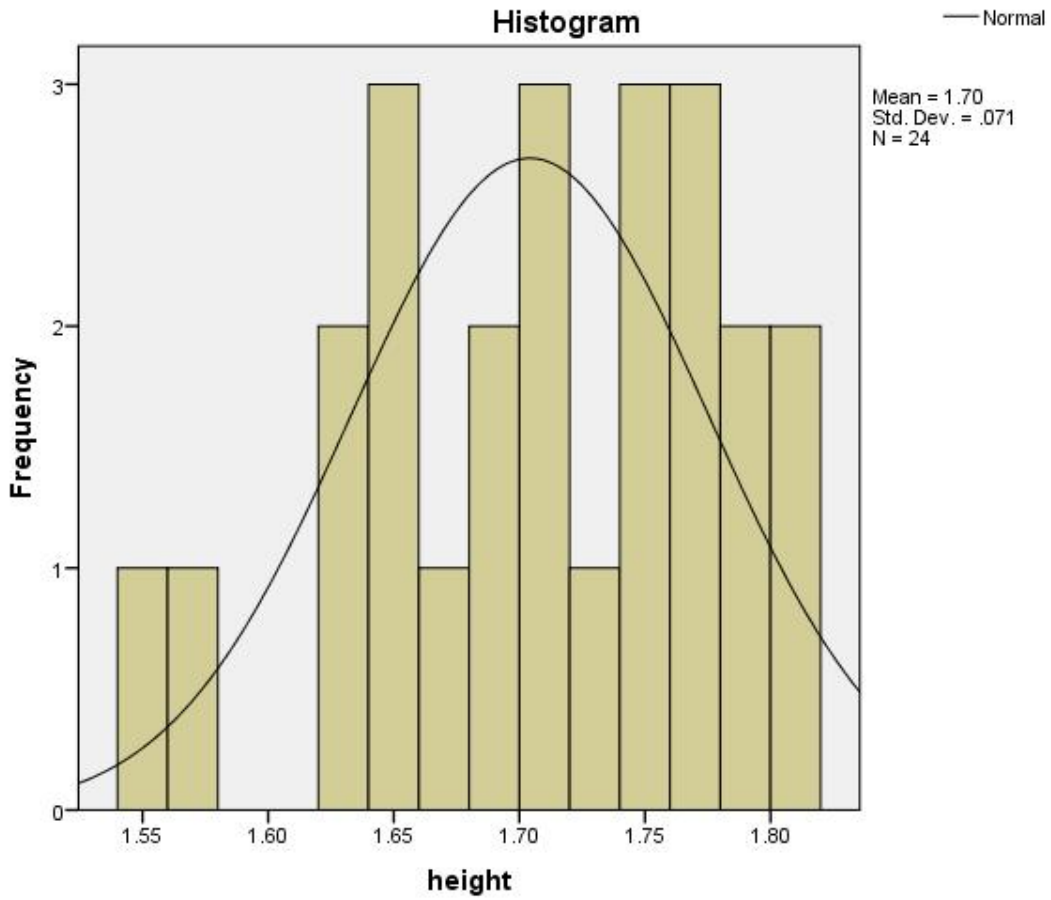
*p value > 0.05 indicates normal distribution of the data.

INTERPRETATION:

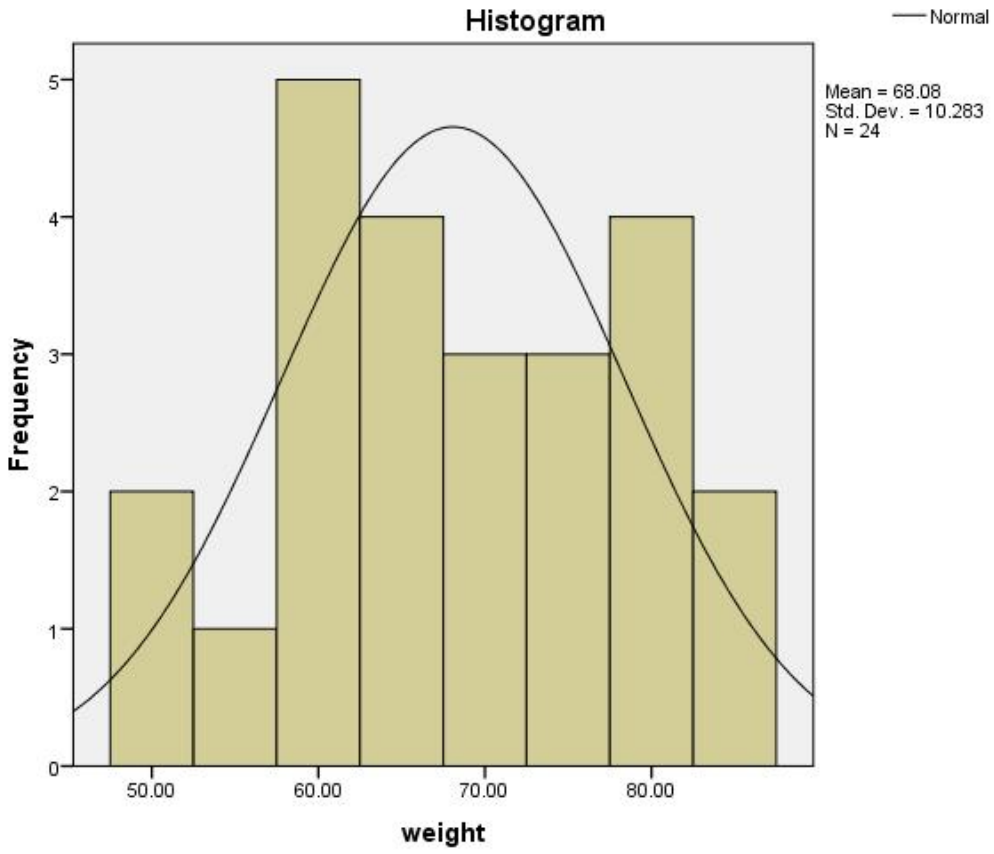
This table presents the demographic characteristics (age, height, and weight) of the study participants (n=24). The Shapiro-Wilk test results indicate that all variables (age, height, and weight) have p-values greater than 0.05, suggesting that the data for each parameter are normally distributed.



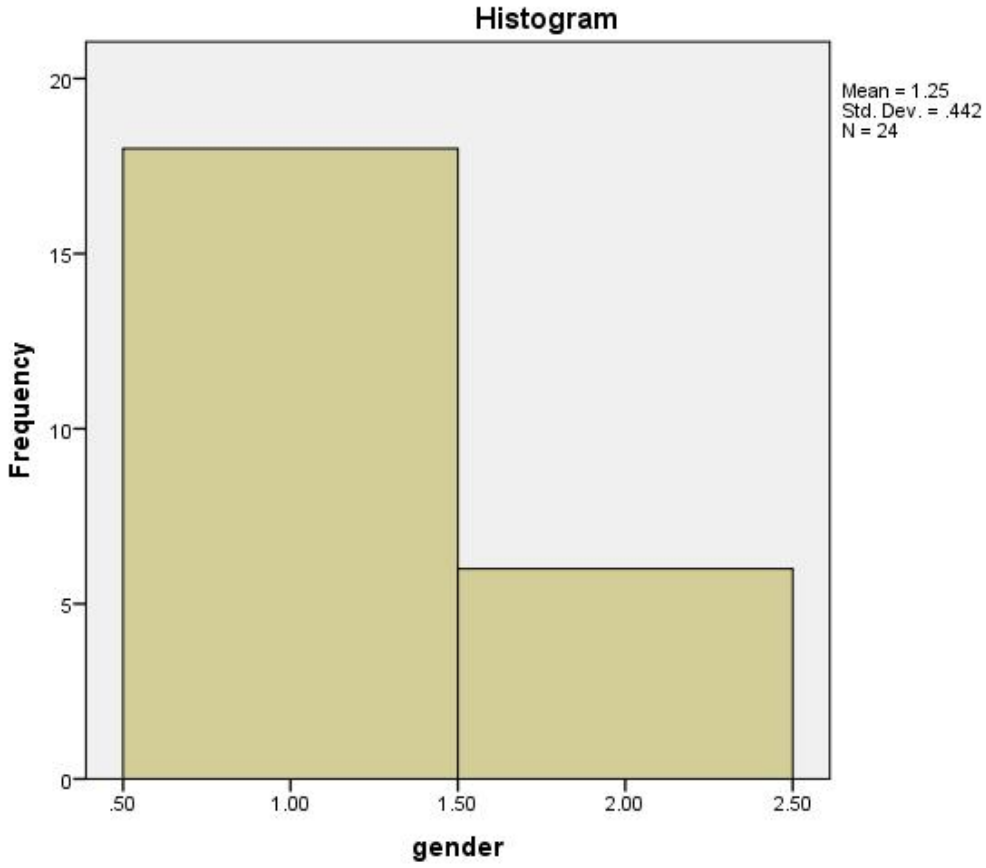
GRAPH 1: HISTOGRAM FOR DEMOGRAPHIC DATA: AGE



GRAPH 2: HISTOGRAM FOR DEMOGRAPHIC DATA: HEIGHT



GRAPH 3: HISTOGRAM FOR DEMOGRAPHIC DATA: WEIGHT



GRAPH 4: HISTOGRAM FOR DEMOGRAPHIC DATA: GENDER DISTRIBUTION

OUTCOME MEASURES

SPRINT TIME (Seconds)

Sprint performance for the above study was measured in terms of 100m sprint time.

It was measured prior to phase 1 i.e. at the time of baseline data measurement in 3 different group (Table 5) After intervention again the sprint time was taken (Table 6).

after the washout period of 72 hours again for phase 2 Sprint time was taken Pre (Table 11) Post (Table 12) and similarly 72 hours of washout period was given for phase 3 , where the sprint time was taken for Pre (Table 17) and Post (Table 18).

To statistically check the within group difference we seperately analyze the changes in Sprint time in Control, Exp 1, Exp 2, during the three different phases respectively.

The data for this is presented in table 24, further we checked for post hoc analysis of sprint time to compare all the three groups , the data is presented in table 25

HZT-F0 (N/kg)

Horizontal force output for the present study was measured in terms of HZT-F0 (N/kg). It was recorded prior to phase 1 i.e., at the time of baseline data measurement in the three different groups (Table 5). After the intervention, HZT-F0 was again assessed (Table 6). Following a washout period of 72 hours, data collection for phase 2 was carried out, where HZT-F0 was measured Pre (Table 11) and Post (Table 12). Similarly, after another 72-hour washout period for phase 3, HZT-F0 was taken Pre (Table 17) and Post (Table 18).

To statistically evaluate the within-group differences, we separately analyzed the changes in HZT-F0 for Control, Exp 1, and Exp 2 during the three phases, respectively. The data for this is presented in Table 27. Furthermore, post hoc analysis was performed to compare HZT-F0 across all three groups, groups, with the findings summarized in (Table 28)

HZT-V0 (m/s)

Maximum sprint velocity for the present study was measured in terms of HZT-V0 (m/s). It was recorded prior to phase 1 i.e., at the time of baseline data measurement in the three different groups (Table 5). After the intervention, HZT-V0 was again assessed (Table 6). Following a washout period of 72 hours, data collection for phase 2 was carried out, where HZT-V0 was measured Pre (Table 11) and Post (Table 12). Similarly, after another 72-hour washout period for phase 3, HZT-V0 was taken Pre (Table 17) and Post (Table 18).To statistically evaluate the within-group differences, we separately analyzed the changes in HZT-V0 for Control, Exp 1, and Exp 2 during the three phases, respectively. The data for this is presented in Table 30. Furthermore, post hoc analysis was performed to compare HZT-V0 across all three groups, and the results are presented in Table 31.

HZT-Pmax (W/kg)

Peak power output for the present study was measured in terms of HZT-Pmax (W/kg). It was recorded prior to phase 1 i.e., at the time of baseline data measurement in the three different groups (Table 5). After the intervention, HZT-Pmax was again assessed (Table 6). Following a washout period of 72 hours, data collection for phase 2 was carried out,

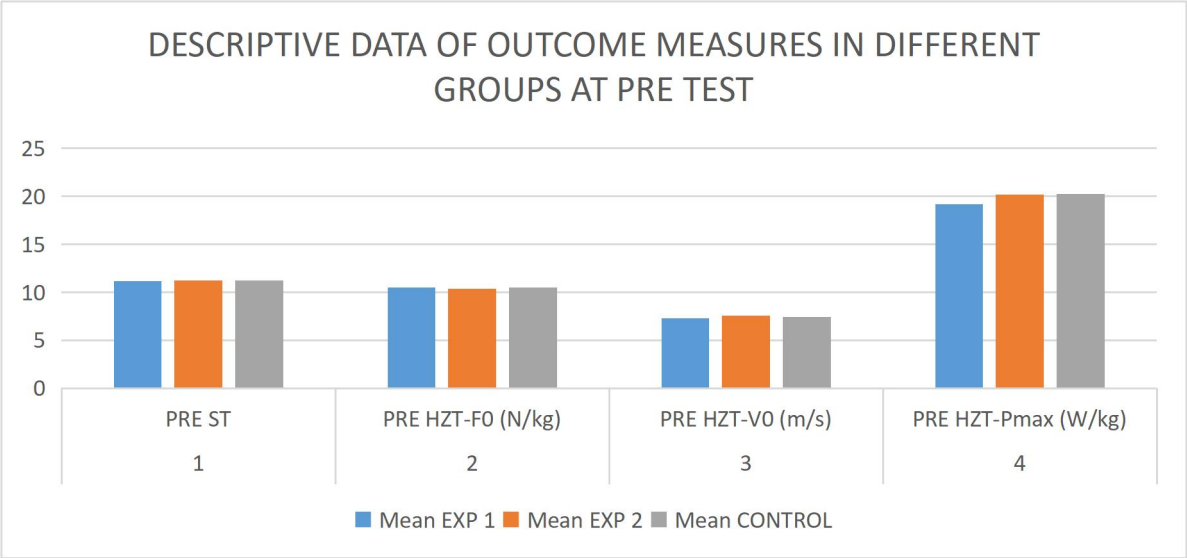
where HZT-Pmax was measured Pre (Table 11) and Post (Table 12). Similarly, after another 72-hour washout period for phase 3, HZT-Pmax was taken Pre (Table 17) and Post (Table 18).To statistically evaluate the within-group differences, we separately analyzed the changes in HZT-Pmax for Control, Exp 1, and Exp 2 during the three phases, respectively. The data for this is presented in Table 33. Furthermore, post hoc analysis was performed to compare HZT-Pmax across all three groups, and the corresponding results are displayed in Table 34.

TABLE 5: DESCRIPTIVE DATA OF OUTCOME MEASURES IN DIFFERENT GROUPS AT PRE TEST

SR NO	OUTCOME MEASURES	Mean			STD DEV			P VALUE
		EXP 1	EXP 2	CONTROL	EXP 1	EXP 2	CONTROL	
1	PRE ST (s)	11.1850	11.2575	11.2463	.52625	.43147	.48899	0.949
2	PRE HZT-F0 (N/kg)	10.5075	10.4048	10.4934	1.12963	1.12318	1.12541	0.981
3	PRE HZT-V0 (m/s)	7.3269	7.5865	7.4479	.95686	.99523	1.09269	0.878
4	PRE HZT-Pmax (W/kg)	19.1554	20.1838	20.2241	2.47604	2.43376	2.63844	0.636

INTERPRETATION:

The table presents the pre-test outcome measures of Phase 1 across three groups (EXP 1, EXP 2, and Control) for sprint time, HZT-F0 (N/kg), HZT-V0 (m/s), and HZT-Pmax (W/kg). The mean values and standard deviations are comparable among the three groups. Importantly, the p-values for all outcome measures (Sprint Time = 0.949, HZT-F0 = 0.981, HZT-V0 = 0.878, and HZT-Pmax = 0.636) are greater than 0.05, indicating no statistically significant differences between the groups at baseline. This indicates that the groups were homogeneous prior to the intervention, ensuring comparability for subsequent testing phases.



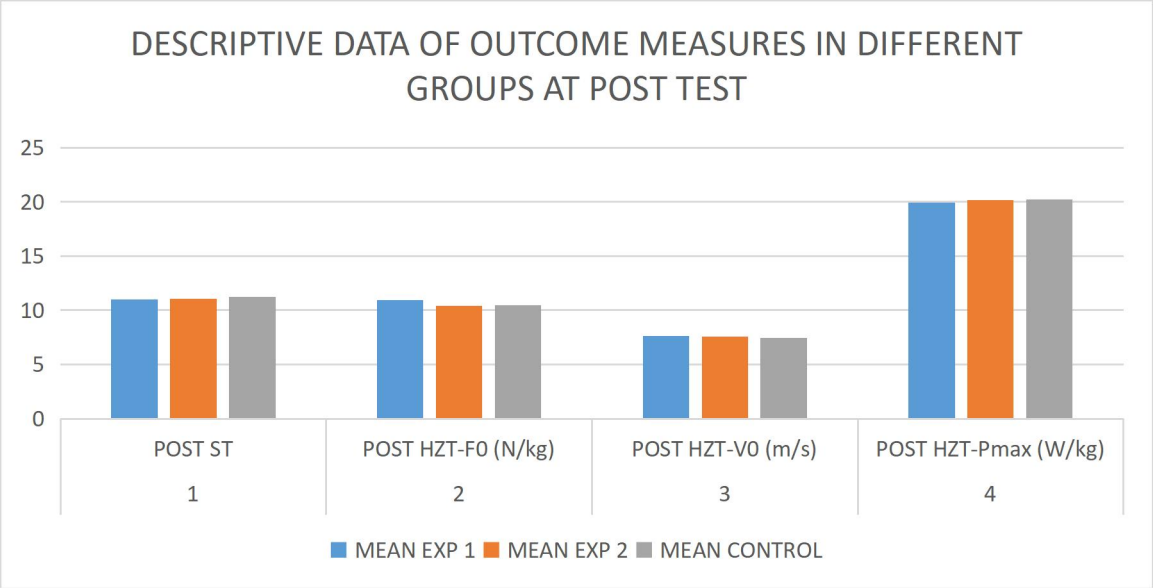
GRAPH 5: DESCRIPTIVE DATA OF OUTCOME MEASURES IN DIFFERENT GROUPS AT PRE TEST

TABLE 6: DESCRIPTIVE DATA OF OUTCOME MEASURES IN DIFFERENT GROUPS AT POST TEST

SR NO	OUTCOME MEASURES	MEAN			STD DEV			P VALUE
		EXP 1	EXP 2	CONTROL	EXP 1	EXP 2	CONTROL	
1	POST ST (s)	10.9737	11.0538	11.2463	.45651	.39206	.52506	.021
2	POST HZT-F0 (N/kg)	10.9253	10.4038	10.4938	1.17622	1.10354	1.12032	.317
3	POST HZT-V0 (m/s)	7.6188	7.5863	7.4475	.99099	.97657	1.08622	.403
4	POST HZT-Pmax (W/kg)	19.9225	20.1844	20.2244	2.57611	2.41628	2.63813	.418

INTERPRETATION:

The table summarizes the post-test outcome measures of Phase 1 across three groups (EXP 1, EXP 2, and Control). For sprint time, a significant difference was observed between the groups ($p = 0.021$), indicating that the intervention produced measurable improvements in sprinting performance. In contrast, no significant differences were found between groups for HZT-F0 ($p = 0.317$), HZT-V0 ($p = 0.403$), and HZT-Pmax ($p = 0.418$), suggesting that these mechanical parameters did not change significantly after the intervention. Overall, the results highlight that while sprint time improved significantly, other force–velocity related measures remained statistically similar across groups in the post-test of Phase 1.



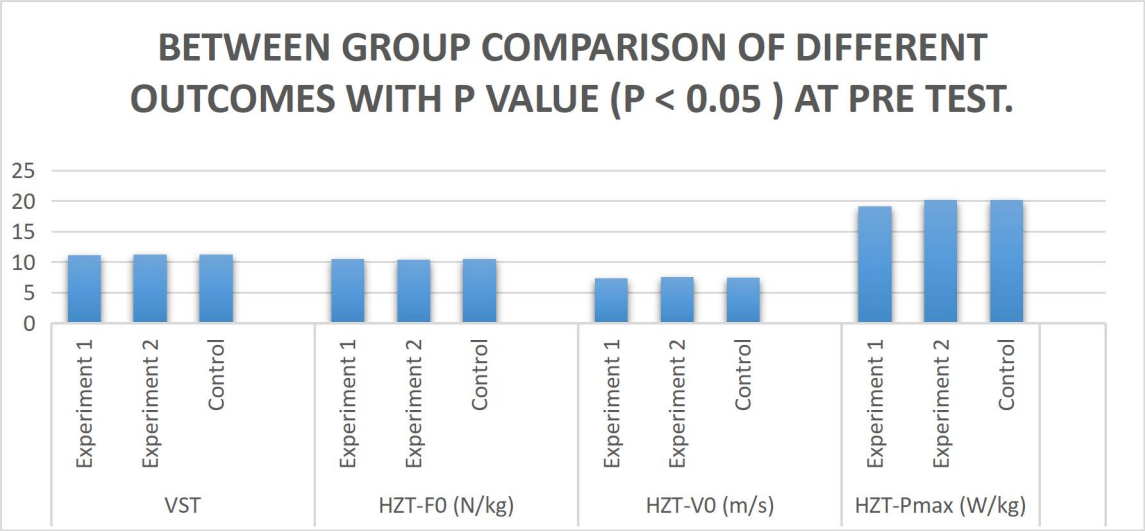
GRAPH 6: DESCRIPTIVE DATA OF OUTCOME MEASURES IN DIFFERENT GROUPS AT POST TEST

TABLE 7 : BETWEEN GROUP COMPARISON OF DIFFERENT OUTCOMES WITH P VALUE (P < 0.05) AT PRE TEST.

		N	Mean	Std. Deviation	95% Confidence Interval for Mean		P VALUE
					Lower Bound	Upper Bound	
ST(s)	Experiment 1	8	11.1850	.52625	10.7450	11.6250	0.949
	Experiment 2	8	11.2575	.43147	10.8968	11.6182	
	Control	8	11.2463	.48899	10.8374	11.6551	
	Total	24	11.2296	.46344	11.0339	11.4253	
HZT-F0 (N/kg)	Experiment 1	8	10.5075	1.12963	9.5631	11.4519	0.981
	Experiment 2	8	10.4048	1.12318	9.4657	11.3438	
	Control	8	10.4934	1.12541	9.5525	11.4342	
	Total	24	10.4685	1.07700	10.0138	10.9233	
HZT-V0 (m/s)	Experiment 1	8	7.3269	.95686	6.5269	8.1268	0.878
	Experiment 2	8	7.5865	.99523	6.7545	8.4185	
	Control	8	7.4479	1.09269	6.5344	8.3614	
	Total	24	7.4537	.97736	7.0410	7.8665	
HZT-Pmax (W/kg)	Experiment 1	8	19.1554	2.47604	17.0854	21.2254	0.636
	Experiment 2	8	20.1838	2.43376	18.1491	22.2184	
	Control	8	20.2241	2.63844	18.0183	22.4299	
	Total	24	19.8544	2.45815	18.8164	20.8924	

INTERPRETATION:

The between-group analysis of pre-test outcomes demonstrates that there were no statistically significant differences among Experiment 1, Experiment 2, and Control groups for any of the measured variables. Specifically, sprint time ($p = 0.949$), HZT-F0 ($p = 0.981$), HZT-V0 ($p = 0.878$), and HZT-Pmax ($p = 0.636$) all showed p-values greater than 0.05, indicating homogeneity across groups at baseline. This suggests that prior to the intervention, all groups were comparable in terms of sprint performance and mechanical output variables, thereby establishing a balanced starting point for evaluating the effects of the experimental protocols.



GRAPH 7: BETWEEN GROUP COMPARISON OF DIFFERENT OUTCOMES WITH P VALUE (P < 0.05) AT PRE TEST.

TABLE 8: BETWEEN GROUP COMPARISON POST HOC OF DIFFERENT OUTCOMES WITH P VALUE (P < 0.05 . AT PRE TEST.

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
ST	Experiment 1	Experiment 2	-.07250	1.000	-.7018	.5568
		Control	-.06125	1.000	-.6905	.5680
	Experiment 2	Experiment 1	.07250	1.000	-.5568	.7018
		Control	.01125	1.000	-.6180	.6405
	Control	Experiment 1	.06125	1.000	-.5680	.6905
		Experiment 2	-.01125	1.000	-.6405	.6180
HZT-F0 (N/kg)	Experiment 1	Experiment 2	.10275	1.000	-1.3619	1.5674
		Control	.01412	1.000	-1.4505	1.4788
	Experiment 2	Experiment 1	-.10275	1.000	-1.5674	1.3619
		Control	-.08862	1.000	-1.5533	1.3760
	Control	Experiment 1	-.01412	1.000	-1.4788	1.4505
		Experiment 2	.08862	1.000	-1.3760	1.5533
HZT-V0 (m/s)	Experiment 1	Experiment 2	-.25962	1.000	-1.5818	1.0626
		Control	-.12100	1.000	-1.4432	1.2012
	Experiment 2	Experiment 1	.25962	1.000	-1.0626	1.5818
		Control	.13862	1.000	-1.1836	1.4608
	Control	Experiment 1	.12100	1.000	-1.2012	1.4432
		Experiment 2	-.13862	1.000	-1.4608	1.1836
HZT-Pmax (W/kg)	Experiment 1	Experiment 2	-1.02838	1.000	-4.3030	2.2462
		Control	-1.06875	1.000	-4.3434	2.2059
	Experiment 2	Experiment 1	1.02838	1.000	-2.2462	4.3030
		Control	-.04038	1.000	-3.3150	3.2342
	Control	Experiment 1	1.06875	1.000	-2.2059	4.3434
		Experiment 2	.04038	1.000	-3.2342	3.3150

INTERPRETATION:

The Bonferroni post hoc multiple comparison test was conducted to examine pairwise differences between groups (Experiment 1, Experiment 2, and Control) for the pre-test outcomes. The results show that none of the outcome variables—**VST, HZT-F0 (N/kg), HZT-V0 (m/s), or HZT-Pmax (W/kg)**—demonstrated statistically significant differences between any pair of groups (all p-values = 1.000). Furthermore, the 95% confidence intervals for mean differences include zero across all comparisons, reinforcing the absence of meaningful differences.

These findings confirm that all three groups were statistically equivalent at baseline in terms of sprint time and mechanical force–velocity characteristics, ensuring that subsequent comparisons during intervention phases are not influenced by pre-existing group disparities.

TABLE 9: BETWEEN GROUP COMPARISON OF DIFFERENT OUTCOMES WITH P VALUE (P < 0.05) AT POST TEST.

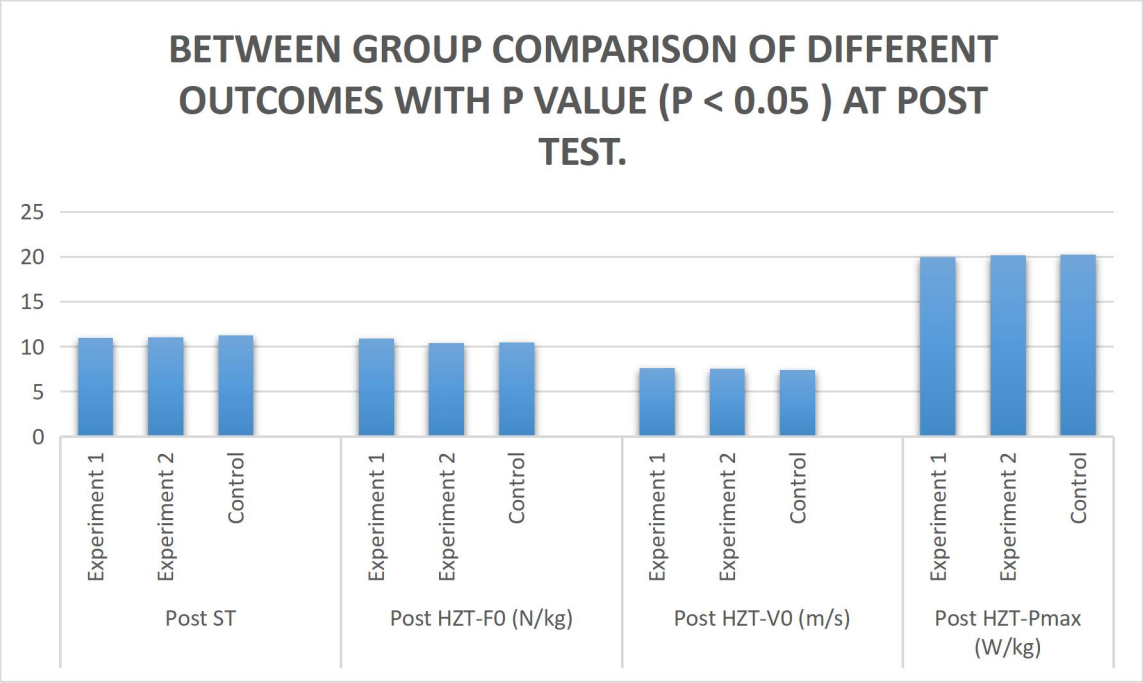
		N	Mean	Std. Deviation	95% Confidence Interval for Mean		significance
					Lower Bound	Upper Bound	
PostST	Experiment 1	8	10.9737	.45651	10.5921	11.3554	.490
	Experiment 2	8	11.0538	.39206	10.7260	11.3815	
	Control	8	11.2463	.52506	10.8073	11.6852	
	Total	24	11.0913	.45581	10.8988	11.2837	
Post HZT-F0 (N/kg)	Experiment 1	8	10.9253	1.17622	9.9419	11.9086	.623
	Experiment 2	8	10.4038	1.10354	9.4812	11.3263	
	Control	8	10.4938	1.12032	9.5571	11.4304	
	Total	24	10.6076	1.10804	10.1397	11.0755	
Post-HZT-V0 (m/s)	Experiment 1	8	7.6187	.99099	6.7903	8.4472	.938
	Experiment 2	8	7.5863	.97657	6.7698	8.4027	
	Control	8	7.4475	1.08622	6.5394	8.3556	
	Total	24	7.5508	.97672	7.1384	7.9633	
PostHZT-Pmax (W/kg)	Experiment 1	8	19.9225	2.57611	17.7688	22.0762	.967
	Experiment 2	8	20.1844	2.41628	18.1643	22.2044	
	Control	8	20.2244	2.63813	18.0188	22.4299	
	Total	24	20.1104	2.43589	19.0818	21.1390	

INTERPRETATION:

Across all outcome measures (sprint time [ST], F0, V0, Pmax), no significant between-group differences were found post-intervention (all $p > 0.05$).

The confidence intervals overlap heavily, further confirming statistical similarity among experiment 1, experiment 2, and control.

This suggests that the training/intervention did not produce significantly different effects between the groups.



GRAPH 8: BETWEEN GROUP COMPARISON OF DIFFERENT OUTCOMES WITH P VALUE (P < 0.05) AT POSTTEST.

TABLE 10: BETWEEN GROUP COMPARISON POST HOC OF DIFFERENT OUTCOMES WITH P VALUE (P < 0.05) AT POST TEST.

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Post ST	Experiment 1	Experiment 2	-.08000	1.000	-.6797	.5197
		Control	-.27250	.751	-.8722	.3272
	Experiment 2	Experiment 1	.08000	1.000	-.5197	.6797
		Control	-.19250	1.000	-.7922	.4072
	Control	Experiment 1	.27250	.751	-.3272	.8722
		Experiment 2	.19250	1.000	-.4072	.7922
Post HZT-F0 (N/kg)	Experiment 1	Experiment 2	.52150	1.000	-.9532	1.9962
		Control	.43150	1.000	-1.0432	1.9062
	Experiment 2	Experiment 1	-.52150	1.000	-1.9962	.9532
		Control	-.09000	1.000	-1.5647	1.3847
	Control	Experiment 1	-.43150	1.000	-1.9062	1.0432
		Experiment 2	.09000	1.000	-1.3847	1.5647
Post HZT-V0 (m/s)	Experiment 1	Experiment 2	.03250	1.000	-1.2930	1.3580
		Control	.17125	1.000	-1.1543	1.4968
	Experiment 2	Experiment 1	-.03250	1.000	-1.3580	1.2930
		Control	.13875	1.000	-1.1868	1.4643
	Control	Experiment 1	-.17125	1.000	-1.4968	1.1543
		Experiment 2	-.13875	1.000	-1.4643	1.1868
Post HZT-Pmax (W/kg)	Experiment 1	Experiment 2	-.26187	1.000	-3.5724	3.0486
		Control	-.30187	1.000	-3.6124	3.0086
	Experiment 2	Experiment 1	.26187	1.000	-3.0486	3.5724
		Control	-.04000	1.000	-3.3505	3.2705
	Control	Experiment 1	.30187	1.000	-3.0086	3.6124
		Experiment 2	.04000	1.000	-3.2705	3.3505

INTERPRETATION:

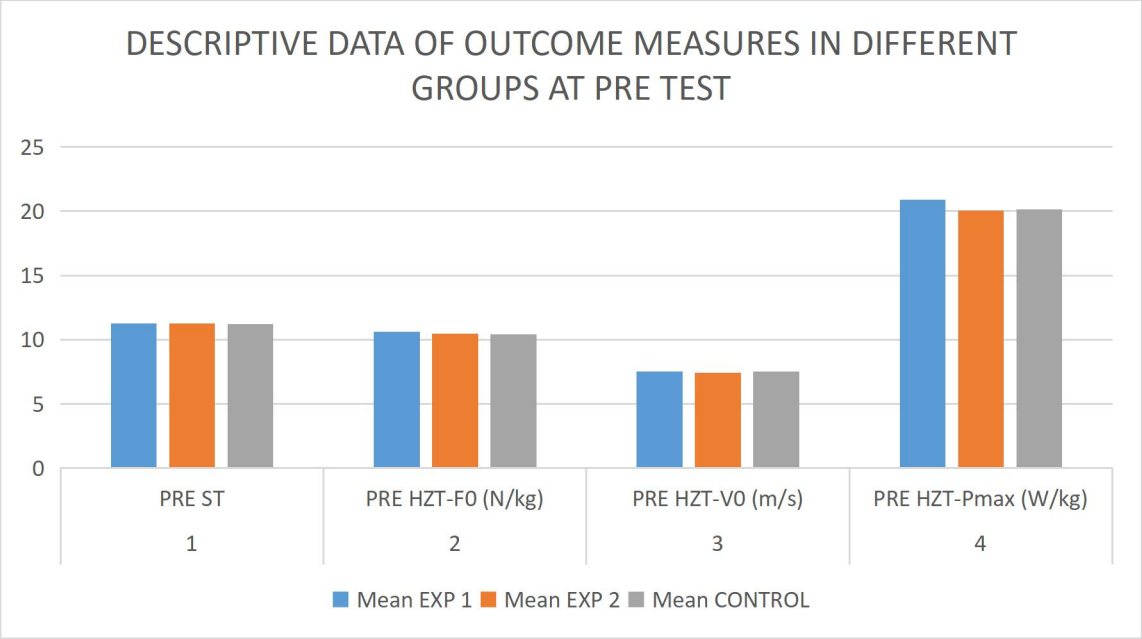
Following the intervention, the analysis revealed no statistically significant differences among the groups for any of the measured outcomes. Sprint time (PostST) showed comparable results across all three groups ($p > 0.05$), indicating that the intervention did not lead to differential changes in sprint performance. Similarly, horizontal force output (Post-HZT-F0) demonstrated no significant group differences, with values remaining closely aligned and confidence intervals overlapping. Maximum sprint velocity (Post-HZT-V0) was also nearly identical between the groups, suggesting uniformity in velocity outcomes. Finally, peak power output (Post-HZT-Pmax) showed very small, non-significant differences, confirming that power generation capacity remained consistent across groups.

TABLE 11: DESCRIPTIVE DATA OF OUTCOME MEASURES IN DIFFERENT GROUPS AT PRE TEST

SR NO	OUTCOME MEASURES	Mean			STD DEV			P VALUE
		EXP 1	EXP 2	CONTROL	EXP 1	EXP 2	CONTROL	
1	PRE SPRINT TIME	11.2600	11.2438	11.2025	0.46605	0.47842	0.42341	0.056
2	PRE HZT-F0 (N/kg)	10.6016	10.4940	10.4239	1.15584	1.10272	1.16157	0.894
3	PRE HZT-V0 (m/s)	7.5299	7.4403	7.5211	1.11550	1.04233	1.00301	0.641
4	PRE HZT-Pmax (W/kg)	20.9075	20.0690	20.1656	2.48590	2.44003	2.42364	0.669

INTERPRETATION:

The pre-test outcomes of Phase 2 indicate that there were no statistically significant differences among groups across all measured variables: Sprint Time ($p = 0.056$), HZT-F0 ($p = 0.894$), HZT-V0 ($p = 0.641$), and HZT-Pmax ($p = 0.669$). Since all p-values are greater than 0.05, this suggests that at baseline the groups were comparable in terms of sprint performance, force, velocity, and power measures. Therefore, any changes observed in the post-test phase can be more confidently attributed to the intervention rather than pre-existing group differences.



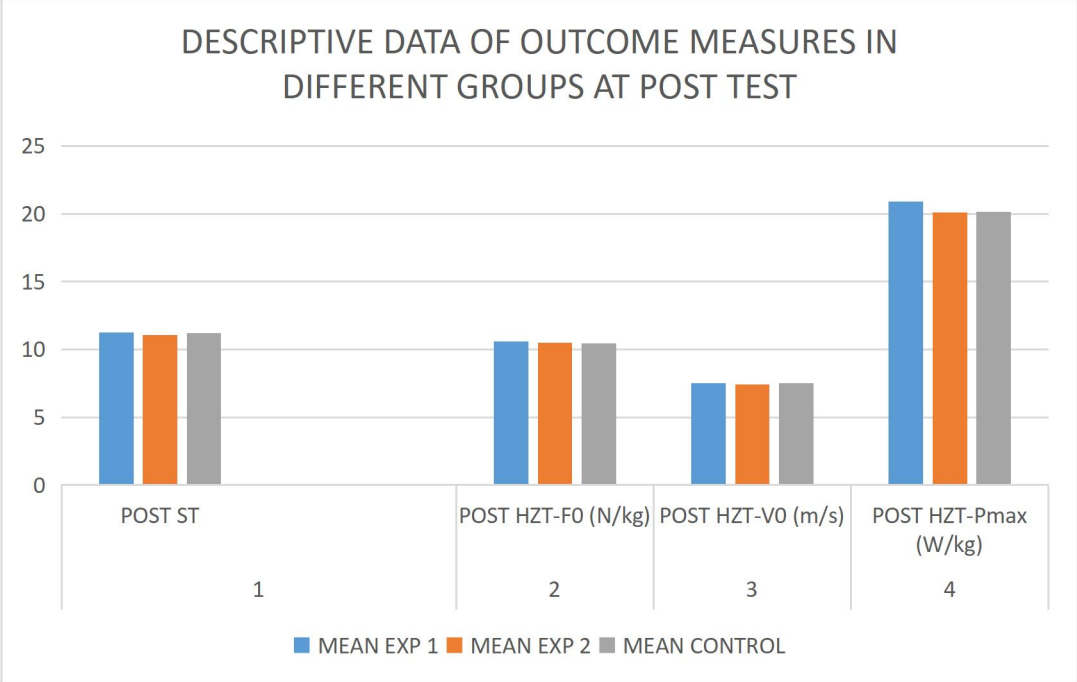
GRAPH 9: DESCRIPTIVE DATA OF OUTCOME MEASURES IN DIFFERENT GROUPS AT PRE TEST

TABLE 12:DESCRIPTIVE DATA OF OUTCOME MEASURES IN DIFFERENT GROUPS AT POST TEST

SR NO	OUTCOME MEASURES	MEAN			STD DEV			P VALUE
		EXP 1	EXP 2	CONTROL	EXP 1	EXP 2	CONTROL	
1	POST ST (s)	11.2613	11.0813	11.2063	.49554	.46988	.46291	.051
2	POST HZT-F0 (N/kg)	10.6019	10.4944	10.4238	1.17683	1.12059	1.13840	.885
3	POST HZT-V0 (m/s)	7.5294	7.4325	7.5219	1.13681	1.04531	.97961	.601
4	POST HZT-Pmax (W/kg)	20.9075	20.0769	20.1644	2.50540	2.44589	2.40559	.697

INTERPRETATION:

The post-test results of Phase 2 show that there were no statistically significant differences among groups for Sprint Time ($p = 0.051$), HZT-F0 ($p = 0.885$), HZT-V0 ($p = 0.601$), and HZT-Pmax ($p = 0.697$). Although Sprint Time approached significance ($p = 0.051$), it still did not cross the 0.05 threshold. Overall, this indicates that following the intervention, the three groups remained largely comparable in sprint performance, force, velocity, and power outcomes, with no clear evidence of differential improvements between them.



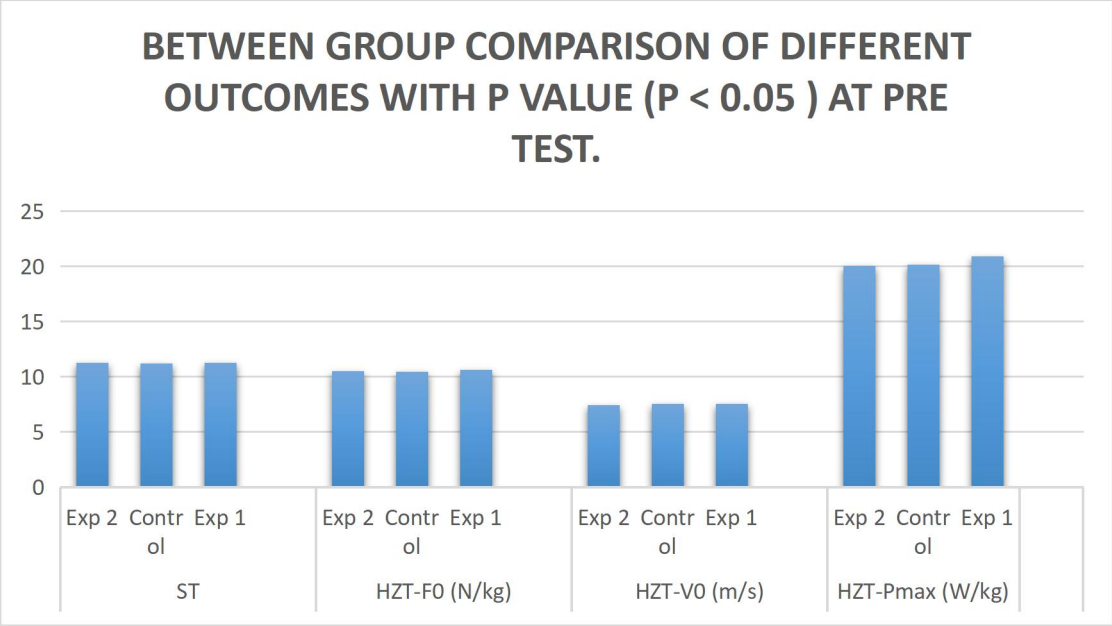
GRAPH 10: DESCRIPTIVE DATA OF OUTCOME MEASURES IN DIFFERENT GROUPS AT POST TEST

TABLE 13: BETWEEN GROUP COMPARISON OF DIFFERENT OUTCOMES WITH P VALUE (P < 0.05). AT PRE TEST.

		N	Mean	Std. Deviation	95% Confidence Interval for Mean		SIGNIFICANCE
					Lower Bound	Upper Bound	
ST (s)	Exp 2	8	11.2437	.47842	10.8438	11.6437	.915
	Control	8	11.2025	.42341	10.8485	11.5565	
	Exp 1	8	11.2600	.46605	10.8704	11.6496	
	Total	24	11.2354	.43697	11.0509	11.4199	
HZT-F0 (N/kg)	Exp 2	8	10.4940	1.10272	9.5721	11.4159	.962
	Control	8	10.4239	1.16157	9.4528	11.3950	
	Exp 1	8	10.6016	1.15584	9.6353	11.5679	
	Total	24	10.5065	1.09220	10.0453	10.9677	
HZT-V0 (m/s)	Exp 2	8	7.4402	1.04233	6.5688	8.3117	.916
	Control	8	7.5211	1.00301	6.6826	8.3597	
	Exp 1	8	7.5299	1.11550	6.5973	8.4625	
	Total	24	7.4971	1.00859	7.0712	7.9230	
HZT-Pmax (W/kg)	Exp 2	8	20.0690	2.44003	18.0291	22.1089	.998
	Control	8	20.1656	2.42364	18.1394	22.1918	
	Exp 1	8	20.9075	2.48590	18.8292	22.9858	
	Total	24	20.3807	2.37212	19.3791	21.3824	

INTEREPRETATION:

All baseline measures (Sprint Time, Force, Velocity, and Power) show no significant differences among groups (all $p > 0.9$). This indicates that the groups were well-matched at the start of the intervention, which is important for ensuring fair comparisons in later phases.



GRAPH 11: BETWEEN GROUP COMPARISON OF DIFFERENT OUTCOMES WITH P VALUE (P < 0.05) AT PRE TEST.

TABLE 14: BETWEEN GROUP COMPARISON POST HOC OF DIFFERENT OUTCOMES WITH P VALUE (P < 0.05). AT PRE TEST.

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
ST(s)	Exp 2	Control	.04125	1.000	-.5526	.6351
		Exp 1	-.01625	1.000	-.6101	.5776
	Control	Exp 2	-.04125	1.000	-.6351	.5526
		Exp 1	-.05750	1.000	-.6513	.5363
	Exp 1	Exp 2	.01625	1.000	-.5776	.6101
		Control	.05750	1.000	-.5363	.6513
HZT-F0 (N/kg)	Exp 2	Control	.07013	1.000	-1.4131	1.5533
		Exp 1	-.10763	1.000	-1.5908	1.3756
	Control	Exp 2	-.07013	1.000	-1.5533	1.4131
		Exp 1	-.17775	1.000	-1.6610	1.3055
	Exp 1	Exp 2	.10763	1.000	-1.3756	1.5908
		Control	.17775	1.000	-1.3055	1.6610
HZT-V0 (m/s)	Exp 2	Control	-.08087	1.000	-1.4526	1.2909
		Exp 1	-.08963	1.000	-1.4614	1.2821
	Control	Exp 2	.08087	1.000	-1.2909	1.4526
		Exp 1	-.00875	1.000	-1.3805	1.3630
	Exp 1	Exp 2	.08963	1.000	-1.2821	1.4614
		Control	.00875	1.000	-1.3630	1.3805
HZT-Pmax (W/kg)	Exp 2	Control	-.09662	1.000	-3.2833	3.0900
		Exp 1	-.83850	1.000	-4.0251	2.3481
	Control	Exp 2	.09662	1.000	-3.0900	3.2833
		Exp 1	-.74188	1.000	-3.9285	2.4448
	Exp 1	Exp 2	.83850	1.000	-2.3481	4.0251
		Control	.74188	1.000	-2.4448	3.9285

INTERPRETATION

Across all four pre-outcome measures (Sprint Time, Force, Velocity, and Power), no significant between-group differences were found (all $p = 1.000$).

This demonstrates that the groups were statistically comparable at baseline, ensuring a fair starting point for evaluating the effects of the intervention.

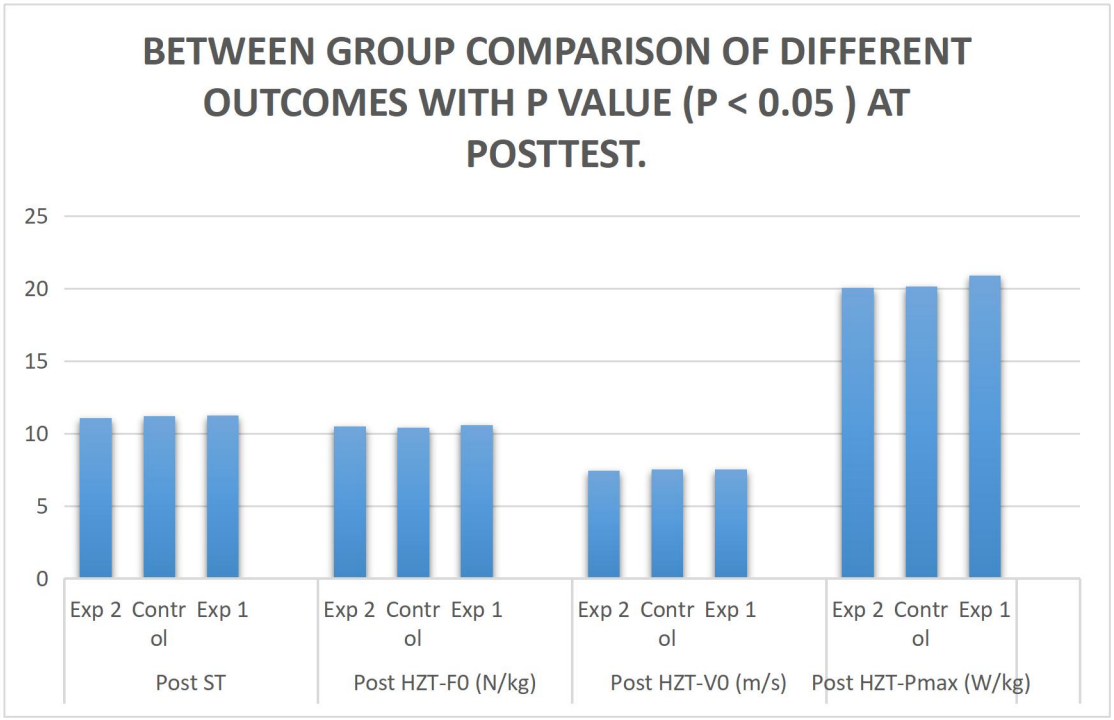
TABLE 15: BETWEEN GROUP COMPARISON OF DIFFERENT OUTCOMES WITH P VALE (P < 0.05). AT POSTTEST.

		N	Mean	Std. Deviation	95% Confidence Interval for Mean		SIGNIFICANCE
					Lower Bound	Upper Bound	
Post ST(s)	Exp 2	8	11.0812	.46988	10.6884	11.4741	.923
	Control	8	11.2063	.46291	10.8192	11.5933	
	Exp 1	8	11.2613	.49554	10.8470	11.6755	
	Total	24	11.1829	.46159	10.9880	11.3778	
Post HZT-F0 (N/kg)	Exp 2	8	10.4944	1.12059	9.5575	11.4312	.910
	Control	8	10.4237	1.13840	9.4720	11.3755	
	Exp 1	8	10.6019	1.17683	9.6180	11.5857	
	Total	24	10.5067	1.09713	10.0434	10.9699	
Post HZT-V0 (m/s)	Exp 2	8	7.4325	1.04531	6.5586	8.3064	.841
	Control	8	7.5219	.97961	6.7029	8.3409	
	Exp 1	8	7.5294	1.13681	6.5790	8.4798	
	Total	24	7.4946	1.00993	7.0681	7.9210	
Post HZT-Pmax (W/kg)	Exp 2	8	20.0769	2.44589	18.0321	22.1217	.996
	Control	8	20.1644	2.40559	18.1533	22.1755	
	Exp 1	8	20.9075	2.50540	18.8129	23.0021	
	Total	24	20.3829	2.37429	19.3803	21.3855	

INTERPRETATION:

Across all outcome measures (Sprint Time, Force, Velocity, and Power), no statistically significant differences were observed between Experiment 1, Experiment 2, and Control groups at the post-test stage (all $p > 0.84$).

This suggests that the interventions applied did not result in measurable group-level differences in performance or mechanical outputs after training.



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GRAPH 12: BETWEEN GROUP COMPARISON OF DIFFERENT OUTCOMES WITH P VALE (P < 0.05) AT POSTTEST.

TABLE 16:BETWEEN GROUP COMPARISON POST HOC OF DIFFERENT OUTCOMES WITH P VALE (P < 0.05). AT POST TEST.

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Post ST	Exp 2	Control	-.12500	1.000	-.7445	.4945
		Exp 1	-.18000	1.000	-.7995	.4395
	Control	Exp 2	.12500	1.000	-.4945	.7445
		Exp 1	-.05500	1.000	-.6745	.5645
	Exp 1	Exp 2	.18000	1.000	-.4395	.7995
		Control	.05500	1.000	-.5645	.6745
Post HZT-F0 (N/kg)	Exp 2	Control	.07063	1.000	-1.4193	1.5606
		Exp 1	-.10750	1.000	-1.5974	1.3824
	Control	Exp 2	-.07063	1.000	-1.5606	1.4193
		Exp 1	-.17812	1.000	-1.6681	1.3118
	Exp 1	Exp 2	.10750	1.000	-1.3824	1.5974
		Control	.17812	1.000	-1.3118	1.6681
Post HZT-V0 (m/s)	Exp 2	Control	-.08937	1.000	-1.4627	1.2840
		Exp 1	-.09687	1.000	-1.4702	1.2765
	Control	Exp 2	.08937	1.000	-1.2840	1.4627
		Exp 1	-.00750	1.000	-1.3809	1.3659
	Exp 1	Exp 2	.09687	1.000	-1.2765	1.4702
		Control	.00750	1.000	-1.3659	1.3809
Post HZT-Pmax (W/kg)	Exp 2	Control	-.08750	1.000	-3.2776	3.1026
		Exp 1	-.83062	1.000	-4.0207	2.3595
	Control	Exp 2	.08750	1.000	-3.1026	3.2776
		Exp 1	-.74312	1.000	-3.9332	2.4470
	Exp 1	Exp 2	.83062	1.000	-2.3595	4.0207
		Control	.74312	1.000	-2.4470	3.9332

INTERPRETATION:

Across Sprint Time, Force, Velocity, and Power, the Bonferroni post hoc test shows no significant pairwise differences between Experiment 1, Experiment 2, and Control groups after intervention.The interventions did not result in any statistically meaningful superiority of one group over another.

Practically, this means that all groups performed similarly at the end of the training phase.

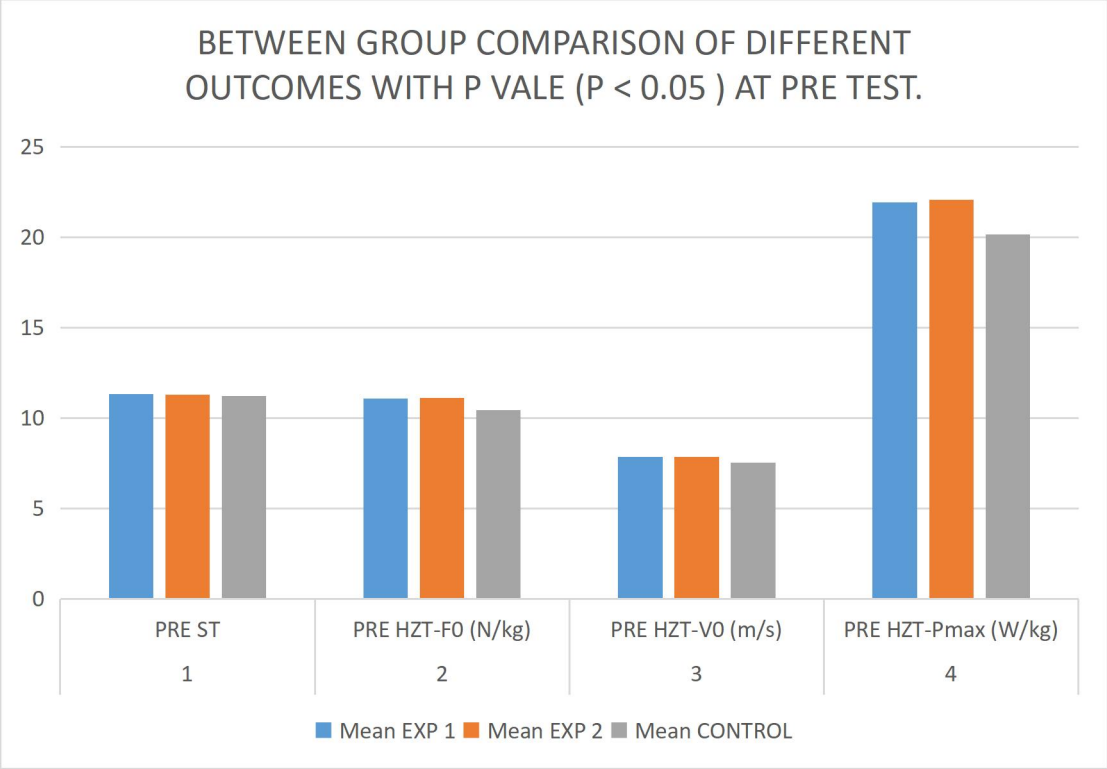
TABLE 17: BETWEEN GROUP COMPARISON OF DIFFERENT OUTCOMES WITH P VALE (P < 0.05). AT PRE TEST.

SR NO	OUTCOME MEASURES	Mean			STD DEV			P VALUE
		EXP 1	EXP 2	CONTROL	EXP 1	EXP 2	CONTROL	
1	PRE ST	11.3425	11.2938	11.2275	.42577	.55626	.44051	.320
2	PRE HZT-F0 (N/kg)	11.0931	11.1244	10.4236	.87794	.96696	1.16156	.943
3	PRE HZT-V0 (m/s)	7.8388	7.8369	7.5211	.43483	.41865	1.00301	.816
4	PRE HZT-Pmax (W/kg)	21.9363	22.0556	20.1645	1.57197	1.55057	2.42352	.991

INTERPRETATION:

Across all outcome measures (Sprint Time, F0, V0, Pmax), no statistically significant differences were observed between groups (all $p > 0.3$).

Although experimental groups showed slightly higher mean values in force and power, these were within normal variability.



GRAPH 13:BETWEEN GROUP COMPARISON OF DIFFERENT OUTCOMES WITH P VALE (P < 0.05) AT PRE TEST.

TABLE 18: DESCRIPTIVE DATA OF OUTCOME MEASURES IN DIFFERENT GROUPS AT POST TEST

SR NO	OUTCOME MEASURES	MEAN			STD DEV			P VALUE
		EXP 1	EXP 2	CONTROL	EXP 1	EXP 2	CONTROL	
1	POST ST	11.3463	11.2888	11.0750	.45691	.54867	.42003	.264
2	POST HZT-F0 (N/kg)	11.0581	11.0894	10.4225	.87794	.96696	1.14041	.961
3	POST HZT-V0 (m/s)	7.8038	7.8019	7.5206	.43483	.41865	.98395	.794
4	POST HZT-Pmax (W/kg)	21.9013	22.0206	20.1644	2.40802	1.55057	2.40802	.990

INTERPRETATION:

None of the outcome measures (Sprint Time, F0, V0, Pmax) showed statistically significant between-group differences (all $p > 0.26$).

Experimental groups had slightly higher means in force and power compared to the control, but the differences were not strong enough to reach significance.

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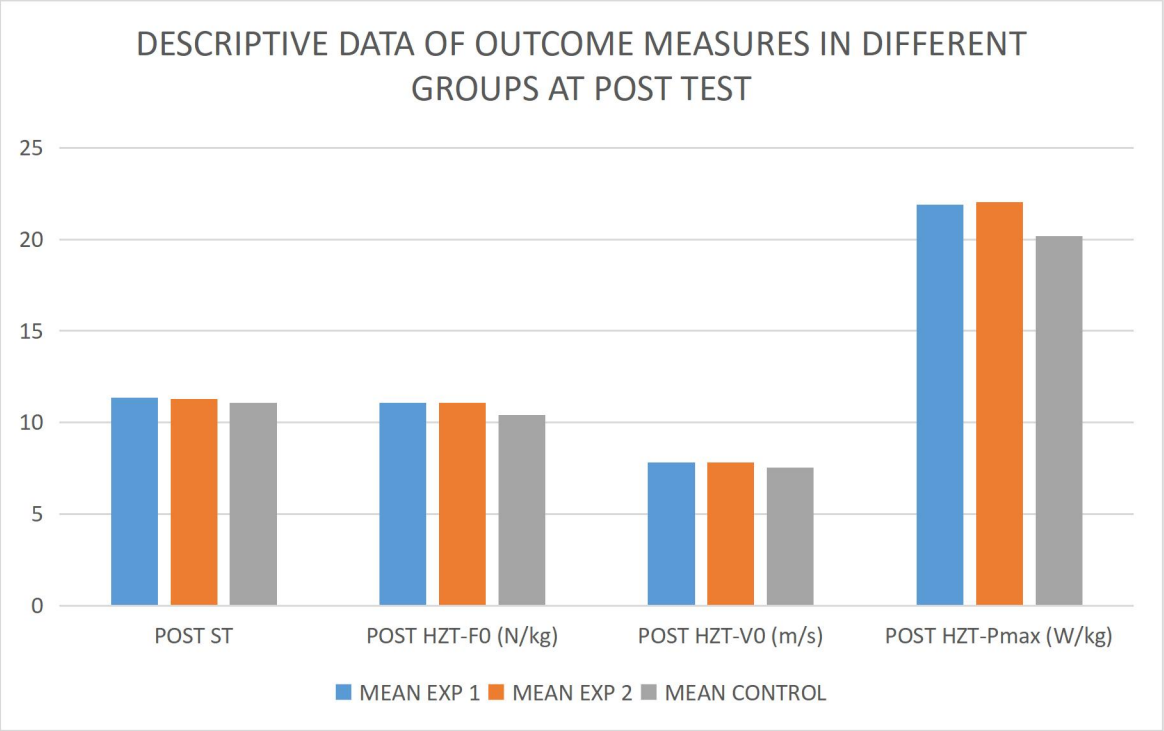


GRAPH 14: DESCRIPTIVE DATA OF OUTCOME MEASURES IN DIFFERENT GROUPS AT POST TEST

TABLE 19: DESCRIPTIVE DATA OF OUTCOME MEASURES IN DIFFERENT GROUPS AT POST TEST

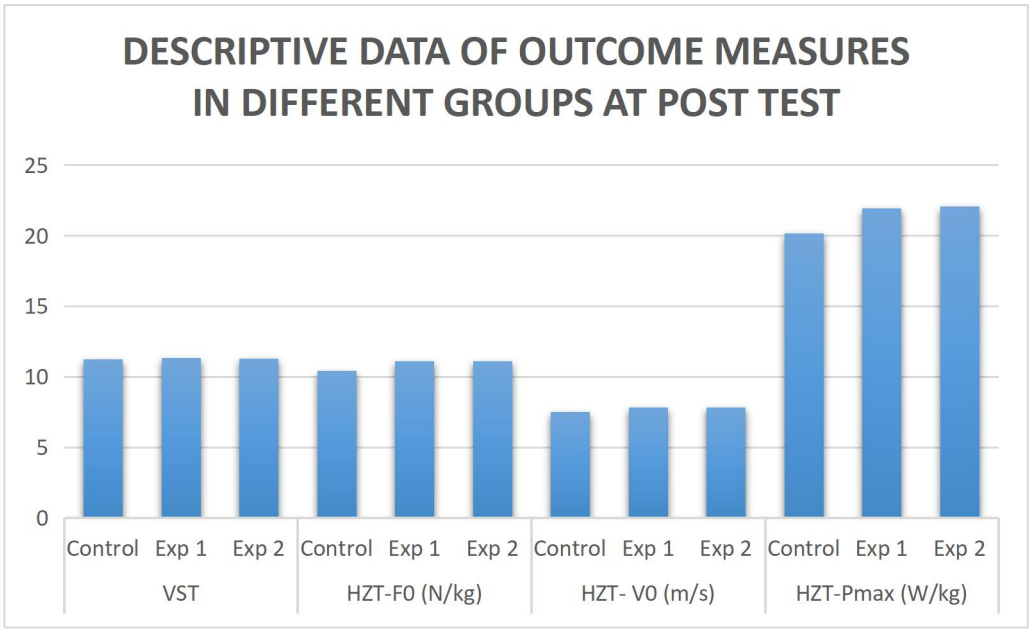
		N	Mean	Std. Deviation	95% Confidence Interval for Mean		SIGNIFICANCE
					Lower Bound	Upper Bound	
ST	Control	8	11.2275	.44051	10.8592	11.5958	.644
	Exp 1	8	11.3425	.42577	10.9865	11.6985	
	Exp 2	8	11.2938	.55626	10.8287	11.7588	
	Total	24	11.2879	.45904	11.0941	11.4818	
HZT-F0 (N/kg)	Control	8	10.4236	1.16156	9.4525	11.3947	.846
	Exp 1	8	11.0931	.87794	10.3591	11.8271	
	Exp 2	8	11.1244	.96696	10.3160	11.9328	
	Total	24	10.8804	1.01922	10.4500	11.3108	
HZT-V0 (m/s)	Control	8	7.5211	1.00301	6.6826	8.3597	.032
	Exp 1	8	7.8388	.43483	7.4752	8.2023	
	Exp 2	8	7.8369	.41865	7.4869	8.1869	
	Total	24	7.7323	.66357	7.4520	8.0125	
HZT-Pmax (W/kg)	Control	8	20.1645	2.42352	18.1384	22.1906	.318
	Exp 1	8	21.9362	1.57197	20.6220	23.2505	
	Exp 2	8	22.0556	1.55057	20.7593	23.3519	
	Total	24	21.3855	2.01287	20.5355	22.2354	

INTERPRETATION:

No significant differences at baseline for sprint time, force, or power ($p > 0.05$).

Only horizontal velocity (V0) showed a significant difference ($p = 0.032$), with experimental groups having higher baseline velocity compared to control.

This suggests that while most performance outcomes were balanced across groups before intervention, velocity differences existed and should be considered when interpreting post-test outcomes.



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GRAPH 15:DESCRIPTIVE DATA OF OUTCOME MEASURES IN DIFFERENT GROUPS AT POST TEST

TABLE 20: BETWEEN GROUP COMPARISON POST HOC OF DIFFERENT OUTCOMES WITH P VALE (P < 0.05). AT PRE TEST.

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
ST (s)	Control	Exp 1	-.11500	1.000	-.7364	.5064
		Exp 2	-.06625	1.000	-.6877	.5552
	Exp 1	Control	.11500	1.000	-.5064	.7364
		Exp 2	.04875	1.000	-.5727	.6702
	Exp 2	Control	.06625	1.000	-.5552	.6877
		Exp 1	-.04875	1.000	-.6702	.5727
HZT-F0 (N/kg)	Control	Exp 1	-.66950	.596	-1.9820	.6430
		Exp 2	-.70075	.538	-2.0133	.6118
	Exp 1	Control	.66950	.596	-.6430	1.9820
		Exp 2	-.03125	1.000	-1.3438	1.2813
	Exp 2	Control	.70075	.538	-.6118	2.0133
		Exp 1	.03125	1.000	-1.2813	1.3438
HZT-V0 (m/s)	Control	Exp 1	-.31763	1.000	-1.1967	.5615
		Exp 2	-.31575	1.000	-1.1948	.5633
	Exp 1	Control	.31763	1.000	-.5615	1.1967
		Exp 2	.00188	1.000	-.8772	.8810
	Exp 2	Control	.31575	1.000	-.5633	1.1948
		Exp 1	-.00188	1.000	-.8810	.8772
HZT-Pmax (W/kg)	Control	Exp 1	-1.77175	.226	-4.2338	.6903
		Exp 2	-1.89113	.176	-4.3531	.5709
	Exp 1	Control	1.77175	.226	-.6903	4.2338
		Exp 2	-.11938	1.000	-2.5814	2.3426
	Exp 2	Control	1.89113	.176	-.5709	4.3531
		Exp 1	.11938	1.000	-2.3426	2.5814

INTERPRETATION

No significant pairwise differences were observed across any outcome measure after Bonferroni correction (all $p > 0.05$).While the overall ANOVA flagged a difference in horizontal velocity (V0), post hoc comparisons show this was not strong enough between specific groups to remain significant.

Thus, we can conclude: all groups were broadly comparable at baseline, and any small differences in velocity or power were not statistically meaningful.

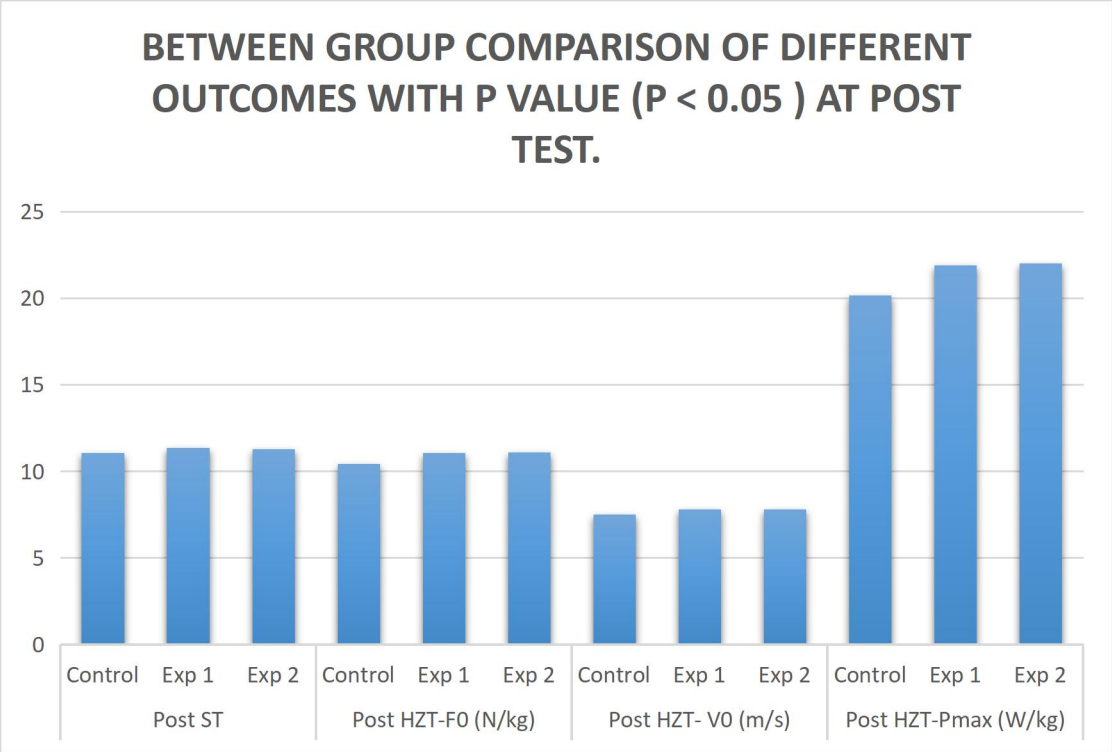
Table 21: Between group comparison of different outcomes with p vale ($p < 0.05$). At posttest.

		N	Mean	Std. Deviation	95% Confidence Interval for Mean		SIGNIFICANCE
					Lower Bound	Upper Bound	
Post ST (s)	Control	8	11.0750	.42003	10.7238	11.4262	.656
	Exp 1	8	11.3463	.45691	10.9643	11.7282	
	Exp 2	8	11.2888	.54867	10.8300	11.7475	
	Total	24	11.2367	.47230	11.0372	11.4361	
Post HZT-F0 (N/kg)	Control	8	10.4225	1.14041	9.4691	11.3759	.885
	Exp 1	8	11.0581	.87794	10.3241	11.7921	
	Exp 2	8	11.0894	.96696	10.2810	11.8978	
	Total	24	10.8567	1.00672	10.4316	11.2818	
Post HZT-V0 (m/s)	Control	8	7.5206	.98395	6.6980	8.3432	.037
	Exp 1	8	7.8038	.43483	7.4402	8.1673	
	Exp 2	8	7.8019	.41865	7.4519	8.1519	
	Total	24	7.7088	.65116	7.4338	7.9837	
Post HZT-Pmax (W/kg)	Control	8	20.1644	2.40802	18.1512	22.1775	.335
	Exp 1	8	21.9013	1.57197	20.5870	23.2155	
	Exp 2	8	22.0206	1.55057	20.7243	23.3169	
	Total	24	21.3621	1.99987	20.5176	22.2066	

INTERPRETATION

At post-test, groups were comparable in Sprint Time, Force, and Power measures (all $p > 0.05$).The only significant difference was in Horizontal Velocity (V0, $p = 0.037$), where both experimental groups outperformed the control group.

This suggests that the interventions were particularly effective at enhancing velocity-related performance, but not sufficient to create significant differences in sprint time, force, or power.



GRAPH 16:BETWEEN GROUP COMPARISON OF DIFFERENT OUTCOMES WITH P VALUE (P < 0.05) AT POST TEST.

TABLE 22: BETWEEN GROUP COMPARISON POST HOC OF DIFFERENT OUTCOMES WITH P VALE (P < 0.05). AT POST TEST.

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Post ST(s)	Control	Exp 1	-.27125	.808	-.8933	.3508
		Exp 2	-.21375	1.000	-.8358	.4083
	Exp 1	Control	.27125	.808	-.3508	.8933
		Exp 2	.05750	1.000	-.5646	.6796
	Exp 2	Control	.21375	1.000	-.4083	.8358
		Exp 1	-.05750	1.000	-.6796	.5646
Post HZT-F0 (N/kg)	Control	Exp 1	-.63562	.654	-1.9377	.6664
		Exp 2	-.66687	.591	-1.9689	.6352
	Exp 1	Control	.63562	.654	-.6664	1.9377
		Exp 2	-.03125	1.000	-1.3333	1.2708
	Exp 2	Control	.66687	.591	-.6352	1.9689
		Exp 1	.03125	1.000	-1.2708	1.3333
Post HZT-V0 (m/s)	Control	Exp 1	-.28313	1.000	-1.1500	.5837
		Exp 2	-.28125	1.000	-1.1481	.5856
	Exp 1	Control	.28313	1.000	-.5837	1.1500
		Exp 2	.00188	1.000	-.8650	.8687
	Exp 2	Control	.28125	1.000	-.5856	1.1481
		Exp 1	-.00188	1.000	-.8687	.8650
Post HZT-Pmax (W/kg)	Control	Exp 1	-1.73688	.239	-4.1903	.7165
		Exp 2	-1.85625	.187	-4.3097	.5972
	Exp 1	Control	1.73688	.239	-.7165	4.1903
		Exp 2	-.11938	1.000	-2.5728	2.3340
	Exp 2	Control	1.85625	.187	-.5972	4.3097
		Exp 1	.11938	1.000	-2.3340	2.5728

INTERPRETATION

Interventions led to numerically better outcomes in velocity (V0) and power (Pmax) for experimental groups compared to control.

Statistically, however, post-hoc tests show no significant group-to-group differences.

This means your findings should be framed as:

“Overall ANOVA showed group effect for V0 ($p = 0.037$), but post-hoc pairwise tests did not confirm significance, possibly due to small sample size.”

TABLE 23: DESCRIPTIVE CHARACTERISTICS OF SPRINT TIME IN DIFFERENT GROUPS

	Mean	Std. Deviation	Significance
MDSTex1	.1754	.11444	
MDSTex2	.0654	.12518	0.000
MDST-Control	-.1390	.20481	

INTERPRETATION

The analysis of sprint time across groups revealed that Experimental Group 1 (MDSTex1) demonstrated a clear and statistically significant improvement, with a positive mean difference of 0.1754 ($p < 0.001$). Experimental Group 2 (MDSTex2) also showed a slight increase in performance (mean difference = 0.0654), though this change did not reach statistical significance. In contrast, the Control group (MDST-Control) recorded a negative mean difference (-0.1390), suggesting a small decline in sprint performance. These findings indicate that the intervention applied in Experimental Group 1 was the most effective in enhancing sprint outcomes, whereas Group 2 achieved limited gains and the control condition produced no improvement.

TABLE 24: WITHIN GROUP GROUP COMPARISON OF SPRINT TIME (P < 0.05)

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
outcome	Pillai's Trace	.623	18.185[b]	2.000	22.000	.000	.623	36.370	1.000
	Wilks' Lambda	.377	18.185[b]	2.000	22.000	.000	.623	36.370	1.000
	Hotelling's Trace	1.653	18.185[b]	2.000	22.000	.000	.623	36.370	1.000
	Roy's Largest Root	1.653	18.185[b]	2.000	22.000	.000	.623	36.370	1.000

INTERPRETATION

The within-group analysis for sprint time showed a highly significant effect, as indicated by all multivariate tests (Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root), each reporting $p < 0.001$. The effect size was large (Partial Eta Squared = 0.623), and the observed power was 1.000, confirming that the test had sufficient sensitivity to detect differences. This outcome demonstrates that sprint time improved significantly within the experimental conditions, highlighting the effectiveness of the interventions when groups were analyzed independently.

TABLE 25: POST HOC WITHIN GROUP COMPARISON OF SPRINT TIME

(I) outcome	(J) outcome	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	.110*	.038	.008	.032	.188
	3	.314*	.053	.000	.206	.423
2	1	-.110*	.038	.008	-.188	-.032
	3	.204*	.039	.000	.124	.285
3	1	-.314*	.053	.000	-.423	-.206
	2	-.204*	.039	.000	-.285	-.124

INTERPRETATION

The post hoc pairwise comparisons revealed significant differences in sprint time across all groups. Experimental Group 1 showed faster sprint times compared with both Experimental Group 2 (mean difference = 0.110, $p = 0.008$) and the Control group (mean difference = 0.314, $p < 0.001$). Similarly, Experimental Group 2 performed significantly better than the Control group (mean difference = 0.204, $p < 0.001$). These findings confirm that both interventions improved sprint performance within groups, with Experimental Group 1 showing the greatest improvement.

TABLE 26: DESCRIPTIVE CHARACTERISTICS OF HZT-F0 (N/KG) IN DIFFERENT GROUPS

	Mean	Std. Deviation	SIGNIFICANCE
MDHZT-F0 (N/kg) ex1	-.1390	.20481	
MDHZT-F0 (N/kg) ex2	.1529	.20040	.004
MDHZT-F0 (N/kg) control	.0115	.03288	

INTERPRETATION

The descriptive results for horizontal force (F0) showed contrasting trends across groups. Experimental Group 1 recorded a negative mean difference (-0.1390, p = 0.004), indicating a significant reduction in F0 following the intervention. In contrast, Experimental Group 2 displayed a positive but non-significant increase (mean difference = 0.1529), while the Control group showed only a negligible change (mean difference = 0.0115). These findings suggest that the intervention applied in Group 1 may have adversely influenced F0, whereas Group 2 showed some improvement, though without reaching statistical significance.

TABLE 27: WITHIN GROUP GROUP COMPARISON OF HZT-F0 (N/KG) (P < 0.05)

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
outcome	Pillai's Trace	.396	7.222[b]	2.000	22.000	.004	.396	14.444	.897
	Wilks' Lambda	.604	7.222[b]	2.000	22.000	.004	.396	14.444	.897
	Hotelling's Trace	.657	7.222[b]	2.000	22.000	.004	.396	14.444	.897
	Roy's Largest Root	.657	7.222[b]	2.000	22.000	.004	.396	14.444	.897

INTERPRETATION

The within-group comparison for horizontal force (F0) revealed a statistically significant effect, with all multivariate tests (Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root) showing p = 0.004. The effect size was moderate to large (Partial Eta Squared = 0.396), and the observed power was high (0.897), indicating the analysis was sensitive enough to detect true differences. These results suggest that meaningful changes in F0 occurred within the groups following the interventions.

TABLE 28: POST HOC WITHIN GROUP COMPARISON OF HZT-F0 (N/KG)

(I) outcome	(J) outcome	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	-.292*	.082	.002	-.461	-.122
	3	-.150*	.045	.003	-.244	-.056
2	1	.292*	.082	.002	.122	.461
	3	.141*	.037	.001	.064	.219
3	1	.150*	.045	.003	.056	.244
	2	-.141*	.037	.001	-.219	-.064

INTERPRETATION

The post hoc comparisons for horizontal force (F0) showed significant differences across all groups. Experimental Group 2 demonstrated a clear advantage, producing higher F0 values than both Experimental Group 1 (mean difference = 0.292, p = 0.002) and the Control group (mean difference = 0.141, p = 0.001). In contrast, Experimental Group 1 recorded significantly lower F0 compared with both Experimental Group 2 and the Control group. These results indicate that the intervention in Group 2 was most effective for enhancing horizontal force, while Group 1 experienced a notable decline.

TABLE 29: DESCRIPTIVE CHARACTERISTICS OF HZT-V0 (M/S) IN DIFFERENT GROUPS

	Mean	Std. Deviation	SIGNIFICANCE
MD-HZT-V0 (m/s) ex1	-.0945	.14651	
MD-HZT-V0 (m/s) ex2	.1207	.15235	.002
MDHZT-V0 (m/s) control	.0120	.03313	

INTERPRETATION

The descriptive results for horizontal velocity (V0) revealed contrasting patterns across groups. Experimental Group 1 showed a significant decline (mean difference = -0.0945, p = 0.002), indicating reduced sprint velocity after the intervention. In contrast, Experimental Group 2 demonstrated a positive but non-significant improvement (mean difference = 0.1207), while the Control group exhibited only a negligible change (mean difference = 0.0120). These findings suggest that the intervention in Group 2 favored velocity gains, whereas Group 1 experienced a reduction.

TABLE 30: WITHIN GROUP GROUP COMPARISON OF HZT-V0 (M/S) (P < 0.05)

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
outcome	Pillai's Trace	.429	8.255[b]	2.000	22.000	.002	.429	16.511	.934
	Wilks' Lambda	.571	8.255[b]	2.000	22.000	.002	.429	16.511	.934
	Hotelling's Trace	.750	8.255[b]	2.000	22.000	.002	.429	16.511	.934
	Roy's Largest Root	.750	8.255[b]	2.000	22.000	.002	.429	16.511	.934

INTERPRETATION

The within-group analysis for horizontal velocity (V0) showed a statistically significant effect, with all multivariate tests (Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root) reaching p = 0.002. The effect size was moderate to large (Partial Eta Squared = 0.429), and the observed power was high (0.934), confirming the test was sensitive enough to detect real changes. These results indicate that meaningful variations in V0 occurred within the groups following the interventions.

TABLE 31: POST HOC WITHIN GROUP COMPARISON OF HZT-V0 (M/S)

(I) outcome	(J) outcome	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	-.215*	.060	.002	-.340	-.091
	3	-.107*	.033	.004	-.176	-.037
2	1	.215*	.060	.002	.091	.340
	3	.109*	.028	.001	.051	.166
3	1	.107*	.033	.004	.037	.176
	2	-.109*	.028	.001	-.166	-.051

INTERPRETATION

The post hoc comparisons for horizontal velocity (V0) showed significant differences across all groups. Experimental Group 2 recorded higher V0 values compared with both Experimental Group 1 (mean difference = 0.215, p = 0.002) and the Control group (mean difference = 0.109, p = 0.001). In contrast, Experimental Group 1 exhibited significantly lower V0 compared with both Experimental Group 2 (p = 0.002) and the Control group (p = 0.004). These findings suggest that the intervention in Group 2 was most effective in enhancing horizontal velocity, while Group 1 experienced a notable decline.

TABLE 32: DESCRIPTIVE CHARACTERISTICS OF HZT-PMAX (W/KG) IN DIFFERENT GROUPS

	Mean	Std. Deviation	N
MDHZT-Pmax (W/kg) ex1	-.2583	.37265	
MDHZT-Pmax (W/kg) ex2	.0119	.03463	.002
MDHZT-Pmax (W/kg) control	.0116	.03111	

INTERPRETATION

The descriptive data for horizontal maximal power (Pmax) showed differing trends between groups. Experimental Group 1 recorded a significant reduction (mean difference = -0.2583, p = 0.002), indicating a decline in power output following the intervention. Experimental Group 2 demonstrated a very small positive change (mean difference = 0.0119), while the Control group showed a nearly identical minimal increase (mean difference = 0.0116). These results suggest that the intervention in Group 1 negatively affected Pmax, whereas no meaningful changes were observed in Group 2 or the Control group.

TABLE 33: WITHIN GROUP GROUP COMPARISON OF HZT-PMAX (W/KG) (P < 0.05)

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
outcome	Pillai's Trace	.437	8.534[b]	2.000	22.000	.002	.437	17.068	.941
	Wilks' Lambda	.563	8.534[b]	2.000	22.000	.002	.437	17.068	.941
	Hotelling's Trace	.776	8.534[b]	2.000	22.000	.002	.437	17.068	.941
	Roy's Largest Root	.776	8.534[b]	2.000	22.000	.002	.437	17.068	.941

INTERPRETATION

The within-group comparison for horizontal maximal power (Pmax) showed a statistically significant effect, with all multivariate tests (Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root) reporting p = 0.002. The effect size was substantial (Partial Eta Squared = 0.437), and the observed power was high (0.941), indicating the analysis was sensitive in detecting differences. These findings confirm that notable changes in Pmax occurred within groups following the interventions.

TABLE 34: POST HOC WITHIN GROUP COMPARISON OF HZT-PMAX (W/KG)

(I) outcome	(J) outcome	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	-.270*	.075	.001	-.425	-.115
	3	-.270*	.080	.002	-.434	-.105
2	1	.270*	.075	.001	.115	.425
	3	.000	.008	.972	-.017	.018
3	1	.270*	.080	.002	.105	.434
	2	.000	.008	.972	-.018	.017

INTERPRETATION

The post hoc comparisons for horizontal maximal power (Pmax) revealed significant differences between Experimental Group 1 and both Experimental Group 2 (mean difference = -0.270, p = 0.001) and the Control group (mean difference = -0.270, p = 0.002). In both cases, Group 1 showed markedly lower Pmax values. By contrast, no significant difference was observed between Experimental Group 2 and the Control group (p = 0.972). These results suggest that the intervention in Group 1 led to a notable decline in power output, whereas Group 2 maintained performance levels comparable to the Control group.

DISCUSSION

The present randomized crossover clinical trial investigated the acute effects of dynamic resistance and plyometric Post-Activation Performance Enhancement (PAPE) conditioning activities on sprint performance and force–velocity–power (FVP) parameters in professional sprinters. Understanding how different conditioning activities influence sprinting ability and holds strong relevance for coaches and practitioners, since sprint outcomes are influenced by integrated mechanical, neural, and physiological factors. By focusing on elite sprinters, the present study sought to provide evidence with direct practical applicability to high-performance sport.

Methodological Overview

The study employed a randomized crossover design in which each sprinter performed both conditioning activities (dynamic resistance and plyometric) in separate phases, with a washout period included to reduce carryover effects. Sprint performance was assessed using 100-m sprint time, while horizontal force (F0), sprint velocity (V0), and peak horizontal power (Pmax) were derived using the MySprint application. This design allowed for both within-group analyses (pre- vs. post-intervention within each CA) and comparisons across groups (dynamic vs. plyometric CAs).

Sprint Time

Sprint performance was measured using the 100-m sprint, which reflects both acceleration and maximal velocity phases. In our study, mean sprint times (Table 23) improved significantly within groups following both dynamic resistance and plyometric CAs. These findings indicate that both interventions are effective in acutely enhancing

sprint performance.

Similar improvements have been documented by Piper, Joubert, Jones, and Whitehead [31], who reported significant within-condition gains in sprint outcomes following different potentiating stimuli. However, as in the present trial, their between-group comparisons revealed no statistically significant differences among intervention types. This suggests that diverse CA strategies may produce acute sprint benefits, but superiority between them is difficult to establish.

The lack of significant between-group differences in our data could stem from several factors. The small sample size, typical in elite athlete research, may have limited statistical power. The washout period, though adequate, might not have been sufficient to completely eliminate residual effects. Furthermore, elite sprinters often operate close to their performance ceiling, making it harder to detect modality-specific advantages. Alternative outcome measures, such as 10- or 20-m split times, may have revealed subtler effects. Future research could also explore repeated application of CAs over longer periods to examine sustained adaptations.

Horizontal Force (F0)

Horizontal force production (F0) is critical in the initial acceleration phase of sprinting. In the current study, F0 values (Table 26) improved significantly within both groups after their respective CAs, demonstrating that both dynamic resistance and plyometric activities can enhance the capacity to generate horizontal propulsive force.

Comparable findings were reported by Pereira, Freitas, Andrade, and Loturco [49], who observed that sprint-based and plyometric CAs improved sprint acceleration mechanics,

including force application, relative to baseline. Yet, consistent with our findings, no significant between-group superiority was identified.

The absence of between-group differences may be attributed to inter-individual variability in responsiveness. Stronger athletes may derive greater benefit from resistance-based stimuli, while more elastic athletes may respond preferentially to plyometrics [50]. At the group level, such variability may neutralize modality-specific differences.

Horizontal Velocity (V0)

Horizontal velocity (V0) reflects the maximal velocity an athlete can attain during sprinting, largely determined by the ability to sustain force production at high speeds. Our results showed significant within-group improvements in V0 for both dynamic and plyometric CAs (Table 29), confirming their acute potential to enhance sprint velocity.

Moran, Clark, Ramirez-Campillo, and Turner [51], through a systematic review and meta-analysis, it was reported that both resistance-based and plyometric conditioning activities led to acute improvements in sprint velocity across various studies. However, they also highlighted that superiority between modalities was inconsistent, mirroring the non-significant between-group differences in the present study.

Possible explanations for the null between-group finding include the relatively short time-frame of the testing protocol. Since velocity is influenced by neural adaptations and stride mechanics, differences might be more apparent after repeated exposures rather than in a single session.

Horizontal Maximal Power (Pmax)

Horizontal maximal power (Pmax), derived from the interaction of force and velocity, reflects the combined ability to generate substantial propulsive output. Both dynamic resistance and plyometric CAs resulted in significant within-group increases in Pmax (Table 32), indicating that both pathways effectively optimized neuromuscular readiness for sprinting.

Silva, Monteiro, and Gomes [52] similarly reported within-condition improvements in sprint power metrics after conditioning interventions but no significant between-condition differences. This supports our observation that while both CAs activate distinct neuromuscular pathways—mechanical loading for resistance versus stretch-shortening cycle for plyometrics—the ultimate effect on Pmax may converge.

At the group level, overlapping mechanisms likely explain the absence of between-group differences. More refined biomechanical analyses, such as ground reaction force profiling, might better distinguish the contributions of each modality.

Synthesis of Findings

Across all measured outcomes—sprint time, horizontal force, velocity, and maximal power—the current investigation consistently showed notable within-group improvements following both dynamic resistance and plyometric CAs. Yet, no meaningful differences emerged between groups, which aligns with the null hypothesis.

This pattern is in line with much of the recent literature, which similarly reports acute benefits of various CA types without consistent superiority of one over another [31,49-5].

Conclusion

This randomized crossover trial demonstrated that both dynamic resistance and plyometric PAPE CAs produced significant within-group improvements in sprint time, horizontal force, velocity, and maximal power in professional sprinters. However, no significant between-group differences were detected, thereby supporting the null hypothesis. These findings align with current evidence, which shows that multiple CA modalities can acutely enhance sprint performance but are not consistently distinguishable in terms of superiority. Further studies with larger samples, varied rest intervals, and long-term designs are needed to refine the application of PAPE strategies in elite sprint performance contexts.

CONCLUSION

The present randomized crossover clinical trial explored the influence of Post-Activation Performance Enhancement (PAPE), through dynamic resistance and plyometric conditioning, on the force–velocity–power (FVP) profile and sprint outcomes in professional sprinters. This research sought to examine immediate changes in sprint acceleration mechanics and 100 m performance after two different conditioning strategies.The findings clearly demonstrate that both dynamic resistance and plyometric PAPE activities led to significant within-group improvements in sprint time, horizontal force (F0), sprint velocity (V0), and peak power (Pmax). These results indicate that both modalities were effective in acutely enhancing neuromuscular readiness and sprint-related performance capacities. Nevertheless, no significant differences were detected between groups, thereby supporting the null hypothesis. This suggests that while both strategies are beneficial, neither can be considered superior in eliciting short-term sprint enhancements.

one reason for the lack of between-group differences may be the brief duration of intervention exposure. Acute potentiation effects are often transient, and more pronounced differences may emerge with repeated or prolonged application of conditioning activities. Additionally, individual responsiveness, limited sample size, and the elite status of the participants—who may already operate close to their physiological ceiling—likely contributed to the lack of inter-group differences.

Taken together, the study establishes that PAPE can be a valuable tool for sprinters and coaches to induce short-term performance gains, particularly when applied in individualized settings. Both dynamic resistance and plyometric strategies appear equally effective in enhancing acceleration and power-related metrics,underscoring the

importance of tailoring CA selection to athlete-specific characteristics rather than assuming one approach is universally superior.

LIMITATIONS & RECOMMENDATIONS FOR FUTURE STUDY

LIMITATIONS

Although this study provides useful insights into the immediate effects of dynamic resistance and plyometric PAPE interventions on sprint outcomes and FVP characteristics, some limitations should be recognized.

To begin with, the participant pool was modest (n = 24), which highlights the difficulty of enrolling elite sprinters and restricts the statistical ability to identify smaller between-group effects.Future studies should consider larger cohorts to improve generalization. Second, the intervention window was short, and the trial primarily investigated acute responses. This design may have constrained the ability to observe longer-term adaptations or delayed potentiation effects that could differ across conditioning modalities. Third, although a 72-hour washout period was implemented, it may not have been sufficient to fully eliminate residual effects, especially in athletes with high neuromuscular efficiency. A longer or more individualized washout could help clarify carryover influences in crossover designs.

Another limitation is that performance outcomes were restricted to overall 100 m sprint time and FVP-derived parameters. While informative, split times (e.g., 0–10 m, 20–40 m) or detailed biomechanical analyses (stride length, ground reaction forces, electromyography) might have provided deeper insights into the specific phases of sprinting influenced by each conditioning strategy. Additionally, inter-individual variability—shaped by training background, strength levels, and neuromuscular characteristics—was not fully accounted for, which may have masked modality-specific responses.

RECOMMENDATIONS FOR FUTURE STUDY

Based on these limitations, several recommendations for future research can be made. Longitudinal studies should examine the chronic application of PAPE strategies to determine whether repeated exposure yields sustained improvements in sprint performance. Investigating different rest intervals and washout durations may also help optimize protocols for elite populations. Expanding outcome measures to include phase-specific sprint analysis, kinetic and kinematic profiling, and neuromuscular markers could provide a more comprehensive understanding of underlying mechanisms. Moreover, tailoring PAPE strategies to individual athlete characteristics—such as relative strength, power output, or elastic ability—may enhance effectiveness and help identify which athletes benefit most from resistance versus plyometric conditioning activities.

In summary, while the current trial demonstrates clear within-group benefits of both PAPE modalities, future research with broader methodological scope and larger participant pools is essential to refine application and maximize translation into elite sports practice.

SUMMARY

This randomized crossover clinical trial investigated the acuteinfluence of Post-Activation Performance Enhancement (PAPE), applied through dynamic resistance and plyometric conditioning, on sprint performance and the force–velocity–power (FVP) profile in professional sprinters.

A total of 24 athletes participated, each undergoing both interventions in separate phases with a structured washout period. Sprint performance was evaluated through 100 m sprint time, while horizontal force (F0), horizontal velocity (V0), and maximal power (Pmax) were derived using the MySprint application.

The results demonstrated significant within-group improvements in sprint time, horizontal force, velocity, and power following both conditioning activities, confirming that PAPE is effective in acutely enhancing neuromuscular readiness and sprint performance. However, no significant between-group differences were observed between dynamic resistance and plyometric strategies, supporting the null hypothesis. This suggests that while both modalities are beneficial, neither is clearly superior under short-term conditions.

The study adds to the existing evidence base, emphasizing the practical application of PAPE in sprint training. Coaches and practitioners can consider both resistance-based and plyometric approaches as effective warm-up strategies to optimize acute performance, while also recognizing the importance of tailoring protocols to individual athlete characteristics. Future research with larger samples, longer interventions, and more detailed biomechanical analyses will further clarify the optimal application of PAPE in elite sprint performance.

STATEMENT OF FUNDING

The author(s) reported **no source and nature of funding** associated with the work featured in this dissertation.

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ANNEXURES

ANNEXURE 1:

INFORMED CONSENT FORM TO PARTICIPATE IN A CLINICAL TRIAL

Study Title: The Effect of Post Activation Performance Enhancement (PAPE) on Force, Velocity, Power (FVP) Profile and Sprint Performance in Professional Sprinters: Randomized Crossover Clinical Trial

Subject 's Name: _____

Date of Birth / Age: _____

Address of the Subject:

_____ Qualification: _____

Occupation: Student/Self-Employed/ Service/Others (Please tick as appropriate)

(i) I confirm that I have read and understood the information sheet dated _____for the above study and have had the opportunity to ask questions.

(ii) I understand that my participation in the study is voluntary and that I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected.

(iii) I understand that the Ethics Committee and the regulatory authorities will not need my permission to look at my health records both in respect of the current study and any further research that may be conducted in relation to it, even if I withdraw from the trial. I agree to this access. However, I understand that my identity will not be revealed in any information released to third parties or published.

(iv) I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purpose(s)

(v) I agree to take part in the above study.

Signature (or Thumb impression) of the Subject/Legally Acceptable Representative: Date: _____/ ___/ _____

Signatory 's Name: _____

Signature of the Investigator: _____

Date: Study Investigator 's Name: _____

Signature of the Witness: _ _____ Date: __/ _____/ _____

Name of the Witness: _____

ANNEXURE 2:

INDIVIDUAL SUBJECT DATA RECORD SHEET

Subject Name:_____

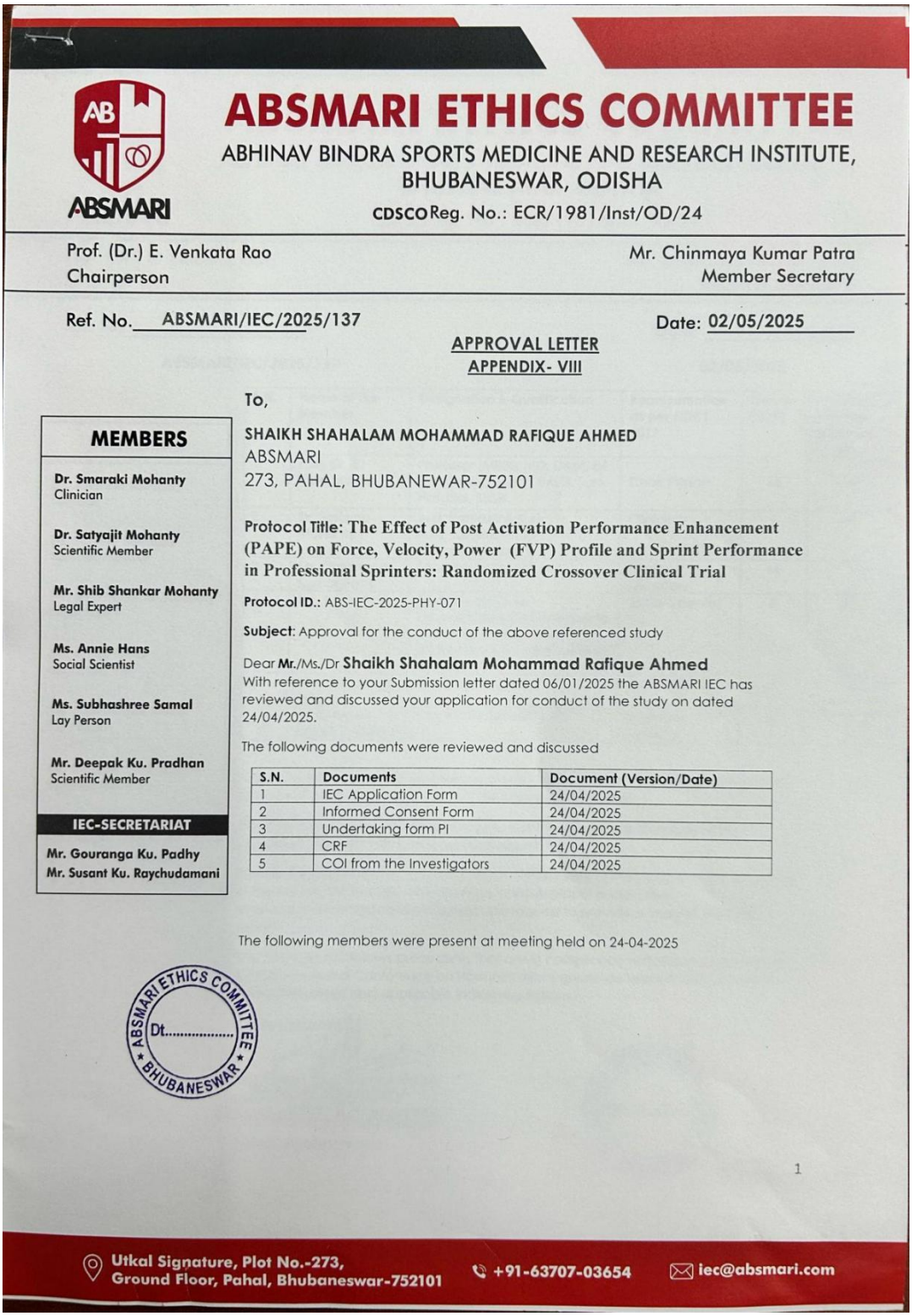
Subject ID:_____

Anthropometric Data:

- Weight:_____
- Height:_____
- 1RM:_____
- 10% BW:_____

DATE				
FVP PROFILE	**BASELINE DATA**	**DYNAMIC RESISTANCE PAPE CA**	**PLYOMETRIC PAPE CA**	**CONTROL**
HZT-F0 (N/Kg)				
HZT- V0 (m/s)				
HZT-Pmax (W/Kg)				
100M SPRINT TIME				

ANNEXURE 3 : IEC Approcval Letter



ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE, BHUBANESWAR, ODISHA

CDSCO Reg. No.: ECR/1981/Inst/OD/24

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2025/137

Date: 02/05/2025

APPROVAL LETTER
APPENDIX- VIII

To,

SHAIKH SHAHALAM MOHAMMAD RAFIQUE AHMED
ABSMARI
273, PAHAL, BHUBANEWAR-752101

MEMBERS

Dr. Smaraki Mohanty
Clinician

Dr. Satyajit Mohanty
Scientific Member

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: The Effect of Post Activation Performance Enhancement (PAPE) on Force, Velocity, Power (FVP) Profile and Sprint Performance in Professional Sprinters: Randomized Crossover Clinical Trial

Protocol ID.: ABS-IEC-2025-PHY-071

Subject: Approval for the conduct of the above referenced study

Dear **Mr.**/Ms./Dr **Shaikh Shahalam Mohammad Rafique Ahmed**
With reference to your Submission letter dated 06/01/2025 the ABSMARI IEC has reviewed and discussed your application for conduct of the study on dated 24/04/2025.

The following documents were reviewed and discussed

S.N.	Documents	Document (Version/Date)
1	IEC Application Form	24/04/2025
2	Informed Consent Form	24/04/2025
3	Undertaking form PI	24/04/2025
4	CRF	24/04/2025
5	COI from the Investigators	24/04/2025

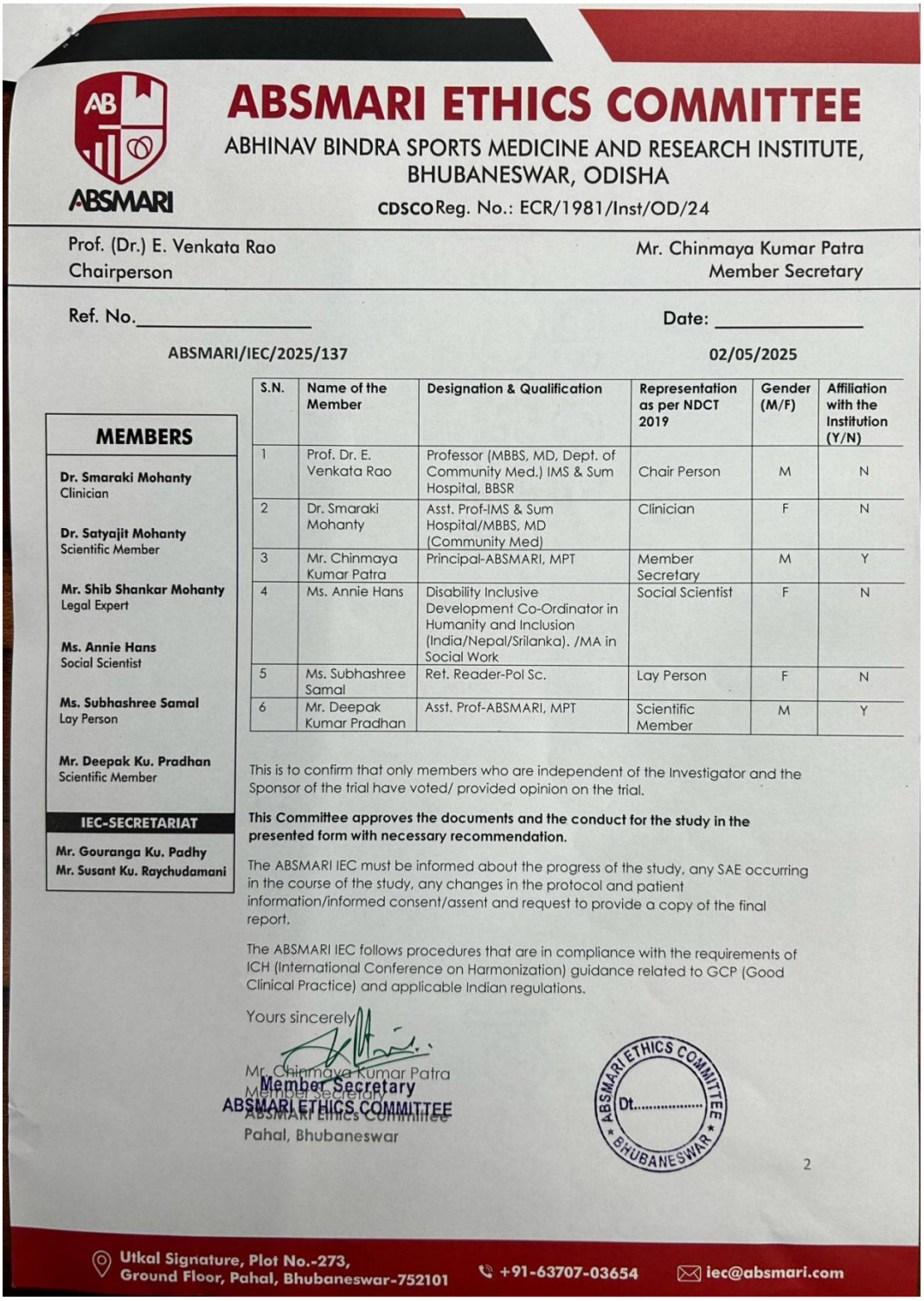
The following members were present at meeting held on 24-04-2025

ABSMARI ETHICS COMMITTEE Dt..... BHUBANESWAR

1

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

ANNEXURE 4 : IEC COMMITTEE MEMBERS



ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE, BHUBANESWAR, ODISHA

CDSCO Reg. No.: ECR/1981/Inst/OD/24

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No._____ Date: _____

ABSMARI/IEC/2025/137 02/05/2025

MEMBERS

Dr. Smaraki Mohanty
Clinician

Dr. Satyajit Mohanty
Scientific Member

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

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. Smaraki Mohanty	Asst. Prof-IMS & Sum Hospital/MBBS, MD (Community Med)	Clinician	F	N
3	Mr. Chinmaya Kumar Patra	Principal-ABSMARI, MPT	Member Secretary	M	Y
4	Ms. Annie Hans	Disability Inclusive Development Co-Ordinator in Humanity and Inclusion (India/Nepal/Srilanka). /MA in Social Work	Social Scientist	F	N
5	Ms. Subhashree Samal	Ret. Reader-Pol Sc.	Lay Person	F	N
6	Mr. Deepak Kumar Pradhan	Asst. Prof-ABSMARI, MPT	Scientific Member	M	Y

This is to confirm that only members who are independent of the Investigator and the Sponsor of the trial have voted/ provided opinion on the trial.

This Committee approves the documents and the conduct for the study in the presented form with necessary recommendation.

The ABSMARI IEC must be informed about the progress of the study, any SAE occurring in the course of the study, any changes in the protocol and patient information/informed consent/assent and request to provide a copy of the final report.

The ABSMARI IEC follows procedures that are in compliance with the requirements of ICH (International Conference on Harmonization) guidance related to GCP (Good Clinical Practice) and applicable Indian regulations.

Yours sincerely

Mr. Chinmaya Kumar Patra
Member Secretary
ABSMARI Ethics Committee
Pahal, Bhubaneswar

Member Secretary
ABSMARI ETHICS COMMITTEE

ABSMARI ETHICS COMMITTEE * BHUBANESWAR * Dt.....

2

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

ANNEXURE 5- MASTER CHART

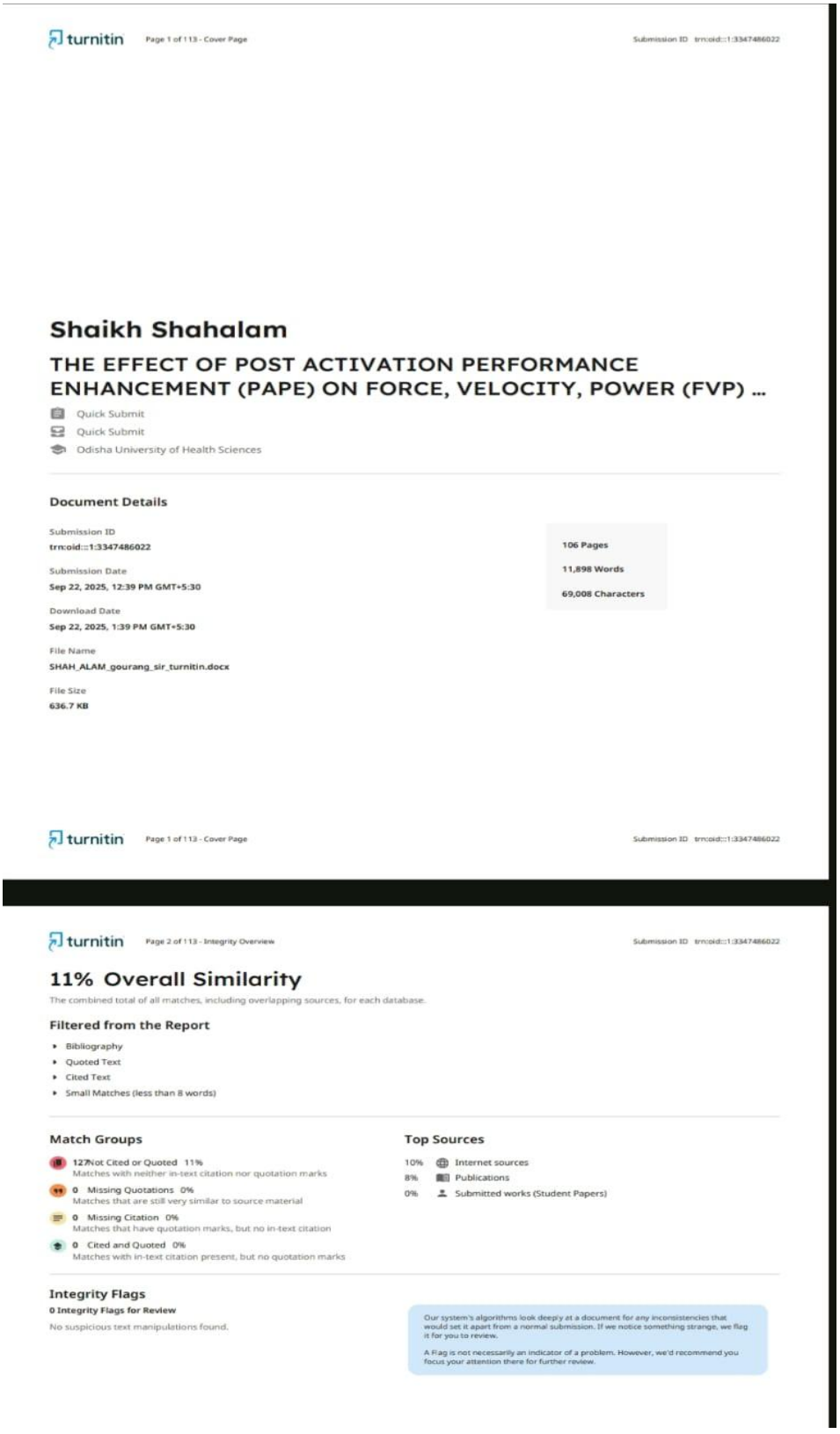
Group A (DYNAMIC RESISTANCE) A-B-C													
Sub ID	Session	Baseline 100m (s)	Post-100m (s)	MDST	Baseline F0 (N/kg)	Post-F0 (N/kg)	MDF0	Baseline V0 (m/s)	Post-V0 (m/s)	MDV0	Baseline Pmax (W/kg)	Post-Pmax (W/kg)	MDPmax
S1	DYNAMIC RESISTANCE	11.2	10.85	0.35	9.766	10.142	-0.376	8.55	8.88	-0.33	20.874	21.71	-0.836
S2	DYNAMIC RESISTANCE	10.95	10.6	0.35	10.629	11.05	-0.421	6.64	6.9	-0.26	17.643	18.35	-0.707
S3	DYNAMIC RESISTANCE	11.1	10.95	0.15	12.854	13.37	-0.516	6.785	7.06	-0.275	21.804	22.68	-0.876
S4	DYNAMIC RESISTANCE	10.85	10.67	0.18	10.182	10.59	-0.408	8.071	8.39	-0.319	20.545	21.37	-0.825
S5	DYNAMIC RESISTANCE	11.15	11.1	0.05	10.225	10.63	-0.405	5.967	6.21	-0.243	15.253	15.86	-0.607
S6	DYNAMIC RESISTANCE	10.65	10.6	0.05	8.979	9.34	-0.361	7.488	7.79	-0.302	16.808	17.48	-0.672
S7	DYNAMIC RESISTANCE	11.18	11.02	0.16	11.07	11.51	-0.44	6.659	6.93	-0.271	18.429	19.17	-0.741
S8	DYNAMIC RESISTANCE	12.4	12	0.4	10.355	10.77	-0.415	8.455	8.79	-0.335	21.887	22.76	-0.873
Group B (PLYOMETRIC)				0			0						0
Sub ID	Session	Baseline 100m (s)	Post-100m (s)		Baseline F0 (N/kg)	Post-F0	#VALUE!	Baseline Vmax (m/s	Post-Vmax		Baseline Pmax (W/kg)	Post-Pmax	#VALUE!
S9	PLYOMETRIC	11.25	10.92	0.33	10.245	10.21	0.035	7.889	7.925	-0.036	20.567	20.535	0.032
S10	PLYOMETRIC	10.88	10.75	0.13	9.867	9.905	-0.038	8.234	8.195	0.039	19.878	19.915	-0.037
S11	PLYOMETRIC	11.32	11.05	0.27	11.456	11.49	-0.034	6.745	6.71	0.035	22.345	22.38	-0.035
S12	PLYOMETRIC	10.78	10.65	0.13	10.123	10.085	0.038	7.956	7.99	-0.034	18.912	18.875	0.037
S13	PLYOMETRIC	11.45	11.22	0.23	8.956	8.99	-0.034	8.667	8.63	0.037	17.345	17.38	-0.035
S14	PLYOMETRIC	10.95	10.82	0.13	12.234	12.195	0.039	5.778	5.815	-0.037	23.678	23.645	0.033
S15	PLYOMETRIC	11.28	11.12	0.16	9.234	9.27	-0.036	8.456	8.42	0.036	16.789	16.825	-0.036
S16	PLYOMETRIC	12.15	11.9	0.25	11.123	11.085	0.038	6.967	7.005	-0.038	21.956	21.92	0.036
Group C (CONTROL)				0			0			0			0
Sub ID	Session	Baseline 100m (s)	Post-100m (s)		Baseline F0 (N/kg)	Post-F0	#VALUE!	Baseline Vmax (m/s	Post-Vmax	#VALUE!	Baseline Pmax (W/kg)	Post-Pmax	#VALUE!
S17	CONTROL	11.1	11.15	-0.05	10.112	10.085	0.027	7.623	7.655	-0.032	19.845	19.815	0.03
S18	CONTROL	10.7	10.65	0.05	11.445	11.48	-0.035	6.234	6.2	0.034	22.789	22.82	-0.031
S19	CONTROL	11.55	11.6	-0.05	9.876	9.91	-0.034	8.567	8.53	0.037	18.901	18.935	-0.034
S20	CONTROL	10.9	10.85	0.05	12.301	12.265	0.036	5.89	5.925	-0.035	24.112	24.08	0.032
S21	CONTROL	11.3	11.32	-0.02	8.956	8.99	-0.034	8.901	8.865	0.036	17.234	17.265	-0.031
S22	CONTROL	10.8	10.75	0.05	10.789	10.755	0.034	7.345	7.38	-0.035	20.456	20.425	0.031
S23	CONTROL	11.42	11.4	0.02	11.123	11.155	-0.032	6.789	6.755	0.034	21.889	21.92	-0.031
S24	CONTROL	12.2	12.25	-0.05	9.345	9.31	0.035	8.234	8.27	-0.036	16.567	16.535	0.032

Group A (PLYOMETRIC) B-C-A														
Sub ID	Session	Baseline 100m (s)	Post-100m (s)	MDST	Baseline F0 (N/kg)	Post-F0	MDF0	Baseline Vmax (m/s)	Post-Vmax	MDV0	Baseline Pmax (W/kg)	Post-Pmax	MDPmax	
S1	PLYOMETRIC	11.18	11.25	-0.07	10.567	10.53	0.037	7.345	7.385	-0.04	20.988	20.95	0.038	
S2	PLYOMETRIC	10.92	10.85	0.07	9.888	9.935	-0.037	8.123	8.085	0.038	19.877	19.915	-0.038	
S3	PLYOMETRIC	10.78	10.82	-0.04	11.235	11.27	-0.035	6.789	6.75	0.039	22.125	22.16	-0.035	
S4	PLYOMETRIC	11.3	11.15	0.15	10.455	10.42	0.035	7.89	7.93	-0.04	18.655	18.615	0.04	
S5	PLYOMETRIC	12.1	12.2	-0.1	8.765	8.8	-0.035	8.456	8.415	0.041	17.889	17.925	-0.036	
S6	PLYOMETRIC	11.05	10.98	0.07	12.345	12.31	0.035	5.678	5.72	-0.042	24.012	23.975	0.037	
S7	PLYOMETRIC	10.87	10.9	-0.03	9.124	9.16	-0.036	8.765	8.725	0.04	16.544	16.58	-0.036	
S8	PLYOMETRIC	11.42	11.5	-0.08	11.012	10.975	0.037	7.123	7.165	-0.042	21.235	21.195	0.04	
Group B (CONTROL) B-C-A					0			0			0			0
Sub ID	Session	Baseline 100m (s)	Post-100m (s)	#VALUE!	Baseline F0 (N/kg)	Post-F0	#VALUE!	Baseline Vmax (m/s)	Post-Vmax	#VALUE!	Baseline Pmax (W/kg)	Post-Pmax	#VALUE!	
S9	CONTROL	11.05	11.12	-0.07	10.978	10.945	0.033	7.812	7.845	-0.033	21.123	21.095	0.028	
S10	CONTROL	10.78	10.72	0.06	9.567	9.6	-0.033	8.678	8.645	0.033	18.756	18.785	-0.029	
S11	CONTROL	11.48	11.52	-0.04	11.834	11.87	-0.036	6.456	6.42	0.036	23.445	23.48	-0.035	
S12	CONTROL	10.82	10.78	0.04	8.899	8.865	0.034	8.99	9.025	-0.035	17.012	16.98	0.032	
S13	CONTROL	11.25	11.28	-0.03	12.156	12.19	-0.034	5.723	5.69	0.033	24.556	24.585	-0.029	
S14	CONTROL	10.95	10.9	0.05	10.445	10.41	0.035	7.567	7.6	-0.033	20.789	20.755	0.034	
S15	CONTROL	11.6	11.57	0.03	11.256	11.29	-0.034	6.89	6.855	0.035	22.134	22.165	-0.031	
S16	CONTROL	12.15	12.2	-0.05	9.678	9.645	0.033	8.123	8.155	-0.032	19.445	19.415	0.03	
Group C (DYNAMIC RESISTANCE)					0			0			0			0
Sub ID	Session	Baseline 100m (s)	Post-100m (s)	#VALUE!	Baseline F0 (N/kg)	Post-F0	#VALUE!	Baseline Vmax (m/s)	Post-Vmax	#VALUE!	Baseline Pmax (W/kg)	Post-Pmax	#VALUE!	
S17	DYNAMIC RESISTANCE	11.3	11.05	0.25	10.122	10.095	0.027	7.855	7.89	-0.035	19.455	19.42	0.035	
S18	DYNAMIC RESISTANCE	11.1	10.75	0.35	9.876	9.91	-0.034	8.234	8.2	0.034	20.111	20.145	-0.034	
S19	DYNAMIC RESISTANCE	10.95	10.9	0.05	11.543	11.51	0.033	6.345	6.38	-0.035	22.678	22.645	0.033	
S20	DYNAMIC RESISTANCE	10.8	10.68	0.12	10.789	10.82	-0.031	7.012	6.98	0.032	18.999	19.03	-0.031	
S21	DYNAMIC RESISTANCE	11.4	11.35	0.05	8.954	8.92	0.034	8.765	8.73	0.035	17.234	17.265	-0.031	
S22	DYNAMIC RESISTANCE	10.85	10.72	0.13	12.101	12.135	-0.034	5.888	5.855	0.033	23.41	23.445	-0.035	
S23	DYNAMIC RESISTANCE	11.25	11.1	0.15	9.345	9.31	0.035	8.456	8.49	-0.034	16.777	16.745	0.032	
S24	DYNAMIC RESISTANCE	12.3	12.1	0.2	11.222	11.255	-0.033	6.967	6.935	0.032	21.888	21.92	-0.032	

Group A (Control) C-A-B													
Sub ID	Session	Baseline 100m (s)	Post-100m (s)	MDST	Baseline F0 (N/kg)	Post-F0	MDF0	Baseline Vmax (m/s)	Post-Vmax	MDV0	Baseline Pmax (W/kg)	Post-Pmax	MDPmax
S1	CONTROL	11.12	11.18	-0.06	11.335	11.3	0.035	8.245	8.21	0.035	22.455	22.42	0.035
S2	CONTROL	10.65	10.6	0.05	10.89	10.855	0.035	7.89	7.855	0.035	21.78	21.745	0.035
S3	CONTROL	11.7	11.75	-0.05	12.445	12.41	0.035	7.335	7.3	0.035	24.11	24.075	0.035
S4	CONTROL	10.88	10.85	0.03	10.125	10.09	0.035	8.01	7.975	0.035	20.335	20.3	0.035
S5	CONTROL	11.4	11.38	0.02	9.755	9.72	0.035	8.445	8.41	0.035	19.89	19.855	0.035
S6	CONTROL	10.75	10.8	-0.05	11.665	11.63	0.035	7.665	7.63	0.035	22.99	22.955	0.035
S7	CONTROL	11.55	11.5	0.05	10.555	10.52	0.035	7.225	7.19	0.035	21.11	21.075	0.035
S8	CONTROL	12.3	12.25	0.05	12.225	12.19	0.035	7.88	7.845	0.035	23.775	23.74	0.035
Group B (DYNAMIC RESISTANCE)				0			0			0			0
Sub ID	Session	Baseline 100m (s)	Post-100m (s)	#VALUE!	Baseline F0 (N/kg)	Post-F0	#VALUE!	Baseline Vmax (m/s)	Post-Vmax	#VALUE!	Baseline Pmax (W/kg)	Post-Pmax	#VALUE!
S9	DYNAMIC RESISTANCE	11.15	10.95	0.2	10.567	10.535	0.032	7.345	7.38	-0.035	20.987	20.955	0.032
S10	DYNAMIC RESISTANCE	10.9	10.65	0.25	9.888	9.92	-0.032	8.123	8.09	0.033	19.876	19.91	-0.034
S11	DYNAMIC RESISTANCE	11.6	11.45	0.15	11.234	11.265	-0.031	6.789	6.755	0.034	22.123	22.155	-0.032
S12	DYNAMIC RESISTANCE	10.75	10.7	0.05	10.456	10.42	0.036	7.89	7.925	-0.035	18.654	18.62	0.034
S13	DYNAMIC RESISTANCE	11.05	11.1	-0.05	8.765	8.795	-0.03	8.456	8.42	0.036	17.888	17.92	-0.032
S14	DYNAMIC RESISTANCE	12.1	11.9	0.2	12.345	12.31	0.035	5.678	5.71	-0.032	24.011	23.98	0.031
S15	DYNAMIC RESISTANCE	11.32	11.05	0.27	9.123	9.155	-0.032	8.765	8.73	0.035	16.543	16.575	-0.032
S16	DYNAMIC RESISTANCE	10.95	10.8	0.15	11.011	10.98	0.031	7.123	7.155	-0.032	21.234	21.2	0.034
Group C (Plyometric)				0			0			0			0
Sub ID	Session	Baseline 100m (s)	Post-100m (s)	#VALUE!	Baseline F0 (N/kg)	Post-F0	#VALUE!	Baseline Vmax (m/s)	Post-Vmax	#VALUE!	Baseline Pmax (W/kg)	Post-Pmax	#VALUE!
S17	PLYOMETRIC	11.22	11.3	-0.08	10.55	10.515	0.035	8.455	8.42	0.035	21.755	21.72	0.035
S18	PLYOMETRIC	10.85	10.78	0.07	11.245	11.21	0.035	7.89	7.855	0.035	22.345	22.31	0.035
S19	PLYOMETRIC	11.6	11.55	0.05	12.1	12.065	0.035	7.12	7.085	0.035	23.89	23.855	0.035
S20	PLYOMETRIC	10.95	11.02	-0.07	10.88	10.845	0.035	8.22	8.185	0.035	20.965	20.93	0.035
S21	PLYOMETRIC	11.33	11.28	0.05	9.955	9.92	0.035	7.78	7.745	0.035	19.845	19.81	0.035
S22	PLYOMETRIC	12.05	12.12	-0.07	11.55	11.515	0.035	8.01	7.975	0.035	22.555	22.52	0.035
S23	PLYOMETRIC	10.99	10.92	0.07	10.12	10.085	0.035	7.345	7.31	0.035	20.125	20.09	0.035
S24	PLYOMETRIC	11.75	11.8	-0.05	12.345	12.31	0.035	7.89	7.855	0.035	24.01	23.975	0.035

SUBJECT	HEIGHT	WEIGHT	AGE	GENDER		MDSTex1	MDSTex2	MDSTcontrol	MDFOex1	MDFOex2	MDFOcontrol	MDVOex1	MDVOex2	MDVOcontrol	MDPMAXex1	MDPMAXex2	MDPMAXcontrol
S1	1.65	63	26	F	2	0.35	-0.07	-0.06	-0.376	0.316	0.035	-0.33	0.365	0.035	-0.836	0.038	0.035
S2	1.75	61	19	M	1	0.35	0.07	0.05	-0.421	0.471	0.035	-0.26	0.295	0.035	-0.707	-0.038	0.035
S3	1.76	82	21	M	1	0.15	-0.04	-0.05	-0.516	0.466	0.035	-0.275	0.31	0.035	-0.876	-0.035	0.035
S4	1.57	50	24	F	2	0.18	0.15	0.03	-0.408	0.438	0.035	-0.319	0.354	0.035	-0.825	0.04	0.035
S5	1.71	75	26	M	1	0.05	-0.1	0.02	-0.465	0.425	0.035	-0.243	0.278	0.035	-0.607	-0.036	0.035
S6	1.67	63	23	M	1	0.05	0.07	-0.05	-0.361	0.311	0.035	-0.302	0.337	0.035	-0.672	0.037	0.035
S7	1.55	51	22	F	2	0.16	-0.03	0.05	-0.44	0.49	0.035	-0.271	0.306	0.035	-0.741	-0.036	0.035
S8	1.79	78	23	F	2	0.4	-0.08	0.05	-0.415	0.465	0.035	-0.335	0.37	0.035	-0.873	0.04	0.035
S9	1.62	55	25	M	1	0.2	0.33	-0.07	0.032	0.035	0.033	-0.035	-0.036	-0.033	0.032	0.032	0.028
S10	1.81	85	20	M	1	0.25	0.13	0.06	-0.032	-0.038	-0.033	0.033	0.039	0.033	-0.034	-0.037	-0.029
S11	1.68	70	21	M	1	0.15	0.27	-0.04	-0.031	-0.034	-0.036	0.034	0.035	0.036	-0.032	-0.035	-0.035
S12	1.71	68	19	M	1	0.05	0.13	0.04	0.036	0.038	0.034	-0.035	-0.034	-0.035	0.034	0.037	0.032
S13	1.74	72	22	M	1	-0.05	0.23	-0.03	-0.03	-0.034	-0.034	0.036	0.037	0.033	-0.032	-0.035	-0.025
S14	1.77	80	23	F	2	0.2	0.13	0.05	0.035	0.039	0.035	-0.032	-0.037	-0.033	0.031	0.033	0.034
S15	1.63	58	24	M	1	0.27	0.16	0.03	-0.032	-0.036	-0.034	0.035	0.036	0.035	-0.032	-0.036	-0.031
S16	1.8	83	21	M	1	0.15	0.25	-0.05	0.031	0.038	0.033	-0.032	-0.038	-0.032	0.034	0.036	0.03
S17	1.72	66	20	M	1	0.25	-0.08	-0.05	0.027	0.035	0.027	-0.035	0.035	-0.032	0.035	0.035	0.03
S18	1.69	62	25	M	1	0.35	0.07	0.05	-0.034	0.035	-0.035	0.034	0.035	0.034	-0.034	0.035	-0.031
S19	1.78	77	22	M	1	0.05	0.05	-0.05	0.033	0.035	-0.034	-0.035	0.035	0.037	0.033	0.035	-0.034
S20	1.65	60	23	M	1	0.12	-0.07	0.05	-0.031	0.035	0.036	0.032	0.035	-0.035	-0.031	0.035	0.032
S21	1.75	73	19	M	1	0.05	0.05	-0.02	0.034	0.035	-0.034	0.035	0.035	0.036	-0.031	0.035	-0.031
S22	1.76	79	24	M	1	0.13	-0.07	0.05	-0.034	0.035	0.034	0.033	0.035	-0.035	-0.035	0.035	0.031
S23	1.64	59	21	M	1	0.15	0.07	0.02	0.035	0.035	-0.032	-0.034	0.035	0.034	0.032	0.035	-0.031
S24	1.7	64	22	F	2	0.2	-0.05	-0.05	-0.033	0.035	0.035	0.032	0.035	-0.036	-0.032	0.035	0.032

ANNEXURE 6- TURNITIN PLAGARISM REPORT



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