

**“FOOTCORE EXERCISES VERSUS CONVENTIONAL FOOT
EXERCISES IN NOVICE BADMINTON PLAYERS AND ITS
EFFECTS ON INTRINSIC FOOT MUSCLE STRENGTH AND
CALF FLEXIBILITY – A RANDOMIZED CONTROLLED TRIAL”**

by

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in

Sports Science

Under the guidance of

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ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE, Bhubaneswar,

Odisha

2024-2025

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List of Abbreviations used

BMI: Body Mass Index

CON: Conventional Training group

FCT: Foot Core Training group

FPI-6: Foot Posture Index

IFM: Intrinsic Foot Muscle

SFE: Short Foot Exercise

WBLT: Weight Bearing Lunge Test

ABSTRACT

Background: The game of badminton being one of the swiftest racket sport the demands of physical capacity are high and skill components like agility and speed are crucial for optimal performance. To meet these demands a novice player needs to master the basics of footwork. Hence the strength and flexibility of intrinsic and extrinsic foot muscles respectively, needs to be worked upon. The aim of this study was to know the effects of footcore training on intrinsic foot muscle strength and calf flexibility using novel IFM dynamometer and WBLT respectively in novice badminton players

Methods: Total of 38 participants were randomly allotted to the footcore training(FCT=18) and conventional foot training group(CON=20) after screening using foot posture index (FPI-6). Novice players aged 9-15years old with FPI-6 score 6 or greater was the target group of this study. The two groups performed the exercises for a period of four weeks two times a day after the demographic details and baseline data for the outcomes intrinsic foot muscle strength(IFM) and weight bearing lunge test(WBLT) were acquired.

Results: The findings prove to be statistically significant that is, there exists a true difference between pre and post IFM measures(Z score: -4.174) and there was a significant difference in pre and post WBLT scores(Z score:- 3.387) for within group analysis using the Wilcoxon signed rank test while the between group analysis for IFM measures and WBLT scores on Mann Whitney U test were 89.000 and Z score: -2.723; 125.000 and Z score: -1.645 respectively indicating that IFM strength improved in the FCT group while WBLT scores did not. Footcore training helped improve intrinsic foot muscle strength in novice badminton players with foot posture index score 6 or greater but not extrinsic foot muscle flexibility.

Keywords: *athlete; foot; muscles; posture; strength*

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Introduction

Badminton is an indoor, non – contact, racket sport played individually or with a partner at competitive and recreational sport levels^[1,2] Its roots can be traced back into the nineteenth century during the British colonisation. The number of participants and its audience has risen past few decades. Indian players have acquired top ranking in the Badminton World Federation (BWF) in categories of both men’s and women’s singles, also the number of men’s singles holding the top 30 ranking is higher compared to other countries^[2,3]

It is considered fastest racket sport as it is extremely high paced demanding excellent physical fitness. In singles category, the demands are even greater as it requires outstanding physical capacities and precise shots. In doubles category, positional play, aggression throughout the game are the most essential components. Overall, badminton demands aerobic strength, quick change of direction, enormous amount of motor coordination, precise racket movements and techniques of accurate shot delivery. Lacunae in any of these may refrain the athlete from performing optimally. The basis for this starts from having a fast and flexible footwork.^[2]

Footwork(movement of foot) is a step movement that regulates the body to place the position in such a way that makes it easier to hit shuttlecock with respect to position of the athlete during the game.^[4,5] Badminton footwork lays the foundation to develop and deliver the shots precisely. Majority of the beginners focus on building the techniques without mastering the footwork which is a complete misnomer as its necessary to have a good footwork and technique simultaneously.^[6]

Determining badminton performance includes thorough evaluation of the footwork. Current trends to assess the footwork (majorly during a lunge movement) is done through the kinetic and kinematic analysis in two dimension or three dimensions that has parameters like velocity at touchdown, vertical ground reaction force peak pressure, maximum force and contact area of the foot, knee and ankle range of motion, foot strike angle, and plantar pressure analysis. In addition,

the other factors are spatiotemporal like approaching speed, total duration and recovery duration, foot contact time, and heel landing time that are used to assess a lunge movement.^[7]

Having quick, justified, precise and flexible movements in appropriate direction defines a good footwork. Training badminton footwork deals with moving ahead while pushing back to the ground at same time, while the other foot took a distant step in the direction of shuttle and this footwork was termed as badminton pedalling step by step. The benefits of having badminton specific foot work are to (1) save the athlete's energy (2) appropriately display offensive defense (3) decrease injuries. As the area available to the athlete is limited it is of utmost importance that he/ she saves energy and performs optimally by judicious use of skills and tactics and the ability to have a reasonable and efficient footwork specific to badminton. To excel in the game of badminton its necessary to adequately adjust the footwork simultaneously with front and back strokes. There are number of training protocols for improving the badminton footwork although less practiced in real life scenario to name a few there are shuttle run and the most popular shadow play^[8]

As stated earlier the physical demands essential for badminton requires addition of repetitive movements, agility, and strength that loads the whole body and making the athlete vulnerable to injury. In addition, insufficient knowledge about the techniques and not being aware of adequate warmup techniques make the novice players prone to injuries.^[9] A study stated that improper use of protective shoe gears and decrease in performance contribute to injuries and the game of badminton justifies it. Appropriate use of footwork or having the ability to adjust the footwork helps overcome the risks of injury.^[8]

Apart from having prone to injuries with insufficient foot work, individuals with flat foot are at a greater risk. Flat feet, medically known as pes planus, involves flattening of the medial longitudinal arch. Factors contributing to flattening of arch are the genetics, injury, and wear

and tear over a period of time. The effects of having a flatfoot on athlete's performance is still a topic of debate and not enough studies exist in the literature to attain a conclusion. However, it is crucial for an athlete to be aware of its significance and adapt as per the needs.

Any disruption or dysfunction in the human anatomy leads to a significant change in the sport performance and flattening of the medial longitudinal arch is no exception. The arch serves the purpose of shock absorption and equally distributing the load enhancing the foot stability during movements. Flattening of the arch makes the athlete vulnerable to injuries (joint and muscles) at the foot and lower limb due to the loss of shock absorption. Other notable risk is that of having the plantar fascia inflamed popularly termed as plantar fasciitis that makes the athlete cumbersome to run, jump or even walk without pain. It is noted that sprains at the ankle are a consequence of having flat feet.

Few studies state that flat feet in athletes may hamper performance as there is lack of arch support and stability, increased risk of injuries, difficulty in proper alignment and balance during movements. Additionally, without the arch's support, the ankle, knee, and hip joints are forced to excessive unequal loading not having to perform optimally.

Flat-footed athletes also commonly experience shin splints, and knee pain as there is compromise in the foot stability; when an athlete lands from a jump or changes direction, the foot pronates excessively causing increased tension at the ankle and knee as well. Repetitive incorrect foot biomechanics that is excessive pronation may cause pain and difficulties performing jump or lunge to be game specific, declining the athlete's performance.

Despite these challenges, there are ways for athletes with flat feet to improve their performance. One of the most effective methods is through proper footwear. Athletic shoes with good arch support can help to reduce the impact of each step and provide additional stability during movements. In addition to footwear, stretching and strengthening exercises can also be helpful

for athletes with flat feet. Exercises that target the muscles in the feet and lower legs can help to improve overall stability and reduce the risk of injury.^[10]

As the game of badminton is a physically and mentally demanding sport that involves quick agile movements, with constant running, jumping and lunging movements it becomes utmost concern to have swift footwork. But having a pronated foot may make it more challenging as it places extra stress on other structures as it cannot roll sufficiently inward, it limits the player's ability to absorb shock effectively. This restriction may cause excessive strain on joints, leading to injuries, while running, jumping and lunging hence to overcome such challenges, they must master the basic badminton footwork that includes shuffle, side step, lunge and jump which commonly involves utilization of intrinsic foot muscle strength in combination with extrinsic foot muscle flexibility.^[8]

The intrinsic foot muscles are the local stabilizers while the extrinsic muscles are the global movers as stated by the work of Patrick O Mckeen et al., 2015. In line with his work, the foot core functions similar to the lumbo-plevic core consisting of sub-systems namely active, passive and neural. For a competitive advantage in sports unrelenting tempo and explosive force demands, flexibility and muscle strength are essential. A player needs to have excellent levels of balance and yet be agile to perform skilful demands of badminton and is quite challenging when a novice player is taken into consideration.

Foot core training fits both of these criteria and its effects on intrinsic foot muscle strength and calf flexibility using novel IFM dynamometer and WBLT isn't studied before. There is limited evidence of foot core training being performed in novice badminton players and also the footwork specific to badminton game as such. The aim of the study is to determine if footcore training can be used to improve the scores of intrinsic foot muscle strength and WBLT in novice badminton players.^[11]

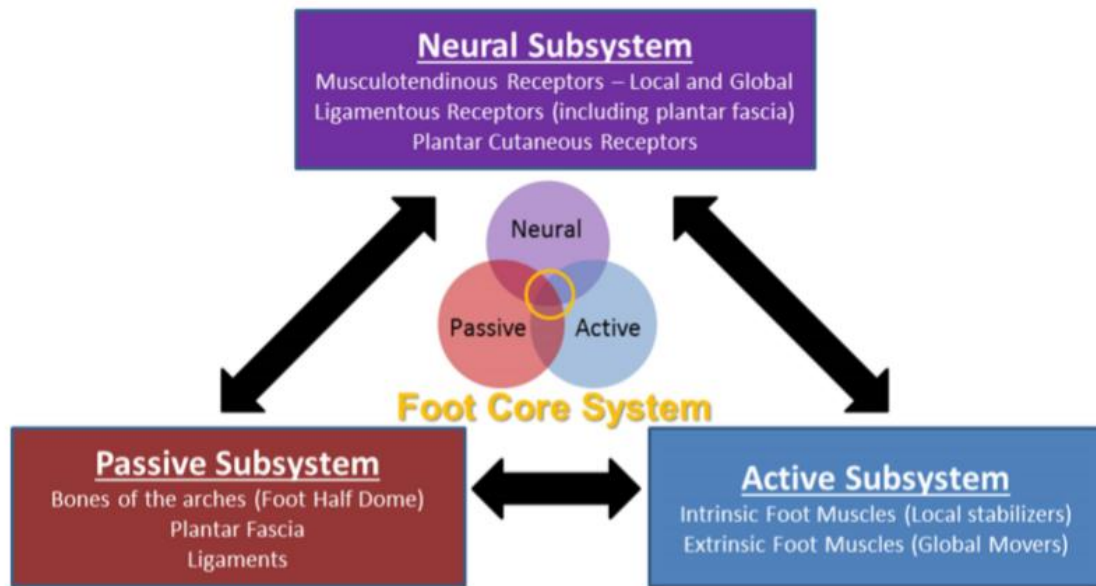


Figure 1: Footcore system adapted from Mckeon et al., 2015

Study Objective

To determine if footcore training can be used to improve the scores of intrinsic foot muscle strength and WBLT in novice badminton players.

Aim of the study

To know the effects of footcore training on intrinsic foot muscle strength and calf flexibility using novel IFM dynamometer and WBLT respectively in novice badminton players.

Need for the study/

Study Rationale

There are enormous studies done to improve overall performance of badminton athletes but a very few on younger individuals of the age group 9-15years. This is the particular age group for development of an athlete to emerge out as a professional having to face many developmental concerns. Among the developmental concerns usually the common ones include Osgood Schlatter disease, medial longitudinal arch formation.

Having a flat medial longitudinal arch is very common, but adjustments can be made as numerous orthotics supports and shoes specifically designed to overcome the effects of having a flattened arch. However, it is difficult to study the difference in having developed flat arch or if the arch is not yet developed there is no substitution for intrinsic foot muscle strength and extrinsic foot muscle flexibility.

Also, there is paucity in studies that address these issues and also lack specific protocols that needs to be administered based on their needs. For a competitive advantage in sports unrelenting tempo and explosive force demands, flexibility and muscle strength are essential. A player needs to have excellent levels of balance and yet be agile to perform skilful demands of badminton and is quite challenging when a novice player is taken into consideration.

Foot core training fits both of these criteria and its effects on intrinsic foot muscle strength and calf flexibility using novel IFM dynamometer and WBLT isn't studied before. There is limited evidence of foot core training being performed in novice badminton players and also the footwork specific to badminton game as such.

Clinical Significance

Foot core training helps improve intrinsic foot muscle strength and extrinsic foot muscle flexibility. As noted earlier in the study by McKeon et al., in 2015 footcore training deals with various components of the foot it is necessary to address all these components separately to gain better outcome and enhance performance. Also, badminton is such a sport that demands extensive and robust fitness levels and the basis for it lies in mastering the footwork or having a flexible footwork that is pliable to swift and precise shots. In order to perform at ones' best the athlete must require enormous strength that has a pivotal role in enabling them to be agile and play with minimal efforts for a long duration of time. Footcore training may have proving effects to strengthen the intrinsic foot muscles and provide flexibility to the calf.

The training includes exercises that focus on maintaining the subtalar neutral position and performing them progressively based on the athlete's capability to hold certain position effortlessly. Majority of the protocols aimed to improve foot muscle strength often tend to neglect to address all the components of the footcore system. Hence, the results of the study add onto already existing literature that the components of the system when addressed isolated have better outcomes and proves as a basic framework for achieving strength and flexibility at the foot muscles.

Novelty of the study

There are few ways to measure strength of the foot muscles due to their physiological cross-sectional area being small it becomes even more tedious to measure. However, there exist countable ones which are expensive and using them is also a complicated process. Literature also states that it is quite a challenge to quantify the intrinsic foot muscle strength. To overcome the challenge of quantifying the intrinsic foot muscle strength and having a cost-effective instrument there was study in 2023 by Jennifer Xu et al., which brought light into use of novel IFM dynamometer to quantify intrinsic foot muscle strength. This study used the same instrument for documenting the intrinsic foot muscle strength changes after footcore training.

Hypotheses of the study

Null hypothesis

Footcore training will not improve intrinsic foot muscle strength, calf flexibility in novice badminton players.

Alternate hypothesis

Footcore training will improve intrinsic foot muscle strength, calf flexibility in novice badminton players.

Review of literature

1) **“The Effects of Intrinsic Foot Muscle Strengthening on Foot Posture, Balance, and Agility in Ice Hockey Players”**

A study conducted by **Rebecca Eve Veltrie in 2020** titled “The Effects of Intrinsic Foot Muscle Strengthening on Foot Posture, Balance, and Agility in Ice Hockey Players” in which 28 ice hockey players were divided into Foot Core Intervention Training group and Traditional foot training group with 14 participants in each group and checked for Star Excursion Balance Test, S-Cornering hockey agility drill, FAAM ADL and Sport, the navicular drop test as study outcomes concluded that both the short foot exercises and traditional exercises can provide a positive impact on balance, foot posture and agility within ice hockey athletes after four weeks.^[12]

2) **“Foot Core Training to Prevent Running –Related Injuries- A Survival Analysis of a Single – blind Randomized Controlled Trial”**

In **2020** a study titled “Foot Core Training to Prevent Running –Related Injuries- A Survival Analysis of a Single – blind Randomized Controlled Trial” conducted by **Ulisses T. Taddei et al** involved 118 recreational runners who were assigned to Intervention group (57) and Controlled group (61) were analysed for incidence of running related injuries and inferred that the intervention group had lower injury rates than the other group and the foot exercise program showed evidence of effective RRI risk reduction in recreational runners at 4 to 8 months of training.^[13]

3) **“Effects of Foot-Core Training on Foot- Ankle Kinematics and Running Kinetics in Runners: Secondary Outcomes From a Randomized Controlled Trial”**

A randomized controlled trial- “Effects of Foot-Core Training on Foot- Ankle Kinematics and Running Kinetics in Runners: Secondary Outcomes From a Randomized Controlled Trial” by **Alessandra B Matias et al.**, in **2022** had 87 recreational runners, assigned to IG=41 and CG=46 with outcomes -Primary outcome: incidence of running related injuries, Secondary outcomes: time of occurrence of first injury, foot health and functionality, foot ankle knee kinematics ankle and knee joint moments and ankle and knee power during walking and running, strength of intrinsic foot muscles, foot muscle trophism, dynamic foot arch strain concluded that exercise program significantly changed the kinematic patterns of the ankle, tarso-metarsal, midtarsal, and MPT joints and some of the biomechanical risk factors for RRI, such as MLA ROM and rear foot angle. Recreational runners landed with a significantly less dorsiflexed midfoot, and a more inverted calcaneus compared to controls. At midstance, runners run with a significantly more abducted hallux, a less plantarflexed and more adducted forefoot. Intervention resulted in a push-off with a significantly less dorsiflexed midfoot, a less adducted and more plantarflexed hallux.^[14]

4) **“Effects of a 12-week gait retraining program combined with foot core exercise on morphology, muscle strength, and kinematics of the arch: A randomized controlled trial”**

“Effects of a 12-week gait retraining program combined with foot core exercise on morphology, muscle strength, and kinematics of the arch: A randomized controlled trial” by **Bin Shen et al.**, in **2022** had 26 male recreational runners in the study divided into INT= 13 and CON=13 groups further were analysed for Arch morphology, Arch muscle strength, Arch kinematics and stiffness inferred that 12-week gait retraining program combined with foot core exercise

improved the arch in both static and dynamic positions with a moderate to large effect size, demonstrating the superiority of this combined intervention over the stand alone interventions.^[15]

5) “Evidence for Intrinsic foot muscle Training in Improving Foot Function: A Systematic Review and Meta-Analysis”

A study “Evidence for Intrinsic foot muscle Training in Improving Foot Function: A Systematic Review and Meta-Analysis” by **Abbis H Jaffri in 2023 included eleven studies that looked for** Balance, Strength, Patient reported outcomes, Sensory function, Motor performance stated that IFM exercises improved balance and strength, reduced self- perceived disability and lowered navicular drop and foot posture index. Sensory and motor function was also improved with IFM exercise.^[16]

6) “A Novel Intrinsic Foot Muscle Strength Dynamometer Demonstrates Moderate-To-Excellent Reliability and Validity”

Jennifer Xu et al., conducted a study in **2023** titled “A Novel Intrinsic Foot Muscle Strength Dynamometer Demonstrates Moderate-To-Excellent Reliability and Validity”. The purpose was to investigate the intra-rater and inter-rater reliability of a novel, budget-friendly IFM dynamometer and determine its agreement with a handheld dynamometer (HHD). The researchers also examined correlations of foot morphology and activity level to IFM strength. A total of 34 healthy volunteers 4 males 30 females were included in the study concluding that the novel IFM dynamometer is a budget-friendly tool that was shown to be reliable {intra- and inter-rater reliability was moderate-to-excellent (ICC = 0.73 – 0.95)}, and valid in a healthy population.^[17]

7) “Normative Data for Calf Muscle Flexibility Tested by Weight Bearing Lunge Test”

A study titled “Normative Data for Calf Muscle Flexibility Tested by Weight Bearing Lunge Test” conducted by **Riddhi Gohil et al., in 2022** aimed to provide normative data using weight bearing lunge test that evaluates tightness in functional position for which 215 subjects (Males=100, females=115) were involved. The values are as follows Males: right: 12.1-13.4cm and left: 12.7-13.9cm, Females: right: 13.6-14.9cm and left: 1.9-14.9cm^[18]

8) “Effect of intrinsic foot muscles training on foot function and dynamic postural balance: A systematic review and meta-analysis”

A study “Effect of intrinsic foot muscles training on foot function and dynamic postural balance: A systematic review and meta-analysis” by **Wei Z et al., in 2022** analysed the effects of intrinsic foot muscle (IFM) training on foot function and dynamic postural balance. The studies exploring Short foot exercises (SFE), Toe posture and hallux-extension drills, Towel curls, MPJ loading protocols, Combined foot–ankle stability exercises were included in the systematic review. The results were: decrease in navicular drop, decrease in scores of foot posture index concerning the medial longitudinal arch also the dynamic postural index was enhanced and no changes observed in IFM muscle strength and morphology^[19]

9) “The Influence of Plantar Short Foot Muscle Exercises on the Lower Extremity Muscle Strength and Power in Proximal Segments of the Kinematic Chain in Long-Distance Runners”

Sulowska I et al., in 2019 conducted a study- “The Influence of Plantar Short Foot Muscle Exercises on the Lower Extremity Muscle Strength and Power in Proximal Segments of the Kinematic Chain in Long-Distance Runners” that evaluated the effects of plantar short foot muscle exercise in long distance runners with respect to lower limb performance. There were two groups in which the first group had runners with neutral foot and the second with slight

and increased pronation. Exercises were performed daily for 6 weeks; knee flexors and extensors torque, work, and power on Isokinetic Dynamometer and Running-Based Anaerobic Sprint Test (RAST) were the outcomes used. Higher values of peak torque of knee flexors were observed. Second group showed statistical significance and the short foot exercises may be included in the runners daily routine.^[20]

10) **“Damage and recovery of the intrinsic and extrinsic foot muscles from running a full marathon”**

“Damage and recovery of the intrinsic and extrinsic foot muscles from running a full marathon” was a study conducted by **Fukano M** et al., in **2023** that evaluated what effects intrinsic and extrinsic foot muscles had on marathon running in relation to height change of the longitudinal foot arch after the race. Transverse relaxation time (T2) of the abductor hallucis, flexor digitorum brevis, quadratus plantae, flexor digitorum longus, tibialis posterior, and flexor hallucis longus were measured before and 1, 3, and 8 days after the race using magnetic resonance imaging. To assess foot posture in three dimensions foot scanner system was used before and after 1,3 and 8 days of the race. As a result, there was a marathon induced increase noted in T2 for the muscles like quadratus plantae, flexor digitorum longus, tibialis posterior, and flexor hallucis longus also it was inferred that there exists a correlation between recovery of the intrinsic and extrinsic foot muscles arch height ratio.^[21]

11) **Predictive Effect of Well-Known Risk Factors and Foot-Core Training in Lower Limb Running-Related Injuries in Recreational Runners- A Secondary Analysis of a Randomized Controlled Trial**

Predictive Effect of Well-Known Risk Factors and Foot-Core Training in Lower Limb Running-Related Injuries in Recreational Runners- A Secondary Analysis of a Randomized Controlled Trial by Suda EY et al., in 2021 aimed to evaluate if the predictive effects of already

established risk factors and shielding factor that is foot-core training on the incidence of lower limb running related injuries in mid and long- distance recreational runners. 118 runners were divided into intervention and control group and the intervention group performed the set of exercise for about 8weeks thrice weekly. A follow up was done after a year and the logistic regression inferred that foot-core training had a guarding role against lower extremity running related injuries, in addition increased age and training volume makes the runner vulnerable to injuries.^[22]

12) Nonsurgical Approach in Management of Tibialis Posterior Tendinopathy With Combined Radial Shockwave and Foot Core Exercises: A Case Series

Nonsurgical Approach in Management of Tibialis Posterior Tendinopathy With Combined Radial Shockwave and Foot Core Exercises: A Case Series by Robinson D et al., in 2020 investigated the effects of adding radial shockwave therapy with a foot core exercises like “foot doming,” “toe yoga,” intrinsic toe abduction/adduction, single-leg balance tasks, and weighted calf raises in patients with refractory tibialis posterior tendinopathy who didn’t find betterment on conservative treatment. Foot and Ankle Ability Measure was the outcome used and concluded that after four months of non -invasive radial shock wave therapy and foot core exercises; this protocol can be used to treat tibialis posterior tendinopathy.^[23]

13) “Effects of 4 Weeks of High-Definition Transcranial Direct Stimulation and Foot Core Exercise on Foot Sensorimotor Function and Postural Control”

“Effects of 4 Weeks of High-Definition Transcranial Direct Stimulation and Foot Core Exercise on Foot Sensorimotor Function and Postural Control”- a study by Xiao S et al., in 2022 explored the effects of high-definition transcranial direct current stimulation and foot core exercises on foot sensorimotor function which includes toe flexor and MPJ strength, passive ankle kinesthesia and postural control had on healthy young adults. 36 participants were

involved in this study for four weeks receiving three sessions per week. It was inferred that the training regime can be used for improving foot sensorimotor function and foot posture control and highlights the improvements on balance while eyes closed.^[24]

14) **“Subgroups of Foot-Ankle Movement Patterns Can Influence the Responsiveness to a Foot-Core Exercise Program: A Hierarchical Cluster Analysis”**

Watari R et al., conducted a study titled- “Subgroups of Foot-Ankle Movement Patterns Can Influence the Responsiveness to a Foot-Core Exercise Program: A Hierarchical Cluster Analysis” in 2020 whose objective was to identify similar clusters of movement patterns in the foot and ankle in recreational runners to evaluate normal kinematic patterns to foot-core exercises. The protocol lasted for eight weeks and the exercise session was monitored by physical therapist that included exercises like towel curls, doming, toe spreading, balance board drills. The participants were divided into two clusters where one cluster had runners with forefoot abduction patterns and the other with runners demonstrating rearfoot adduction and midfoot abduction. After 8 weeks it was found that first cluster had decreased forefoot abduction, increased rearfoot adduction and midfoot dorsiflexion, which were appearing to be similar to that of the second cluster while the second cluster demonstrated little to no change as a response to the protocol.^[25]

15) **“Running Intralimb Coordination Patterns After a Foot Core Exercise Program in Recreational Runners”**

“Running Intralimb Coordination Patterns After a Foot Core Exercise Program in Recreational Runners”- a study by **Suda EY et al.**, in 2024 aimed at investigating what effects an eight-week footcore strength training has on intra- limb coordination utilizing the vector coding techniques. There were two groups involved in this study where the intervention group performed the exercises three times per week while the other was a placebo group. To capture

the foot segment motion the participants ran on a treadmill and it was inferred that, the protocol assists in decreasing the running related by enhancing the resistance to calcaneus pronation and providing rigidity and support while the limb is in push- off phase of running.^[26]

16) “Effect of Incorporating Short-Foot Exercises in the Balance Rehabilitation of Flat Foot: A Randomized Controlled Trial”

A study by **Moon D et al.**, titled- “Effect of Incorporating Short-Foot Exercises in the Balance Rehabilitation of Flat Foot: A Randomized Controlled Trial” in 2021 explored the effects of sensorimotor training alone versus sensorimotor training along with short foot exercises in individuals with flatfeet. There were 32 participants involved in the study who further were divided into two groups that is the one which performs sensorimotor training alone and the other that performs sensorimotor training along with short foot exercises for three times a week for six weeks. After six weeks static and dynamic balance were assessed which improved in the combination of treatment group while there was no significant change in other counterpart.^[27]

17) “The Influence of Plantar Short Foot Muscle Exercises on Foot Posture and Fundamental Movement Patterns in Long-Distance Runners, a Non-Randomized, Non-Blinded Clinical Trial”

A study by **Sulowska I et al.**, titled “The Influence of Plantar Short Foot Muscle Exercises on Foot Posture and Fundamental Movement Patterns in Long-Distance Runners, a Non-Randomized, Non-Blinded Clinical Trial” -investigated the effects of plantar short muscle exercise on foot posture index and functional movement screen for which twenty -five long-distance runners aged 22–35 years were considered. The runners were divided into two groups where the first group performed “Vele’s Forward Lean” and “Reverse Tandem Gait” and other performed the “Short Foot Exercise.” After a period of six weeks the runners were assessed for

FPI and FMS and was concluded that short foot muscles strengthening exercises had improved the inversion/eversion of the calcaneus component in FPI and can be used in the daily training.^[28]

18) **“The effect of short foot exercise using visual feedback on the balance and accuracy of knee joint movement in subjects with flexible flatfoot”**

In 2020, a study by **Kim SJ et al.**, was conducted titled- “The effect of short foot exercise using visual feedback on the balance and accuracy of knee joint movement in subjects with flexible flatfoot” aimed to find out the influence short foot exercise had with visual feedback affects for which 30 participants were divided to 2 groups they were the flexible flatfoot group and normal foot group. All subjects performed the SFE with visual feedback for 20 minutes a day, 5 times a week for 5 weeks. The static balance improved in the flexible flatfoot group and no change in normal foot group was observed. Also, the accuracy of knee movements were significantly gained in closed kinetic chain.^[29]

19) **“Short foot exercises have additional effects on knee pain, foot biomechanics, and lower extremity muscle strength in patients with patellofemoral pain”**

“Short foot exercises have additional effects on knee pain, foot biomechanics, and lower extremity muscle strength in patients with patellofemoral pain” is a study by **Kisacik P et al.**, in 2022 explored what effects Short Foot Exercises had on knee pain, foot biomechanics, and lower limb muscle strength in individuals with patellofemoral pain. There were 30 participants with a ‘weak and pronated’ who were divided into two groups; the control group performed hip and knee strengthening and stretching while the other performed short foot exercises along with hip and knee strengthening and stretching for six weeks. Outcomes used in the study were pain visual analogue scale, Kujala Patellofemoral Score, navicular drop test, rear foot angle, foot posture index, and lower limb strength tests. The pain score reduced in short foot exercise

group and control group while navicular drop test scores, rear foot angle score and foot posture index score was higher in control group indicating that inclination towards short foot exercises has a role in overcoming impairments associated with patellofemoral pain. Involving short foot exercises as a part of training protocol or in rehabilitation of patellofemoral pain have proven to improve the outcomes as it provides greater stability which has a beneficial role over other joints that is hip and knee.^[30]

Methodology

Research study design: Randomized controlled trial

Study Population: Novice badminton players(9-15yrs)

Study Setting: Regional Sports Authority of India Badminton Academy- Shaeed Nagar and Power Shuttle Badminton Academy- Millenium city, Bhubaneshwar

Sampling Design: Simple Random sampling

Sampling Criteria:

Inclusion: (1) Novice badminton players aged 9-15 years (male and female) with FPI score: +6 or greater (2) Players' training past a year to participate at competitive levels (3) A weekly badminton training duration of minimum 4hrs (4) No prior experience of isolated foot and ankle strengthening.

Exclusion: (1) Players receiving any kind of physical therapy intervention to lower limb (2) Players with lower limb injuries past 6 months (3) Players with any lower limb musculoskeletal injury or pain that might lead to stopping of badminton practice

Sample Size: Calculated using the formula for experimental studies that is $n = \frac{2k * SD^2}{d^2}$ where, n= number of samples, k= power, SD = standard deviation, d= MCID value

Duration: One year

Materials to be used: novel IFM dynamometer, inch tape, white tape, wall

Outcome Measures: IFM dynamometer, Weight Bearing Lunge Test

Study Design

The study is a randomized controlled trial conducted at the SAI Badminton academy and Power Shuttle Badminton Academy Bhubaneswar that involves foot core training group and traditional foot training group respectively. It consists of total 34 participants with 17 in each group. Sample Size was calculated using G-power with: effect size=1, $\alpha= 0.05$, power= 0.80, $N2/N1= 1$, Total Sample= 34 and in each group= 17 participants

Outcome Measures

Novel -Intrinsic Foot Muscle(IFM) dynamometer

To measure the intrinsic foot muscle strength the novel IFM dynamometer was used in which the athlete was in crook lying position and the assessor placed the card that is attached to dynamometer underneath the foot to be tested while the athlete was instructed to apply pressure on the card that was placed and held for 10sec and the reading was noted in the instrument either in pounds or kg. Both the extremities were measured.



Figure 2: Novel IFM dynamometer



Figure 3: Reading on the dynamometer

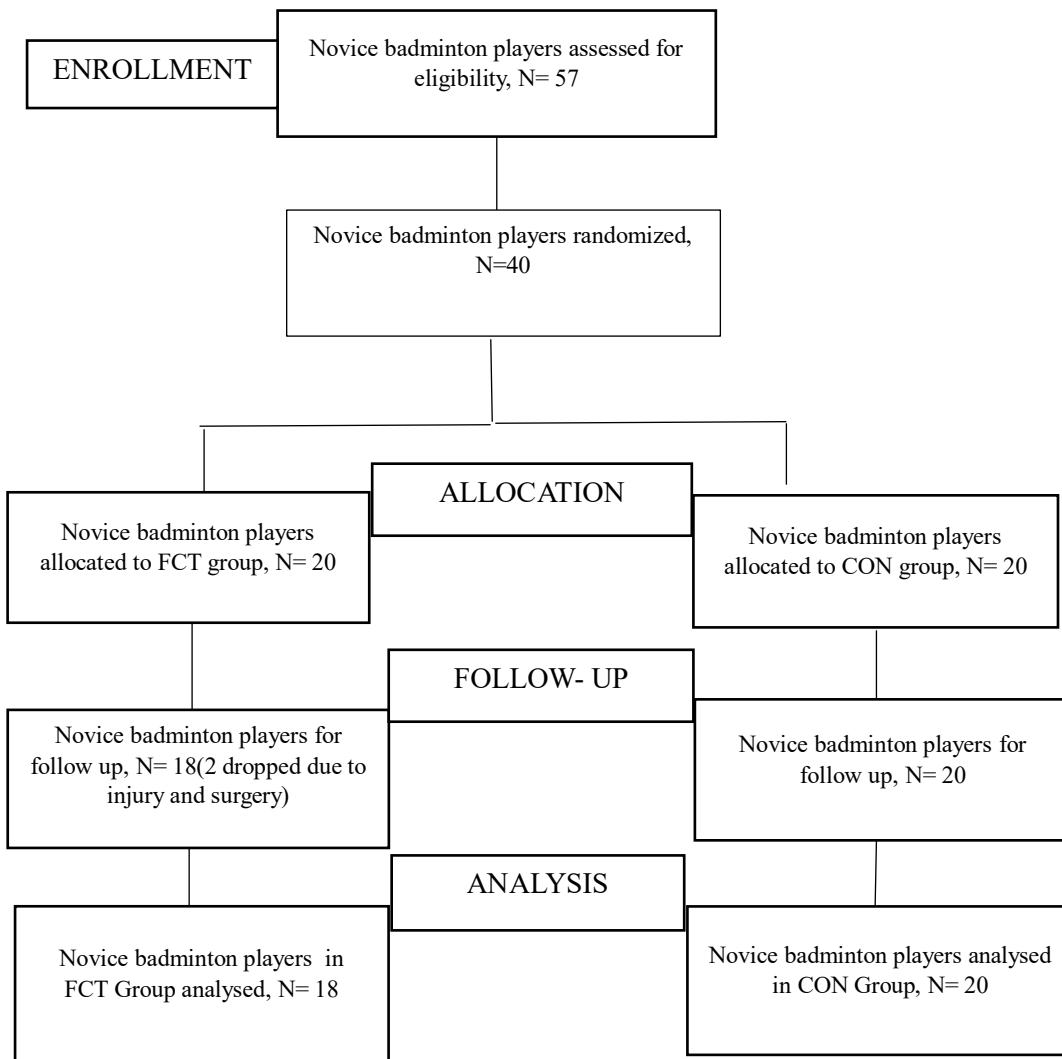
Weight Bearing Lunge Test (WBLT)

Weight bearing lunge test in this study was used to measure flexibility of the calf muscle for this the athlete had to place his/her foot on the inch tape stuck on the ground in a straight line so that heel and second toe appeared to lie as one unit. The athlete placed the foot at 90 degrees angulation to the wall as if he/ she attempts to perform a lunge in the direction of wall. The athlete then holds that position in a maximum dorsiflexed range of motion. The leg to be tested for calf flexibility is the one that was placed on the inch tape and the distance that athlete moved with the dorsiflexed ankle without lifting his/ her heel above the ground is taken into account as the measure for his/ her flexibility at the calf. Both the extremities were measured.



Figure 4: Test position of weight bearing lunge test

CONSORT flow chart



Interventions

The intervention group or the footcore group and control group or conventional foot exercise group participants both performed plantar fascia massage for about 2min either by themselves or a tennis ball was used for the same following which the groups respectively performed their set of exercises as told to them which are as follows:

FOOTCORE EXERCISES

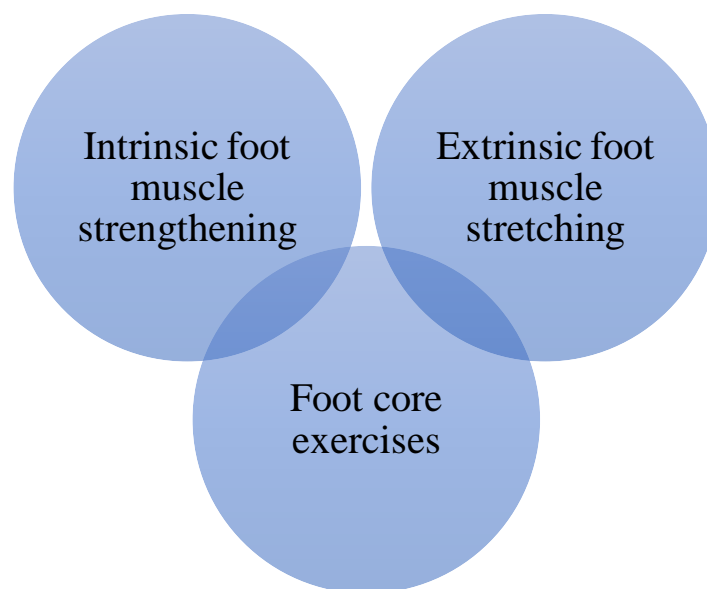


Figure 5: Foot core training depiction

Intrinsic foot muscle strengthening

Short Foot Exercise

1. The athlete was taught to sense the subtalar position that is, the athlete was asked to place both the feet on the ground sitting in a comfortable position and then bring his/ her heel closer to the great toe. Once this awareness regarding subtalar neutral was achieved they were taught the actual footcore exercises.
2. The athlete was instructed to create a dome at the medial side of his/ her feet and then hold it for about 10 seconds and then relax. The protocol was set to 10 repetitions for 10 seconds hold for 3sets.
3. This is progressed each week. The progression consisted of seated, then standing, then to single leg standing with support and finally single leg standing without support.
4. The athlete performed this bilaterally.



Figure 6: Short foot exercise

Toes-Spread-Out Exercise

- 1.The athlete then performed the next exercise that involved spreading the toes while maintaining the foot in contact with the ground for 10 seconds.
- 2.Then the athlete performed it while maintaining the great toe in contact with the ground while lifting the other toes followed by the fifth toe touching the ground and other toes extended up. At the end the great toe and fifth toe touched the ground while keeping the other toes extended.
- 3.The athlete performed this exercise for 3 sets of 10 repetitions each progression.
- 4.The athlete performed this bilaterally and simultaneously.

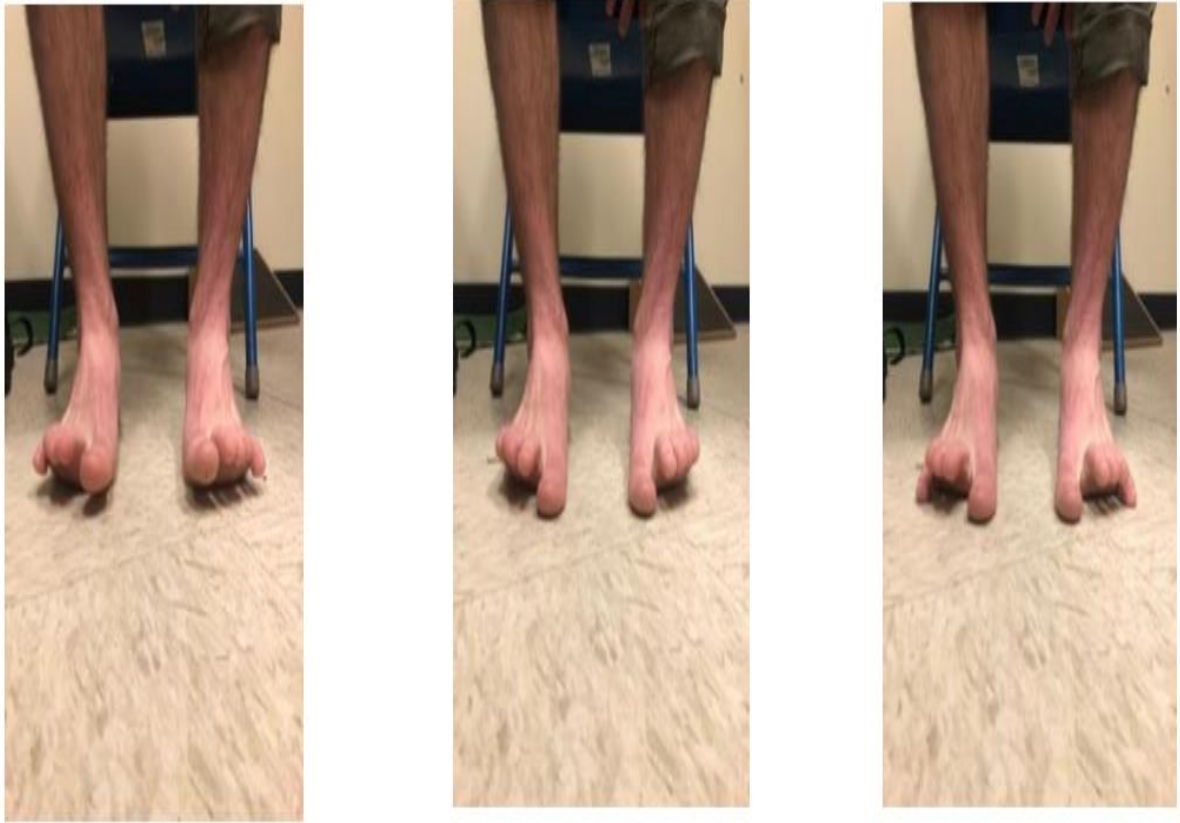


Figure 7: Foot core exercises performed in sitting

Extrinsic foot muscle stretching- CALF Stretch with 30sec hold for three times

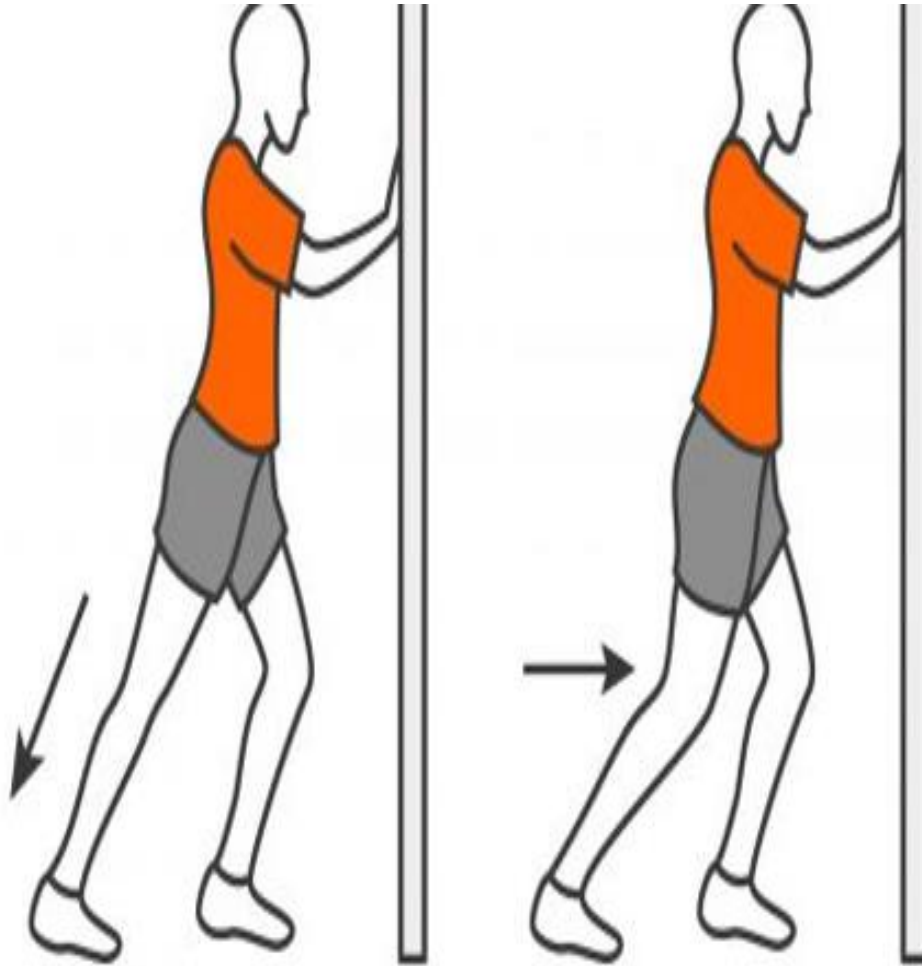


Figure 8: Calf stretch

CONVENTIONAL FOOT EXERCISES

Towel curl exercises

- 1.The athlete performed this exercise with a towel placed underneath the foot, in sitting, where he/ she was asked to bring their toes closer as if it appeared to be curling the towel with feet.
- 2.The athlete held it for about 3 seconds and performed it thrice.
- 3.The athlete performs this bilaterally alternating feet.



Figure 9: Towel curl

Foam Pick Ups

1. The athlete was asked to pick up the foam pieces lying on the floor with the help of their toes and drop them in a container placed next to them.
2. The athlete had to pick 15 pieces of foam from the left as well as from the right for three sets.
3. The athlete performed this bilaterally, alternating the feet.

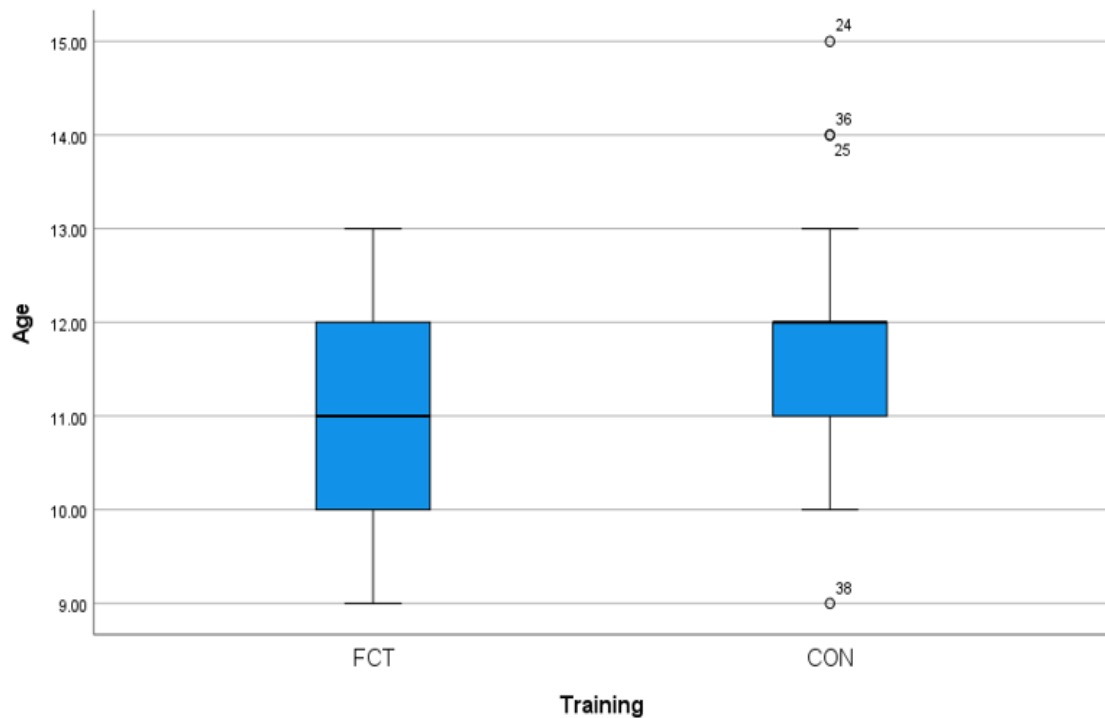
Results and Statistical Analysis

Descriptive statistics

Baseline characteristics	Footcore training group	Conventional training group	p-value
Participants	N=18	N=20	
Age	10.95	11.7	0.107
Gender	Females= 7 Males= 11	Females= 6 Males= 14	0.052
Weight(kg)	33.61	39.35	0.022
Height(cm)	141.86	146.85	0.142
Body Mass Index	16.51	18.17	0.025

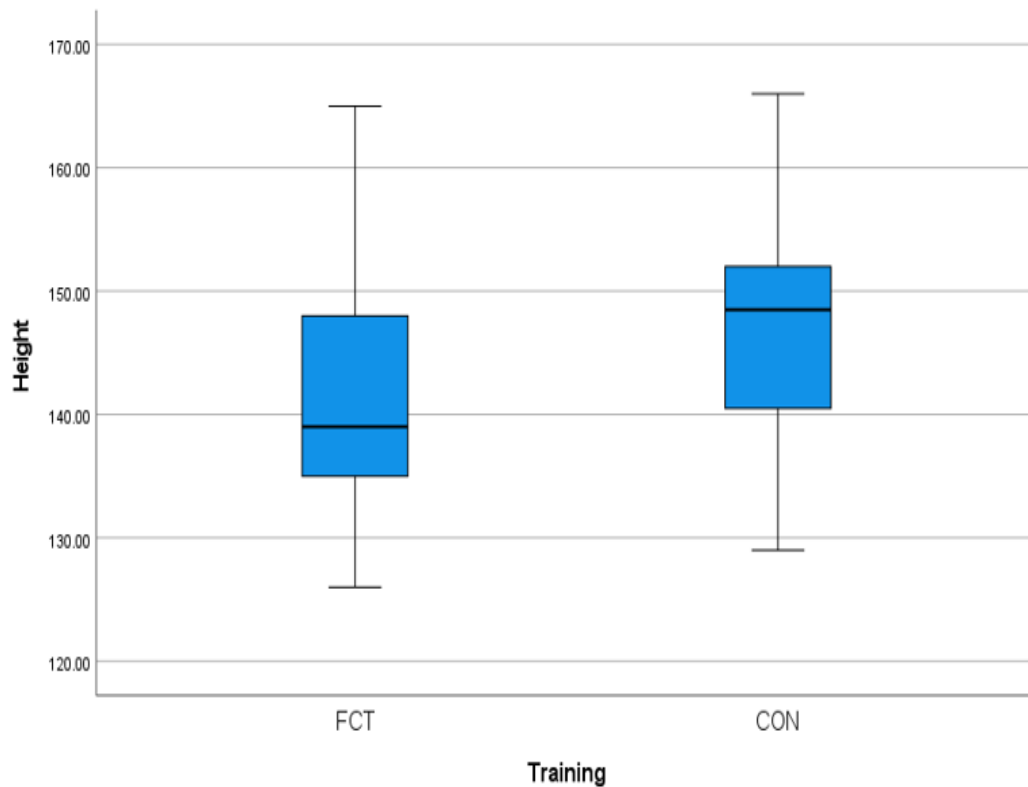
Table 1: Shows Demographic details

Considering the p value to be significant at 0.05 and values greater than this would be not statistically significant the following are taken into account that is: gender (p value= 0.052) is borderline significant, weight (p value= 0.022) is statistically significant, height (p value= 0.142) is not significant, body mass index (p value= 0.025) is statistically significant.



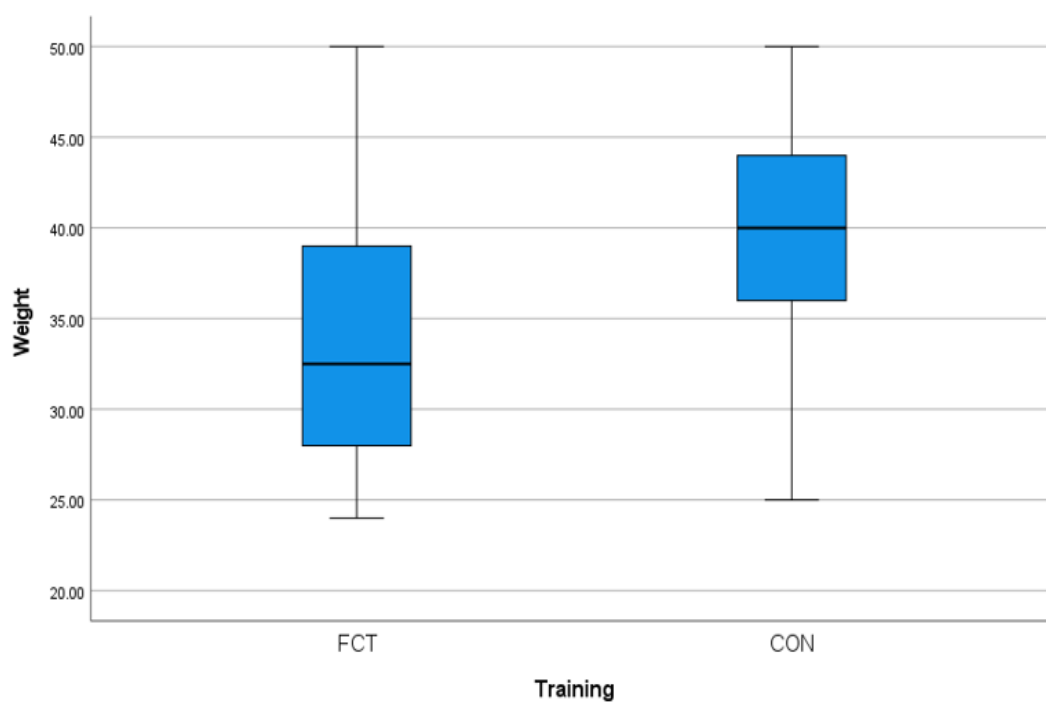
Graph 1: Box plot comparing the distribution of age of novice badminton players in footcore training group and conventional foot exercises group.

The median age indicated by the line inside the box is slightly lower for the FCT group compared to CON group. Also, the interquartile range that is the height of the box for FCT is larger than CON indicating that there is more variability in ages within the FCT. The age distributions are comparable between FCT and CON groups while FCT has slightly lower median age and more variability.



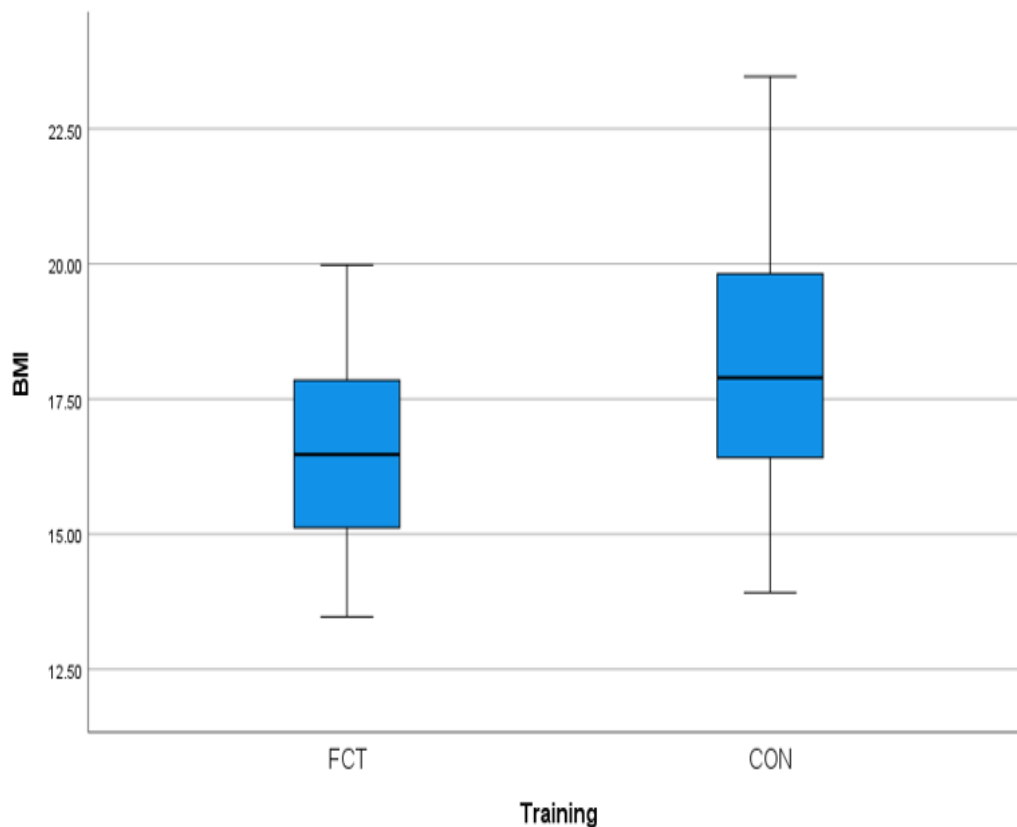
Graph 2: Box plot comparing the heights of novice badminton players in the FCT and CON groups.

The dark line inside the box represents the median height. The median for CON is slightly higher than FCT group and the interquartile range for CON is slightly higher and wider compared to the FCT. Both the groups have a similar range making them comparable while the CON group trends appear to be higher when heights are compared.



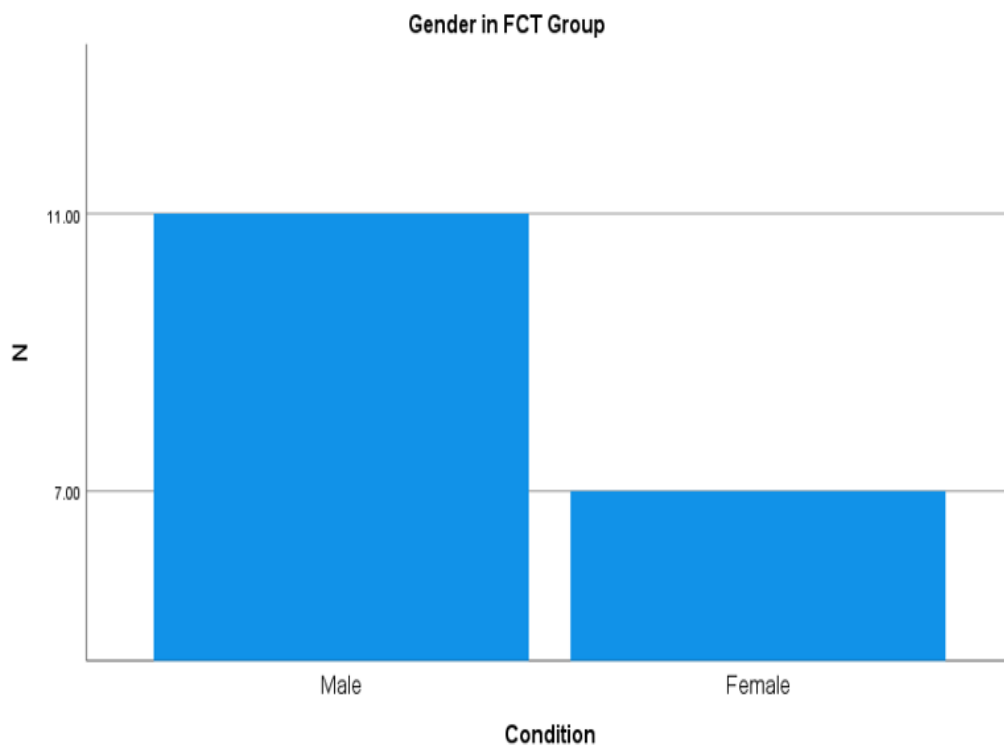
Graph 3: Box plot comparing the weights of novice badminton players in the FCT and CON groups.

The median weight is indicated by the line inside the boxes which is lower in the FCT group compared to CON group which suggests that FCT group players have lower weights than CON group. The interquartile range for FCT group is slightly narrower than for the CON group indicating less variability in weights in FCT group.

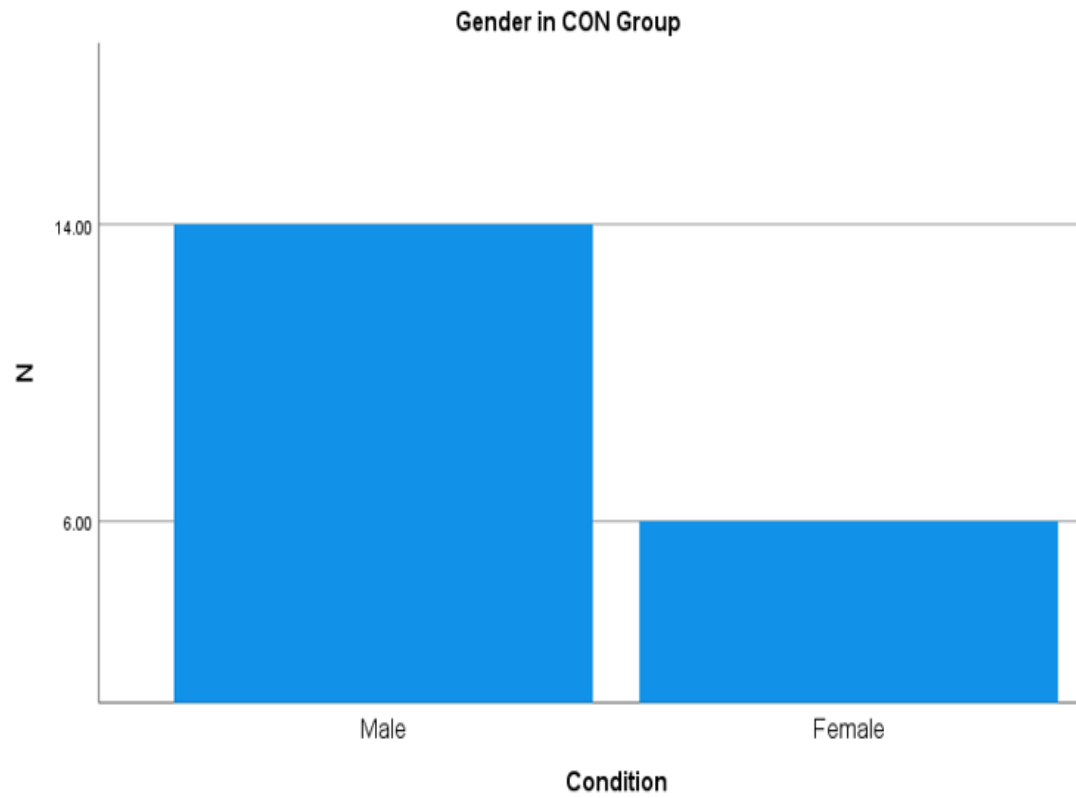


Graph 4: Box plot comparing the body mass index of novice badminton players in the FCT and CON groups.

In the FCT group the median BMI is lower compared to the CON group, interquartile range is smaller indicating that there is less variability in BMI among the group. In the CON group the median BMI is higher and interquartile range is larger showing more variability.



Graph 5: Bar graph demonstrating the distribution of males and females in the FCT group. It indicates the number of females are less in number compared to the males in the FCT group.



Graph 6: Bar graph demonstrating the distribution of males and females in the CON group. It indicates the number of females are less in number compared to the males in the CON group.

Tests of Normality

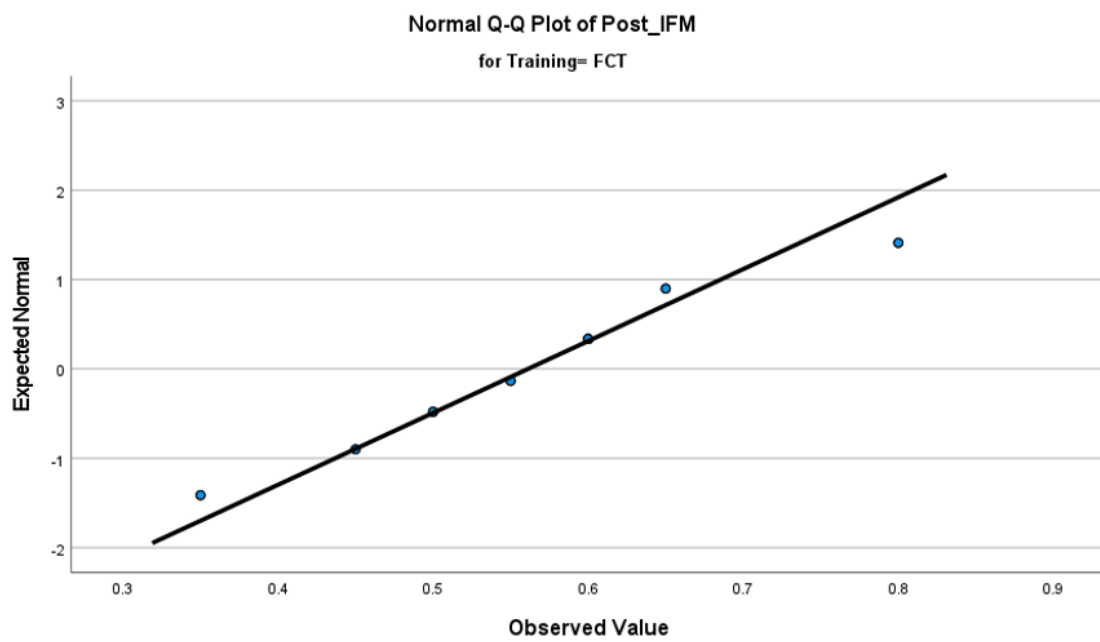
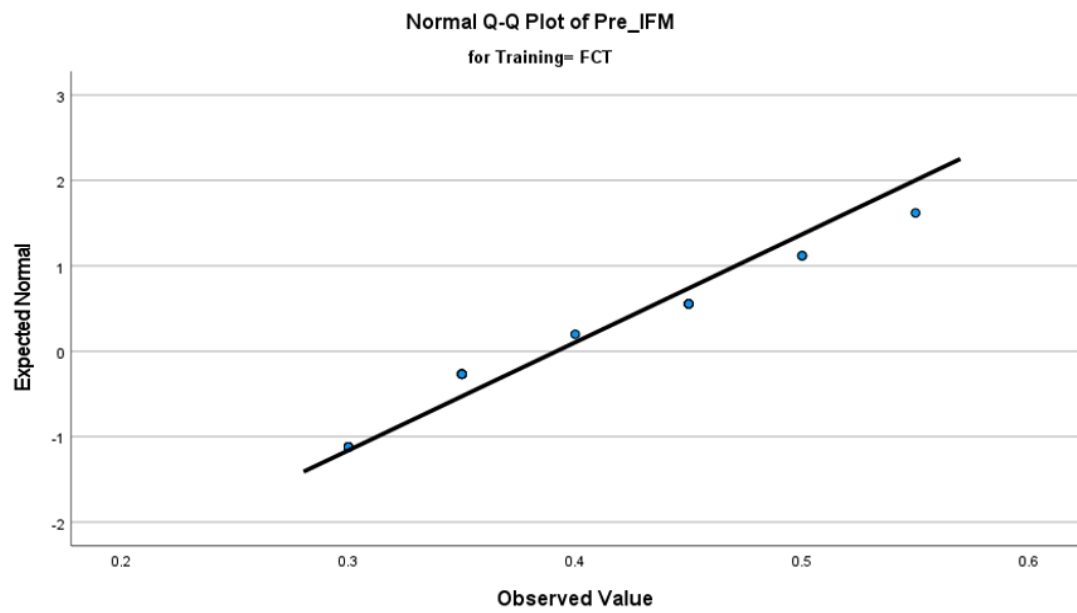
As the sample size is less than 50 that is 38(FCT= 18 and CON = 20) Shapiro- Wilk test was used to check normality.

Training	Group	Statistics	Difference(df)	Significance
PRE IFM	FCT	0.889	18	0.037
	CON	0.953	20	0.413*
PRE WBLT	FCT	0.865	18	0.015
	CON	0.868	20	0.011
POST IFM	FCT	0.942	18	0.309*
	CON	0.955	20	0.450*
POST WBLT	FCT	0.956	18	0.520*
	CON	0.911	20	0.066*

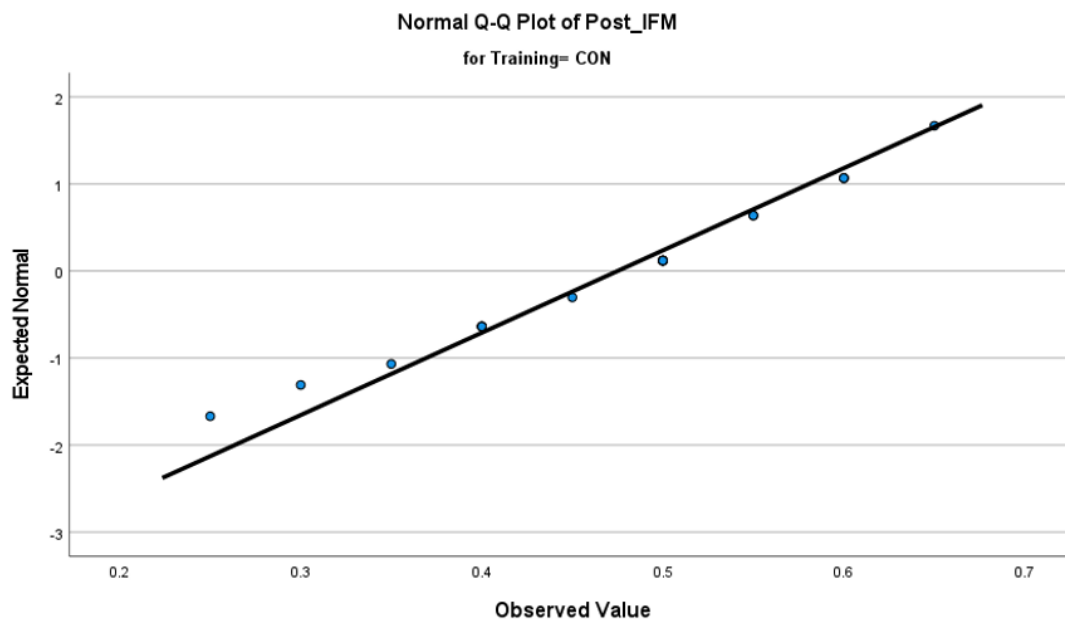
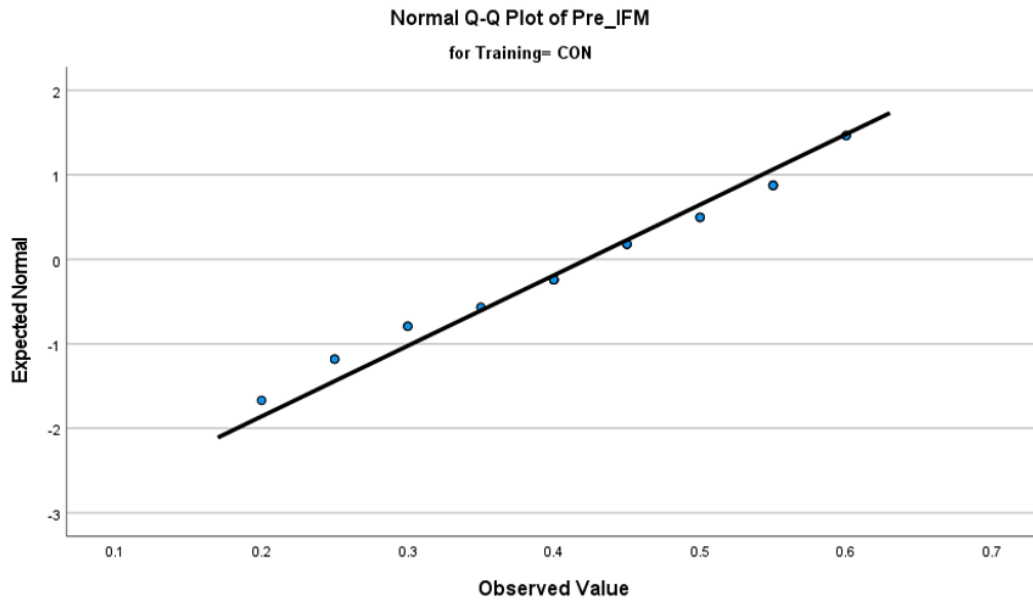
Table 2: Shows the Shapiro- Wilk normality test results

*significant values indicating the collected data are normally distributed

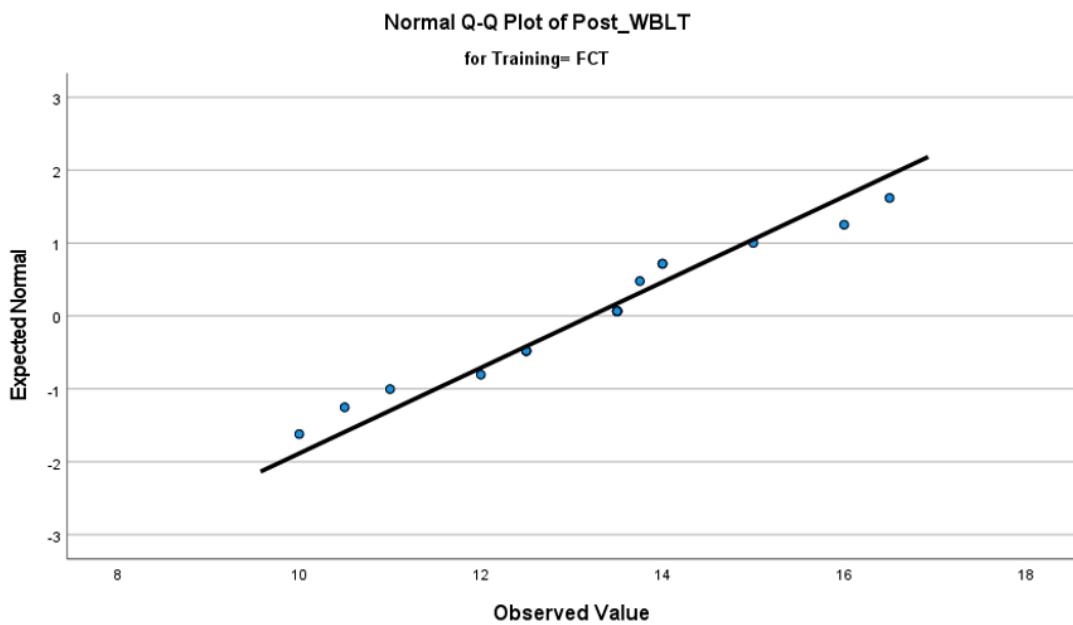
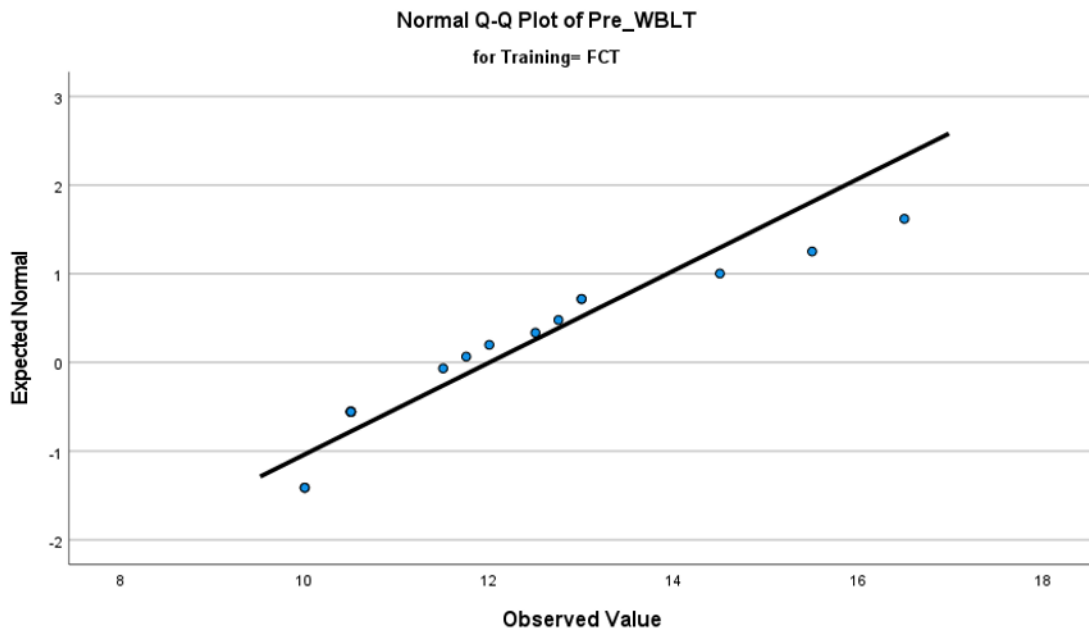
In this table the entries for which p value that is the significance is greater than 0.05 suggests that data doesn't significantly deviate from a normal distribution. For the CON group(PRE IFM, PRE WBLT, POST IFM, POST WBLT) the significance values are greater than 0.05 indicating statistical significance and are normally distributed. For the FCT group (PRE IFM and PRE WBLT) have significance values less than 0.05(0.037 and 0.015) respectively indicating that data is not normally distributed. POST IFM and POST WBLT have significance values greater than 0.05(0.039 and 0.520) respectively indicating the data is normally distributed.



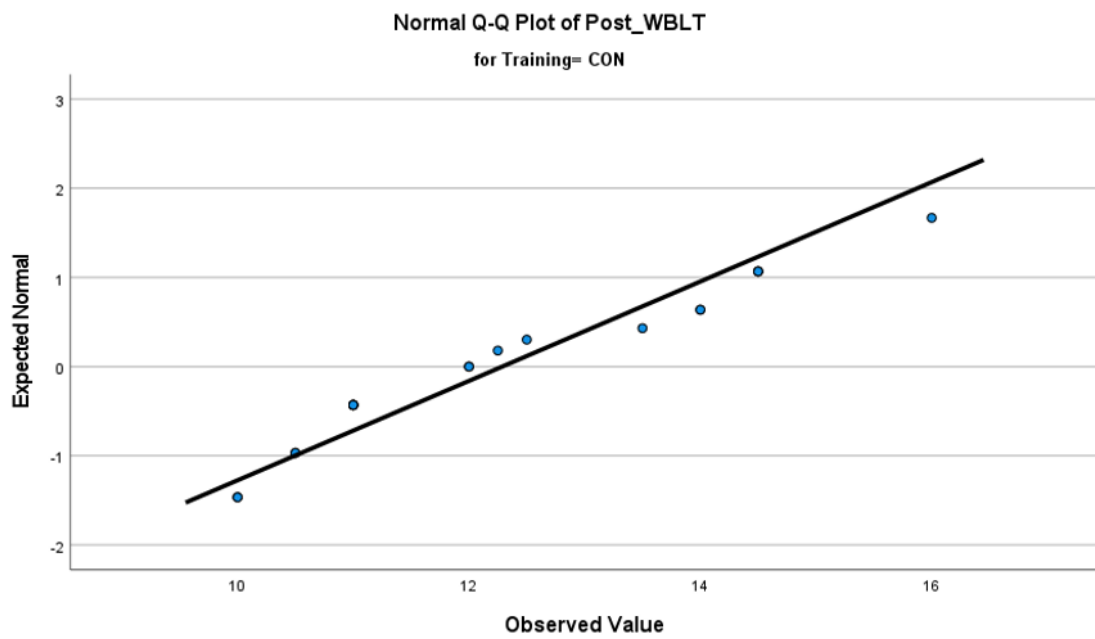
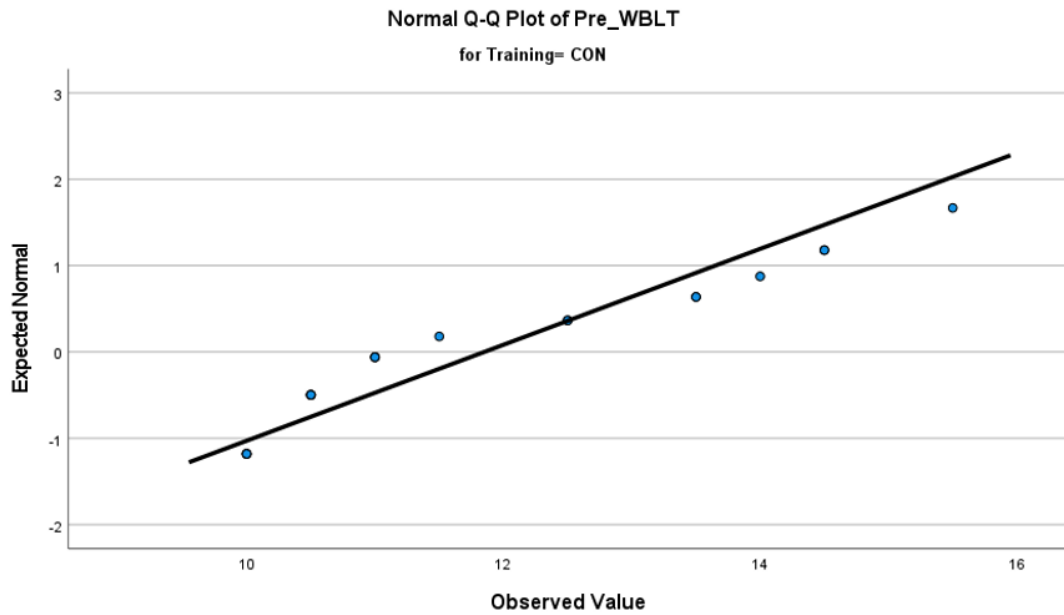
Graph 7: Normality graphs of PRE and POST IFM strength of the FCT group.



Graph 8: Normality graphs of PRE and POST IFM strength of the CON group



Graph 9: Normality graphs of PRE and POST WBLT scores of the FCT group



Graph 10: Normality graphs of PRE and POST WBLT scores of the CON group

Inferential Statistics

Non-parametric tests.

The test used in hypothesis testing is Wilcoxon-signed rank test

Within-group: Analysis for IFM strength pre and post intervention in the footcore group.

The Z score indicates difference between pre and post IFM strength measurements. Also, the asymptotic significance value points towards the result being statistically significant that is there exists a true difference between pre and post IFM measures.

Test Statistics

Z score	-4.174
Asymptotic significance(2- tailed)	0.000

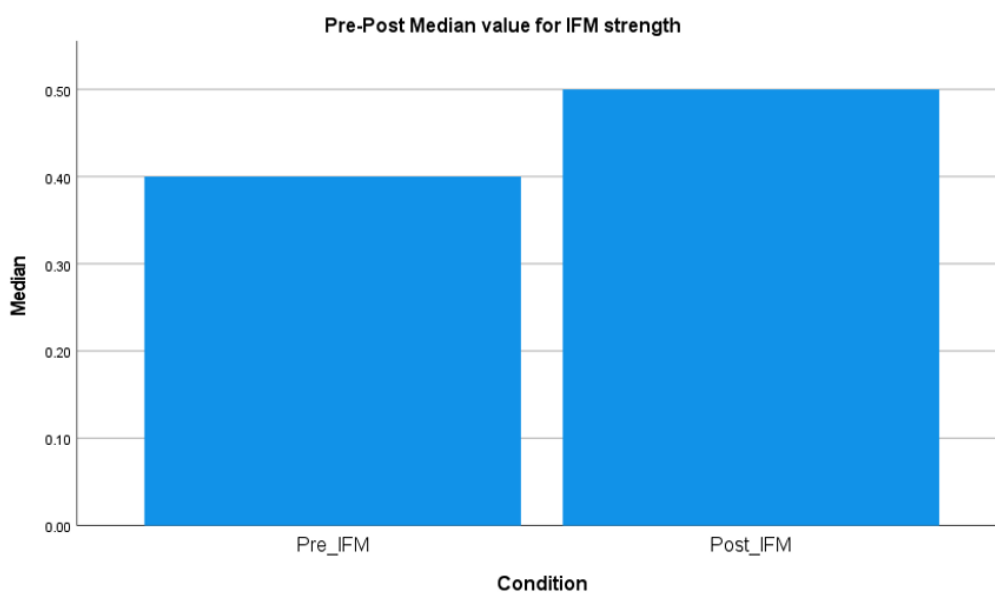
Table 3: Within group analysis table for IFM strength

The Z score of 4.174 and the p value (that is the asymptotic significance) of 0.000 indicates the result is statistically significant as it is less than 0.05 suggesting a significant difference in the FCT group which is purely due to the exercise protocol.

Pre- IFM Median	0.40000
Post- IFM Median	0.50000

Table:4 Median values for IFM strength

There is an improvement from pre to post within the footcore group for IFM strength. The null hypothesis is rejected as the result is significant.



Graph 11: The PRE(0.40000) and POST(0.50000) median values for IFM strength indicating the change observed in the FCT group was lower before the exercise protocol while it improved after the four weeks of the footcore exercises as the value for POST is higher than that of PRE IFM strength values.

Between-group: The mean change in IFM strength (post-test minus pre-test) for the footcore training group is not significantly different from the mean change for the conventional training group. The Mann-Whitney U test was used and analysis.

Test statistics

Mann-Whitney U test	89.000
Z score	-2.723
Asymptotic significance (2 tailed)	0.006

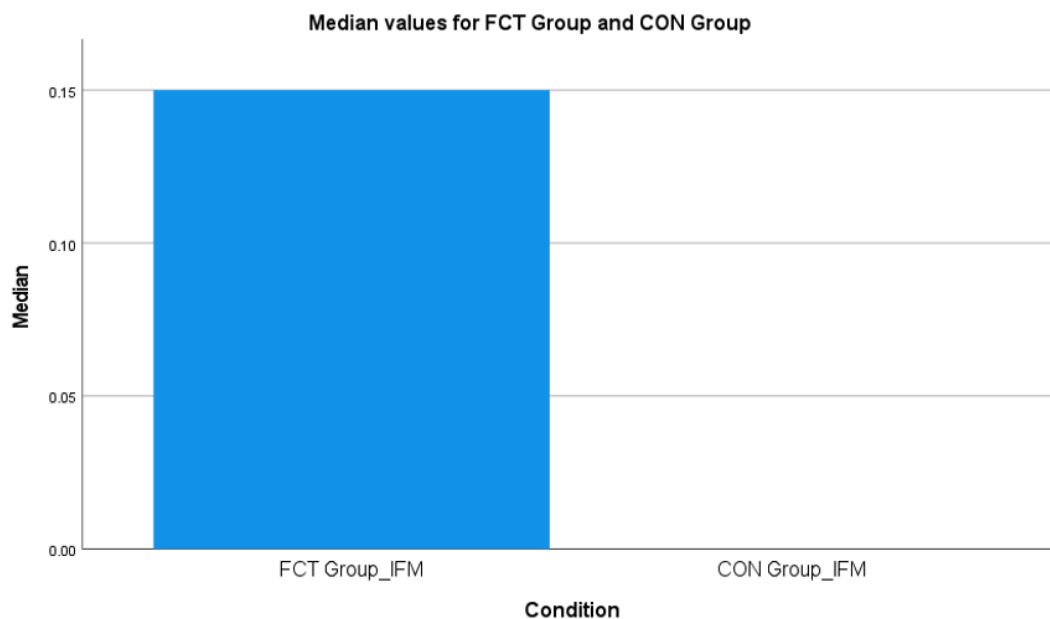
Table 5: Between group analysis for IFM strength

The Z score indicated that there exists a significant difference between the foot core group and conventional training group. Also, there is true change in the IFM strength that is statistically significant and the null hypothesis rejected. The Z score of 2.723 and the p value (that is the asymptotic significance) of 0.006 indicates the result is statistically significant as it is less than 0.05 suggesting a significant difference in the FCT group which is purely due to the exercise protocol when compared with the CON group.

FCT Median	0.1500
CON Median	0.0000

Table 6: Median values for IFM strength in FCT and CON group

There is improvement in footcore group compared to the conventional foot exercise group as the median scores for FCT group are 0.1500 and CON group are 0.000 respectively which directs towards a difference in the exercises performed by the two groups where FCT median score is superior.



Graph 12: Median values for FCT and CON groups for IFM strength.

The median CON group values for IFM strength are 0.000 indicated that there wasn't statistically significant difference on comparison with FCT group. This might have resulted as a consequence of the exercises performed by the players that didn't prove to improve the IFM strength scores using the IFM dynamometer.

Within-group: Analysis for WBLT found that there is significant difference in WBLT scores in the pre-test and post-test measurements within the footcore training group. Wilcoxon signed rank test was done and here the negative Z score indicates that there is a significant difference in pre and post WBLT scores. Also, the asymptotic significance value points towards the result being statistically significant that is there exists a true difference between pre and post WBLT measures.

Test statistics

Z score	-3.387
Asymptotic significance(2-tailed)	0.001

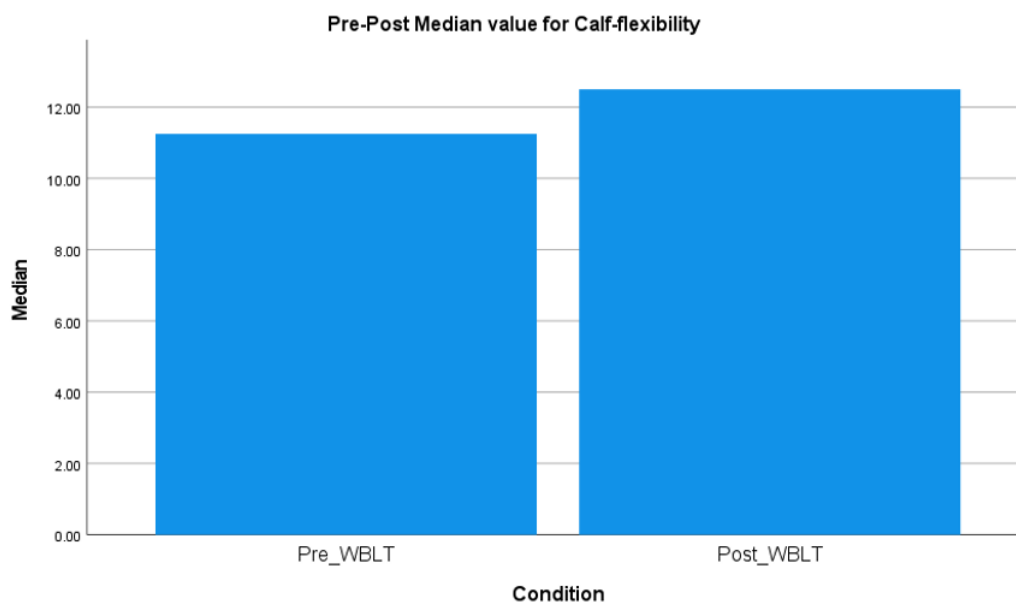
Table 7: Within group analysis table for WBLT

The Z score of 3.387 and the p value (that is the asymptotic significance) of 0.001 indicates the result is statistically significant as it is less than 0.05 suggesting a significant difference in the FCT group for WBLT scores which is purely due to the exercise protocol of performing the calf stretching exercises.

Pre-WBLT Median	11.2500
Post-WBLT Median	12.5000

Table 8: Median values for WBLT

As there is an improvement from pre to post intervention in WBLT scores the null hypothesis is rejected indicating that the result is significant.



Graph 13: Median values for PRE and POST calf flexibility measures using WBLT scores.

The median values for PRE and POST are 11.2500 and 12.5000 respectively indicating the change observed in the PRE WBLT was lower before the exercise protocol while it improved after the four weeks of calf stretching as the value for POST is higher.

Between-group: The mean change in WBLT scores (post-test minus pre-test) for the footcore training group is not significantly different from the mean change for the conventional training group. Z score indicates that the observed difference between FCT and CON groups is below the expected difference hence the null hypothesis is accepted as the result is not significant. In addition, the asymptotic significance value is greater than 0.05 which also enables to accept the null hypothesis

Test statistics

Mann-Whitney U test	125.000
Z score	-1.645
Asymptotic significance (2 tailed)	0.100

Table 9: Between group analysis for WBLT

The Z score of 1.645 and the p value (that is the asymptotic significance) of 0.100 indicates the result is not statistically significant as it is greater than 0.05 suggesting that there is no significant difference in the FCT group for WBLT scores and CON group.



(i)



(ii)



(iii)



(iv)



(v)

Figure 10: (i)- (v) Pictures demonstrating flat feet and foot posture analysis



Figure 11: Starting position of WBLT





(i)



(ii)



(iii)



(iv)

Figure 12: (i)- (iv) Glimpse of players performing footcore training



Figure 13: Plantar fascia massage



Figure 14: Starting position of calf stretch

Discussion

The present randomized controlled trial compared the effects of footcore training and conventional foot exercises on intrinsic foot muscle (IFM) strength and calf flexibility in novice badminton players. The findings revealed that footcore training produced significant improvements in IFM strength within the group, and also demonstrated superiority over conventional exercises in between-group comparisons. However, while calf flexibility improved within the footcore group, there was no significant between-group difference when compared with conventional training.

Intrinsic Foot Muscle (IFM) Strength

The present study demonstrated that footcore training significantly improved intrinsic foot muscle strength within the group, and also showed superiority over conventional training in between-group comparisons. These results are consistent with previous research that supports the effectiveness of footcore interventions.

Shen B et al., in “Effects of a 12-week gait retraining program combined with foot core exercise on morphology, muscle strength, and kinematics of the arch”, reported notable improvements in arch morphology and muscle strength following combined footcore interventions ^[15]. Similarly, Matias AB et al., in “Effects of Foot-Core Training on Foot-Ankle Kinematics and Running Kinetics in Runners” found significant adaptations in intrinsic muscle activity and biomechanical risk factors for running-related injuries ^[14]. These findings support the present study, indicating that footcore programs effectively enhance IFM strength.

Meta-analytic evidence further strengthens this view. Jaffri AH et al., in “Evidence for Intrinsic Foot Muscle Training in Improving Foot Function: A Systematic Review and Meta-Analysis”, concluded that IFM exercises improved balance, strength, and foot posture ^[16].

Wei Z et al., in their review “Effect of intrinsic foot muscles training on foot function and

dynamic postural balance”, also found significant improvements in foot posture and dynamic balance, though strength results were inconsistent ^[19].

Performance--related benefits have been observed across different athletic populations.

Sulowska I et al., in “The Influence of Plantar Short Foot Muscle Exercises on the Lower Extremity Muscle Strength and Power in Long-Distance Runners”, reported improved knee flexor torque after intrinsic foot training ^[20]. Veltrie RE et al., in “The Effects of Intrinsic Foot Muscle Strengthening on Foot Posture, Balance, and Agility in Ice Hockey Players”, also demonstrated improvements in balance and agility ^[12]. These findings parallel the present results in badminton players, a sport requiring balance, rapid changes of direction, and strong foot control.

Overall, the evidence suggests that footcore training is a reliable method to enhance IFM strength and performance in both athletic and clinical populations.

Calf Flexibility

In the present study, calf flexibility, assessed using the Weight Bearing Lunge Test (WBLT), improved significantly within the footcore group, but no significant between-group differences were found when compared with conventional training. This suggests that while footcore training contributes to ankle mobility, conventional exercises may be equally effective in enhancing calf flexibility.

Our findings are in line with Gohil R et al., who in “Normative Data for Calf Muscle Flexibility Tested by Weight Bearing Lunge Test” emphasized the validity of WBLT in detecting changes in calf flexibility ^[18]. However, the absence of superiority of footcore training over conventional training in this domain may indicate that calf flexibility improvements are not primarily dependent on intrinsic foot muscle activation, but rather on generalized lower limb stretching and strengthening protocols.

Previous studies have largely focused on IFM strength and balance, with limited research directly linking footcore interventions to calf flexibility outcomes. Therefore, the present study adds novel insight by highlighting that although calf flexibility improves with footcore training, its effect is not significantly greater than that of conventional exercises.

Conclusion

Badminton is one of the fastest racket sport that requires extensive physical fitness with appropriate footwork judgement while conserving the energy to deliver precise shots. In this concern it becomes essential for novice badminton players to work on developing flexible footwork. To improve strength of the intrinsic muscles of the foot in novice badminton players four weeks of footcore training can be inculcated in those with flat feet(pronated foot). Also, to overcome the challenges in quantifying the IFM strength the novel IFM dynamometer may be used which is proven to be reliable. The ability to quantify the strength gains in the intrinsic foot encourages the novice badminton player perform better as it may provide feedback to give his best. However, the footcore training protocol and the conventional foot training had the same results when the extrinsic foot muscle flexibility is considered. It can be inferred from the study that footwork plays a pivotal role in the game of badminton and improving its strength helps in performance excellence.

Limitations

This study was the first to use novel IFM dynamometer for measuring intrinsic foot muscle strength in novice badminton players and added light into the literature regarding the use of an instrument as such to overcome the challenge of measuring intrinsic foot muscle strength. Though the study contributed to gains in the intrinsic foot muscle strength it has some limitations that include the novice players undergoing different mobility training protocols that may have been influenced in flexibility making it a confounding factor. Also, the players ability to perceive the footcore training protocol and comply to the same was a hardship hence future studies must consider addressing these concerns.

Future recommendations

As the study had few limitations the future studies may address these shortcomings of the study that is allowing the players to adequately comply to the exercise protocol and then progress appropriately. Also, the study was done in novice badminton players with a score of 6 or greater for foot posture on FPI-6 it may be conducted in other athletes as well to know and understand the outcomes.

Statement of funding

Source of funding: There was no source of funding for this study.

Nature of funding: The study was self- supported with no external financial assistance

Conflict of interest

There are no conflict of interest.

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Annexures

Ethical clearance from the institutional ethics committee

 ABSMARI	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. <u>ABSMARI/IEC/2025/163</u>	Date: <u>09/05/2025</u>																		
APPROVAL LETTER APPENDIX- VIII																			
MEMBERS	To,																		
Dr. Smaraki Mohanty Clinician	S APOORVA ABSMARI 273, PAHAL, BHUBANEWAR-752101																		
Dr. Satyajit Mohanty Scientific Member	Protocol Title: "Footcore exercise versus conventional foot exercises in novice badminton players and its effects on intrinsic foot muscle strength and calf flexibility-a randomized controlled trial"																		
Mr. Shib Shankar Mohanty Legal Expert	Protocol ID.: ABS-IEC-2025-PHY-067																		
Ms. Annie Hans Social Scientist	Subject: Approval for the conduct of the above referenced study																		
Ms. Subhashree Samal Lay Person	Dear Mr./Ms./Dr S Apoorva																		
Mr. Deepak Ku. Pradhan Scientific Member	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.																		
IEC-SECRETARIAT	The following documents were reviewed and discussed																		
Mr. Gouranga Ku. Padhy Mr. Susant Ku. Raychudamani	<table border="1"><thead><tr><th>S.N.</th><th>Documents</th><th>Document (Version/Date)</th></tr></thead><tbody><tr><td>1</td><td>IEC Application Form</td><td>24/04/2025</td></tr><tr><td>2</td><td>Informed Consent Form</td><td>24/04/2025</td></tr><tr><td>3</td><td>Undertaking form PI</td><td>24/04/2025</td></tr><tr><td>4</td><td>CRF</td><td>24/04/2025</td></tr><tr><td>5</td><td>COI from the Investigators</td><td>24/04/2025</td></tr></tbody></table>	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
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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																			
																			
1																			



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/2025/108

Date 10-01-2025

APPENDIX – XV

IEC ACKNOWLEDGEMENT RECEIPT

MEMBERS

Dr. Smaraki Mohanty
Clinician

Dr. Satyajit Mohanty
Scientific Member

Mr. Shih 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

Proposal ID: ABS-IEC-2025-PHY-067

Title "Foot core Exercise Versus Conventional Foot Exercises in Novice Badminton Players and Its Effects on Intrinsic Foot Muscle Strength and Calf Flexibility-A Randomized Controlled Trial"

Submitted on: Date 06/01/2025 Time:

Submitted by: Internal

Proposal Type: Academic proposal without funding

Investigator's (s) Name:

Dear Dr./ Mr./ Ms. S APOORVA

The undersigned do hereby acknowledge that your proposal for the Ethical Review has been received by the I.E.C Secretariat of ABSMARI as on date and time stated above. The Secretariat shall keep you inform about its progress, schedule of the review meeting for presentation as well as the proponent on the result of evaluation as per the SOP.

With best regards

Member Secretary,
ABSMARI Ethics Committee

Member Secretary
ABSMARI ETHICS COMMITTEE



Utkal Signature, Plot No.-273,
Ground Floor, Pahal, Bhubaneswar-752101

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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/2025/163

Date: 09/05/2025

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

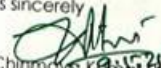
This is to confirm that only members who are independent of the Investigator and the Sponsor of the trial have voted/ provided opinion on the trial.

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 in the prescribed format attached, 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
ABSMARI ETHICS COMMITTEE



Rearfoot Score	-2	-1	0	1	2
Talar head palpation	Talar head palpable on lateral side/ but not on medial side	Talar head palpable on lateral side/ slightly palpable on medial side	Talar head equally palpable on lateral and medial side	Talar head slightly palpable on lateral side/ palpable on medial side	Talar head not palpable on lateral side/ but palpable on medial side
Curves above and below the malleoli	Curve below the malleolus either straight or convex	Curve below the malleolus concave, but flatter/ more shallow than the curve above the malleolus	Both infra and supra malleolar curves roughly equal	Curve below malleolus more concave than curve above malleolus	Curve below malleolus markedly more concave than curve above malleolus
Calcaneal inversion/eversion	More than an estimated 5° inverted (varus)	Between vertical and an estimated 5° inverted (varus)	Vertical	Between vertical and an estimated 5° everted (valgus)	More than an estimated 5° everted (valgus)
Forefoot Score	-2	-1	0	1	2
Talo-navicular congruence	Area of TNJ markedly concave	Area of TNJ slightly, but definitely concave	Area of TNJ flat	Area of TNJ bulging slightly	Area of TNJ bulging markedly
Medial arch height	Arch high and acutely angled towards the posterior end of the medial arch	Arch moderately high and slightly acute posteriorly	Arch height normal and concentrically curved	Arch lowered with some flattening in the central portion	Arch very low with severe flattening in the central portion – arch making ground contact
Forefoot abd/adduction	No lateral toes visible. Medial toes clearly visible	Medial toes clearly more visible than lateral	Medial and lateral toes equally visible	Lateral toes clearly more visible than medial	No medial toes visible. Lateral toes clearly visible

Foot Posture Index-6 scoring

Foot Posture Index Datasheet

Patient name	ID number
---------------------	------------------

	FACTOR	PLANE	SCORE 1		SCORE 2		SCORE 3	
			Left -2 to +2	Right -2 to +2	Left -2 to +2	Right -2 to +2	Left -2 to +2	Right -2 to +2
Rearfoot	Talar head palpation	Transverse						
	Curves above and below the lateral malleolus	Frontal/ transverse						
	Inversion/eversion of the calcaneus	Frontal						
Forefoot	Prominence in the region of the TNJ	Transverse						
	Congruence of the medial longitudinal arch	Sagittal						
	Abd/adduction forefoot on rearfoot	Transverse						
TOTAL								

Reference values
 Normal = 0 to +5
 Pronated = +6 to +9, Highly pronated 10+
 Supinated = -1 to -4, Highly supinated -5 to -12

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www.leeds.ac.uk/medicine/FASTER/FPI

Foot posture index data sheet and interpretation

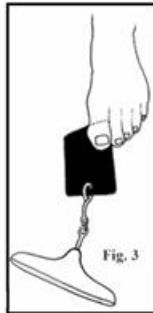
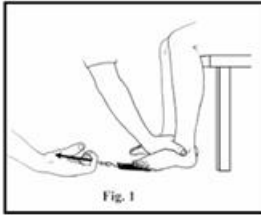
Baseline and Post interventional data

Name	Age(yr)	Gender(M=1, F=2)	Height (ft)	Weight(kg)	BMI	FPI-score(L)	FPI-score(R)	Pre IFM-L(kg)	Pre IFM-R(kg)	Pre WBLT-L(cm)	Pre WBLT-R(cm)	Group 3, (FCT=CON=4)	Post IFM-L(kg)	Post IFM-R(kg)	Post WBLT-L(cm)	Post WBLT-R(cm)
Athlete 1	12	1	152	36	15.58	8	8	0.5	0.5	16	17	3	0.5	0.5	16	17
Athlete 2	10	2	126	24	15.12	6	7	0.2	0.4	11	10	3	0.4	0.5	14	14
Athlete 3	12	1	146	41	19.23	8	8	0.3	0.4	15	16	3	0.5	0.7	16	16
Athlete 4	11	1	140	46	23.47	8	8	0.4	0.5	11	11	4	0.4	0.6	11	11
Athlete 5	11	1	148	38	17.35	7	7	0.4	0.4	10	12	4	0.5	0.5	12	12.5
Athlete 6	10	1	134	25	13.92	6	6	0.4	0.4	13	14	4	0.4	0.4	13	14
Athlete 7	11	1	137	32	17.05	6	6	0.4	0.5	12.5	13	3	0.5	0.8	12	13
Athlete 8	12	1	141	40	20.12	6	6	0.3	0.4	11	12	4	0.4	0.4	14	14
Athlete 9	11	2	165	50	18.37	6	6	0.4	0.5	10	11	3	0.4	0.5	12	12
Athlete 10	11	1	140	32	16.33	7	6	0.6	0.5	12	14	3	0.6	0.6	13	14
Athlete 11	13	2	163	57	21.45	6	6	0.6	0.4	14	13	3	Dropped due to injury			
Athlete 12	12	2	144	43	20.74	7	7	0.4	0.4	10	10	4	0.5	0.5	11	11
Athlete 13	15	1	160	40	15.62	6	6	0.4	0.5	16	15	4	0.6	0.7	16	16
Athlete 14	14	2	145	48	22.83	7	6	0.3	0.3	10	10	4	0.3	0.3	10	10
Athlete 15	12	1	150	36	16	6	6	0.5	0.6	10	11	4	0.5	0.5	12.5	12.5
Athlete 16	9	1	133	28	15.83	7	7	0.3	0.3	10	10	3	0.3	0.4	10	10
Athlete 17	12	1	149	44	19.82	6	6	0.6	0.5	12	13	4	0.6	0.6	14	15
Athlete 18	10	1	166	50	18.14	6	6	0.6	0.6	12	13	4	0.4	0.7	12	12
Athlete 19	12	1	153	42	17.94	6	6	0.5	0.5	13	14	4	0.5	0.5	11	11
Athlete 20	11	1	141.5	29	14.59	8	8	0.3	0.4	10	11	3	0.5	0.6	12	13
Athlete 21	11	1	135	26	14.27	6	7	0.3	0.3	10	10	3	0.6	0.6	11	11
Athlete 22	12	1	149	44	19.82	6	6	0.6	0.6	10	11	4	0.6	0.6	10	11
Athlete 23	13	2	151	40	17.54	6	6	0.2	0.3	10	10	4	0.2	0.3	10	10
Athlete 24	11	1	130	28	16.57	7	7	0.4	0.3	11.5	12	3	0.3	0.4	14	14
Athlete 25	11	2	150	40	17.78	7	8	0.4	0.4	14	15	4	0.4	0.4	14	15
Athlete 26	11	1	136	34	18.38	6	6	0.3	0.2	14	14	4	0.4	0.4	14	14
Athlete 27	13	2	155	48	19.98	6	6	0.5	0.4	10	11	3	0.4	0.7	13	14
Athlete 28	12	2	140	33	16.84	7	7	0.3	0.3	10	11	3	0.8	0.8	15	15
Athlete 29	9	1	138	34	17.85	6	6	0.4	0.3	14	15	3	0.6	0.6	13	14
Athlete 30	10	2	129	28	16.83	7	7	0.3	0.3	10	11	4	0.6	0.6	11	11
Athlete 31	11	2	142	36	17.85	6	6	0.5	0.6	11	11	4	0.5	0.6	11	11
Athlete 32	9	1	136	24	13.52	7	7	0.4	0.4	11	12	3	0.7	0.9	12	13
Athlete 33	12	2	162	43	16.38	6	6	0.4	0.6	13	13	3	0.4	0.6	13	14
Athlete 34	14	1	161	47	18.13	6	6	0.5	0.4	15	14	4	0.5	0.4	15	14
Athlete 35	12	1	155	38	15.61	6	6	0.5	0.5	10	10	4	0.5	0.5	12	12
Athlete 36	10	2	136	28	15.14	7	7	0.2	0.3	11	10	4	Dropped due to ankle surgery			
Athlete 37	13	2	148	39	17.8	6	6	0.3	0.4	10	11	3	0.5	0.5	10	11
Athlete 38	9	2	133	24	13.47	7	6	0.4	0.3	12	13	3	0.5	0.8	13	14
Athlete 39	9	1	134	28	15.59	6	6	0.2	0.2	10	11	4	0.3	0.4	10	11
Athlete 40	11	1	136	34	18.38	7	7	0.4	0.5	12	12	3	0.5	0.7	14	13.5



Instructions for Using the Toe Strength Dynamometer

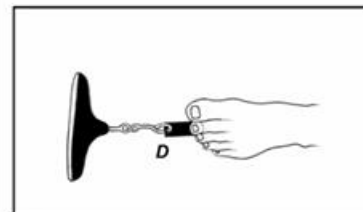
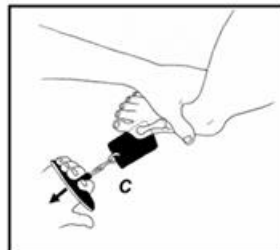
Measuring Toe Strength:



1. The patient should be seated comfortably, with their legs tilted back about 5 degrees (**Fig. 1**).
2. Place the card under the lesser toes so that the longest part of the card is positioned beneath the fifth toe (**Fig. 2**).
3. Place your hand on top of the patient's foot to keep it stable and detect if the patient attempts to lift their heel from the ground. Say "keep your heel on the ground, and try to stop me from pulling this card out." Instruct the patient to grip the card as firmly as possible while you slowly pull the card out from beneath their toes. Repeat the test until a consistent measurement is achieved, usually 2 to 3 times.
4. Flip the card over and place the long end of the card beneath the big toe of the same foot (**Fig. 3**). Record the measurement and repeat the strength test on the patient's other foot. As a general rule, **adults can produce about 10% of their body weight in force with their great toe, and 7% of their body weight in force beneath the lesser toes.** Athletes should be able to achieve 15 to 20% of their body weight beneath the big toe, and 10 to 15% of their body weight beneath the lesser toes.
5. **Peroneus longus** strength is measured by placing the card underneath the first metatarsal head (**C**). People should generate at least 10% of their body weight with this test.



For more information, including articles and a video on how to use the Dynamometer, and attachments for the device including the strap for hip strength measurement and the plantar plate card, click on the QR code above, or go to:
www.HumanLocomotion.com



6. For a **plantar plate injury**, use the optional plantar plate attachment card and place it under the involved toe (**D**). It is not uncommon for a person to generate only 2 or 3% body weight with this test. Because the dynamometer does not record scores less than 3 pounds, you have to look at the dynamometer screen while performing this test and record the highest number.

Warning and disclaimer: Because injury may result from inappropriate use of this product, which is beyond control of the manufacturer, user assumes all risks. Under no circumstances shall the buyer be entitled to damages associated with the use of this product, and use of this product constitutes agreement to these terms.

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