LOWER LIMB BIOMECHANICAL DIFFERENCES DURING JUMP AND SQUAT TASKS AMONG INDIVIDUALS WITH DIFFERENT FOOT MORPHOLOGIES: AN OBSERVATIONAL STUDY

Dissertation Submitted to the UTKAL UNIVERSITY Bhubaneswar, Odisha

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In Partial fulfilment of the requirements for the degree of

MASTER OF PHYSIOTHERAPY (M.P.T)

In

SPORTS PHYSIOTHERAPY

Under the guidance of

Dr. Deepak Kumar Pradhan

H.O.D, ABSMARI

ABHINAV BINDRA SPORTS MEDICINE & RESEARCH INSTITUTE

Bhubaneswar, Odisha

2022-2024

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I hereby declare that this dissertation entitled **LOWER LIMB BIOMECHANICAL DIFFERENCES DURING JUMP AND SQUAT TASKS AMONG INDIVIDUALS WITH DIFFERENT FOOT MORPHOLOGIES: AN OBSERVATIONAL STUDYis** a bonafide and genuine research work carried out by me under the guidance of Dr. Deepak Kumar Pradhan, H.O.D , Abhinav Bindra Sports Medicine and Research Institute, Odisha.

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Date: Signature of the Candidate

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LIST OF ABBREVIATIONS

1. ABSMARI **–** Abhinav Bindra Sports Medicine and Research Institute
2. EMG**-** Electromyography
3. FPI- Foot posture index
4. GM- Gluteus maximus
5. BF- Biceps femoris
6. VM- Vastus medialis
7. VL- Vastus lateralis
8. GN- Gastronemius
9. **SD-** Standard Deviation
10. MD- Mean Deviation
11. SPSS **–** Statistical package for social science
12. Analysis Of Variance

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ABSTRACT

Lower Limb Biomechanical Differences During Jump and Squat Tasks Among Individuals With Different Foot Morphologies: An Observational Study

Background-Barbell squat and Counter movement jump [CMJ] is a commonly used exercise in training lower limb explosive strength in different sports activities. However, there is no evidence about how foot morphologies change the muscle activity and joint angkes during squat and jump tasks individuals. Therefore, this study aimed to investigate and to compare the relationship between different foot morphologies with the kinetic and kinematics changes during squat and jump tasks among healthy adults.

Method- Thirty male and female active participants (age 23±5, height 1.6m±0.4m, weight 55kg±10kg) categorized in three groups (flatfoot, Normal, High-arch) with each 10 individuals by foot posture index (FPI), then performed barbell squat and CMJ with three repetitions each.

The kinetic and kinematic analysis were done using the EMG & motion capture system respectively.

RESULT-

The kinetic differences were seen in vastus medialis and lateralis muscle ($p < 0.05$) during jump task. However, there was no kinetic differences during squat task

($p > 0.05$). The kinematics differences were seen in only lumbar and ankle component($p<0.05$) in jump task where as in squat all three components lumbar, knee and ankle ($p<0.05$) shows significant different.

CONCLUSION-

The kinetics and kinematics parameters can be altered in subjects with different foot morphologies despite having no differences in field based squat and jump task. So, individuals should consider the present findings when selecting specific exercises aiming to improve physical fitness in different foot morphologies in field based as well as platform based.

Keywords- Electromyographic activity, foot posture, lower extremity, movement, strength training

LOWER LIMB BIOMECHANICAL DIFFERENCES DURING JUMP AND SQUAT TASKS AMONG INDIVIDUALS WITH DIFFERENT FOOT MORPHOLOGIES: AN OBSERVATIONAL STUDY

INTRODUCTION

The squat is a exercise performed by individuals to reduce pain and improve the quality of exercise performance (1-3). It has biomechanical and neuromuscular similarities of athletic movements and thus is included as a core exercise in many sports designed to increase the athletic performance (4,5). Counter movement jump [CMJ] is a commonly used exercise in training lower limb explosive strength in different sports activities (6,7). As foot is the most distal part of the body and plays a major role in squat and jump task. So change in foot position can activate different muscles groups(4).

Generally both high and low arched feet have been reported to be factors making the individual foot more prone to injury during physical activities(26). Many different factors are taken into consideration for influential on the formation and function of the medial longitudinal arch and age, gender, race, shoes at which age wearing shoes begins are among factors noted to influence the formation of the arch(21-25). The effects of the foot posture may cause an increased risk of musculoskeletal stress or injury during squat and jump task for athletes (Dyrby et al., 1997; Kaneda et al., 2001). Foot morphology are associated with differences in foot function during movements, especially in weight-bearing activities and locomotion(9).

squat exercise is considered as a closed kinetic chain exercise where the force is expressed through the end (length) of the limb while it is fixed to the ground (8). Kinematic, kinetic, and electromyographic (EMG) studies have reported muscle activation of the lower limb resulting from variations of depth of squat, foot placement and training status and training intensity (8,4,1). The barbell squat considered as a key exercise in the preparation of athletes before the growing body of scientific evidence describing activation of muscle in variations of this exercise(5,1).

In CMJ, initiates a downward movement, which is immediately followed by an upward movement leading to takeoff(7).Counter-movement jumps are commonly used to assess strength and power where in athletes, jumps may be used to monitor neuromuscular status and also used to assess the leg function of patients with different diagnoses(18,19,20).CMJ taking place in the vertical axis are widely used to determine the jumping height and lower extremity strength(10).

In CMJ protocols occurring in the vertical axis, for a drop in a predetermined area,movement series includes planning the route to be followed by the body mass center, controlling the body position during jumping phase, and providing postural control with ground contact (landing) needs to be performed successfully(11).Recently, wearable inertial sensors are widely used to estimate motion kinematics in different functional activity(12). Movements were captured using a sophisticated 3D motion analysis system. MVN Awinda (Xsens) is a wireless motion capture system that is user-friendly, quick, and dependable. It can be used to evaluate entire body kinematics data, including joint angles, center of mass, segment orientations, and accelerations during more complex, functional and multiplanar movements. In this study, Kinematic data from the KNEE joint, ankle joint and lumbar were obtained.

Electromyography is a dependable research method that is frequently used to examine the physiological characteristics of muscle activity during exercise. Through the use of small wire electrodes attached to the skin. Electromyography (EMG) is a technique for electrically detecting muscle activity .

Previous investigations studying the assessment of thigh muscle activation during back squat have generally found no significant differences in myoelectrical activity across different foot angles or stance widths conditions(13,14,15,16). Escamilla et al. (18) reported statistically significant 15% and 16% increases in patellofemoral and tibiofemoral compressive forces, respectively, in subjects who squatted with a wide stance (defined as 87 to 118% of shoulder width) as compared with a narrow stance (defined as 158 to 196% of shoulder width)(17).

Lower limb kinematic analysis is a booming research field due to the emerging need to improve clinical diagnostics and rehabilitation procedures(27). Monitoring the movement of the lower limb is particularly challenging due to the complexity of the joint kinematics, which requires the development of protocols that exploit a detection technology that is as reliable and non-intrusive as possible(28).

In a review of the literature, it is clearly shown that no general consensus exists on an ideal method for foot type classification. So, existing methods are typically based on the measurement of morphological parameters of the foot, mostly in the standing weight-bearing position. Here, FOOT POSTURE INDEX is used to classify the different foot posture of the individual (high arch, Normal, flat feet). The result is a six criterion observational scoring system that provides valid quantification of foot posture.

The objective of the study is to find the lower limb muscle activation in squat and jump tasks on individuals with different foot morphologies.

NEED FOR THE STUDY

1. Squatting and jumping is the major integral part of strength training for both prevention and rehabilitation , so there is a need for analyzing the ideal mechanics(4)
2. Foot morphologies being the commonest confounding factor for alternating lower extremity mechanics during functional close kinetic chain activities , so there is a need to compare the mechanics with normal and altered foot morphologies(7).
3. Dearth of evidences on finding the relations between close kinematic lower limb functional task with different foot morphologies.

AIM OF THE STUDY

To compare the muscle activity and joint angle between different foot morphologies with the kinetic and kinematics changes during squat and jump tasks among healthy adults.

OBJECTIVE OF THE STUDY

- To compare the muscle activation patterns during squat and jump tasks using surface EMG recordings on individuals with different foot morphologies .
- To compare the joint kinematics during squat and jump tasks using 2D motion analysis on individuals with different foot morphologies
- To evaluate the different foot morphologies using Foot posture index-6.

Hypotheses

- **Null Hypothesis-**
- There will be no significant difference in muscle activity of different types of foot morphologies during squat.
- There will be no significant difference in muscle activity of different types of foot morphologies during jump.
- **Alternate Hypothesis-**
- There will be significant difference between muscle activity of differenct types of foot morphologies during squat.
- There will be significant difference between muscle activity of differenct types of foot morphologies during JUMP

REVIEW OF LITERATURE

REVIEW OF LITERATURE

1. Stacy A. Schurr,Ashley N. Marshall,Jacob E. Resch, Susan A Saliba (2017)- study was conducted on TWO-DIMENSIONAL VIDEO ANALYSIS IS COMPARABLE TO 3D MOTION CAPTURE IN LOWER EXTREMITY MOVEMENT ASSESSMENT It was concluded that the lack of precision and ability to capture rotations, 2D measurements may provide a pragmatic method of evaluating sagittal plane joint displacement for assessing gross movement displacement.

2. Jose M. MuyorI, Isabel Martı´n-FuentesI, David Rodrı guez-Ridao, Jose A. Antequera-Vique (2020)- A study was conducted on Electromyographic activity in the gluteus medius, gluteus maximus, biceps femoris, vastus lateralis, vastus medialis and rectus femoris during the Monopodal Squat, Forward Lunge and Lateral Step-Up exercises. It was concluded that in the three evaluated exercises, vastus lateralis and vastus medialis showed the highest EMG activity, followed by gluteus medius and gluteus maximus.

3. George S Murley, Hylton B Menz and Karl B Landorf(2009)- A study was conducted on Foot posture influences the electromyographic activity of mb muscles during gait. It was concluded that differences in muscle activity in people with flat-arched feet in contact phase and midstance phase.

4. SCOTT W. TALPEY, WARREN B. YOUNG, AND BRADLEY BESELER(2014)**-** A study was conducted on EFFECT OF INSTRUCTIONS ON SELECTED JUMP SQUAT VARIABLES It was

concluded that jump height, peak velocity, peak force, and the downward dip distance in the JS were all influenced by the instructions provided.

5. Ralf Roth , Lars Donath , Oliver Faude & Andrew G. Cresswell(2020)- The study was on Biomechanical Analysis of Squat Jump and Countermovement Jump From Varying Starting Positions. It was concluded that Trunk muscle activity is notably altered by performing different types of squat exercises.

6. Mackala, Krzysztof; Stodółka, Jacek; Siemienski, Adam; Ćoh, Milan(2013)- The study was on Biomechanical Analysis of Squat Jump and Countermovement Jump From Varying Starting Positions. It was con concluded that differences in the foot placement during initiation of take-off, found that the CMJ position tends to lead to a slightly higher performance level than the SJ.

METHODOLOGY

- STUDY DESIGN- Observational study
- SAMPLING TECHNIQUE- Purposive sampling
- STUDY POPULATION- Healthy Asymptomatic Adults (without any pain in the foot)
- SAMPLING SIZE- 30(The sample size was calculated by using the G Power)
- STUDY SETTING - ABSMARI
- STUDY DURATION- 6 MONTHS

INCLUSION CRITERIA

- Healthy asymptomatic adults with no muscular and neurological disorders
- Both male and female are included
- AGE- 18 to 30 years

EXCLUSION CRITERIA

- Age > 28
- Individuals having any recent injury, fracture, open wounds or surgery o lower limb and upper limb over the past 6 months.

- Any individuals suffering from mental disorder like dementia, anxiety disorder or any addiction etc.
- Individuals having any musculoskeletal pain or discomfort or neurological disorders.
- Any biomechanical abnormalities that affected their ability to walk, deformity, congenital flat feet , LLD , obvious postural deformity.

STUDY MATERIALS

- EMG- 4 channel of Clarity EMG Octopus machine
- XSENSE 3D MOTION motion analyser
- Inch tape
- Body markers
- Barbell – weight of 10kg

Fig 1.1-Clarity EMG Octopus)

Fig 1.2- Xsens motion capture

Outcome Measures:

1. **FPI:-** To asses the FPI the participants are asked to remove their socks and boots and wear shorts for better foot observation. Then participants were instruted to stand in their respective position and therapist will score the according to the FPI.

2. EMG Test: 4 channel of Clarity EMG Octopus machine used to evaluate and record the electrical activity of lower limb muscles (V.M, V.L, B.F, G.N) during jump and (G.M, V.M, B.F, G.N) during squat task.

Fig 1.3- Emg squat

3. **Xsens Motion Capture:** Kinematic data from the lumbar, knee, ankle joint were collected from the affected arm of each person from three

different foot morphologies, using the available inertial sensor system 'MVN Awinda motion capture system' (Xsens Technologies). Data collection was done via wireless 17 inertial motion sensors connected to the mentioned body part.

Fig1.4-Jump kinematics motion capture

Fig1.5-squat kinematics motion capture

Sample selection:

The institutional Ethical Committee evaluated and approved current study. A total 90 samples were screened by using purposive sampling. 30 participants were selected based on inclusion and exclusion criteria and 60 subjects were excluded. Participants were explained about the study in their comfortable language. Everyone who participated in this study was informed about the procedure and their informed consent were taken. Each subject completed a short form regarding their current injury, history, demographic information along with information about the sports they played. Each participant's weight was measured in kilograms and height in centimeters. The participant were screened by FPI and allocated in their respective group according to their foot posture.

According to that group allocation was done.

10 subjects were placed in Group A (healthy individuals)

10 subjects were placed in Group B (flat foot)

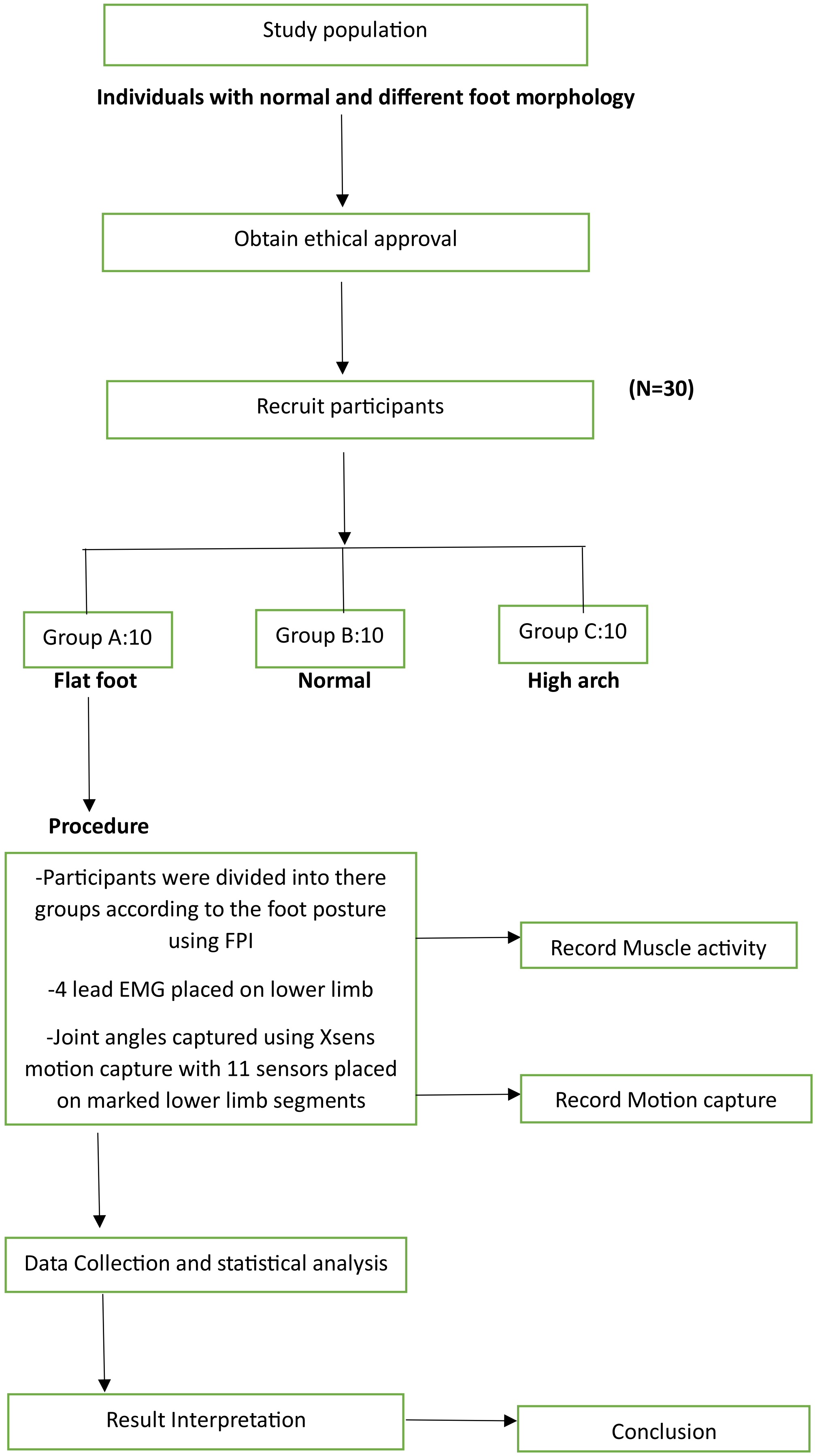
10 subjects were placed in Group C (high arch foot)

Procedure:

First the participants were screened by foot posture index(FPI) and categorized into 3 groups- flat, high arch foot and normal group. In FPI more then 6 score categorized in flat foot group, between (0-6) is normal group and less then 0 is categorized as high arch foot group. So, while screening the both foot which ever foot score maximum score according to category that foot is to be selected either left or right.

Kinetics of squat and jump was measured during an open kinetics chain and close kinetic chain movement. Squat was done with a barbell and followed by a counter-movement jump.

Barbell squat and jump procedure was explained to each group participants. Participants performed squat and jump activity for 3 times with 4 lead EMG attached to lower limb for squat (gluteus maximus, vastus medialis, biceps femoris and gastrocnemius) muscle and for jump (vastus medialis, vastus lateralis , biceps femoris and gastrocnemius). Muscle activity recorded during this activity.



2.2- Methodology Flowchart

SAMPLE SIZE ESTIMATION

The sample size was calculated using the G*power software with,

Effect size d **=** 0.67

α err prob **=** 0.05

Power (1-β err prob) **=** 0.90

Allocation ratio N2/N1 = 1

The total sample size was calculated was 30 i.e, 10 in each group

RESULTS

RESULTS

Statistical Analysis

Data was analyzed using statistical package SPSS 22 software program and level of significance was set at $p \leq 0.05$ Descriptive statistics was performed to assess the mean and standard deviation of three groups. Normality of the data was assessed using Shapiro-Wilk test**.** A one-way ANOVA measures between group (group x muscles) with a **post hoc Tukey test** was used to determine the effect of the group, compare inter-muscle EMG activity for barbell bench press exercise and evaluate the interaction of factors. For all analyses the level of significance was **$p \leq 0.05$**.

squat	Groups			
Variables	**Flat foot**	**High Arch**	**Normal**	**P Value**
Lumbar	**4.52±2.26**	**6.45±71.84**	**3.77±2.43**	**0.051**
Knee	**140.77±16.28**	**105.42±26.5**	**153.53±5.36**	**0.00**
Ankle	**47.03±11.17**	**28.76±7.97**	**51.90±9.68**	**0.06**

squat	Groups			
Variables	Flat foot	High Arch	Normal	P Value
Gluteus Max	737.8±187.44	646.1±167.33	759.6±175.38	0.711
Biceps F	799.35±399.98	677.95±169.24	623.3±147.32	0.329
Vastus M	633.1±139.50	619.04±113.45	619.2±112.42	0.942
Gastro	630.16±110.84	635.09±121.16	621±138.41	0.485

Jump	Groups			
Variables	Flat foot	High Arch	Normal	P Value
Lumbar	6.49±2.801	4.35±2.73	4.01±1.97	0.078
Knee	105.67±8.87	94.06±23.06	100.32±36.88	0.604
Ankle	42.53±8.34	30.06±10.08	46.64±10.81	0.006

Jump	Groups			
Variables	**Flat foot**	**High Arch**	**Normal**	**P Value**
Biceps femoris	**958±403.21**	**1233.53±351.05**	**1175.35±287.22**	**0.198**
Vastus medialis	**806.2±64.61**	**1142.68±137.73**	**1293.98±61.95**	**0**
Gastrocnemius	**589.47±130.64**	**616.05±97.83**	**705.49±117.001**	**0.167**
Vastus lateralis	**1242.07±72.3**	**856.01±856.63**	**1175.07±102.70**	**0**

SQUAT

Pair (groups) - lumbar	Mean difference	P- value
Flatfoot – higharch	1.92	0.141
Higharch - normal	0.75	0.727
Normal- flatfoot	2.68	0.029

Pair (groups) - knee	Mean difference	P- value
Flatfoot – higharch	35.35	0.001
Higharch - normal	11.19	0.393
Normal- flatfoot	46.55	0.000

Pair (groups) - ankle	Mean difference	P- value
Flatfoot - higharch	18.27	0.001
Higharch - normal	4.87	0.509
Normal- flatfoot	23.14	0.000

(Fig 3.5- pair wise analysis of kinematics variables)

Pair (groups) – Gluteus maximus	Mean difference	P- value
Flatfoot - higharch	91.70	0.487
Higharch - normal	113.57	0.337
Normal- flatfoot	21.87	0.959

Pair (groups) – Biceps femoris	Mean difference	P- value
Flatfoot - higharch	121.40	0.568
Higharch - normal	54.65	0.890
Normal- flatfoot	176.05	0.313

Pair (groups) – Vastus medialis	Mean difference	P- value
Flatfoot - higharch	14.06	0.964
Higharch - normal	0.25	1.000
Normal- flatfoot	13.81	0.966

Pair (groups) - gastrocnemius	Mean difference	P- value
Flatfoot - higharch	4.93	0.996
Higharch - normal	55.91	0.578
Normal- flatfoot	60.84	0.524

(fig 3.6- pair wise analysis of kinetics variables

Jump

Pair (groups) - lumbar	Mean difference	P- value
Flatfoot - higharch	2.13	0.162
Higharch - normal	2.47	0.092
Normal- flatfoot	0.33	0.953

Pair (groups) - Knee	Mean difference	P- value
Flatfoot - higharch	11.61	0.575
Higharch - normal	5.35	0.887
Normal- flatfoot	6.26	0.849

Pair (groups) - ankle	Mean difference	P- value
Flatfoot - higharch	11.92	0.029
Higharch - normal	3.92	0.647
Normal- flatfoot	15.85	0.003

(fig 3.7- pair wise analysis of kinematics variables)

Pair (groups) – Vastus lateralis	Mean difference	P- value
Flatfoot - higharch	386.06700	0.000
Higharch - normal	319.0600	0.000
Normal- flatfoot	67.00700	0.221

Pair (groups) – Vastus medialis	Mean difference	P- value
Flatfoot - higharch	336.48000	0.000
Higharch - normal	151.30000	0.004
Normal- flatfoot	487.78000	0.000

Pair (groups) - Gastrocnemius	Mean difference	P- value
Flatfoot - higharch	26.58000	0.904
Higharch - normal	89.44000	0.336
Normal- flatfoot	116.02000	0.168

Pair (groups) – Biceps femoris	Mean difference	P- value
Flatfoot - higharch	275.53000	0.203
Higharch - normal	58.18000	0.927
Normal- flatfoot	217.35000	0.362

(fig 3.8- pair wise analysis of kinetics variables)

DISCUSSION

DISCUSSION

The aim of the study was to investigate and to compare the relationship between different foot morphologies with the kinetic and kinematics changes during squat and jump tasks among healthy asymptomatic adults. As we know squatting jumping task are the major integral parts for both prevention and rehabilitation training. As the foot morphologies being the commonest confounding factor for alternating lower extremity mechanics. Foot morphologies (flat foot , high arch and normal) have been taken in three groups with 10 each individuals. Then muscle activity has been checked in each individual by using EMG in squat and jump tasks.so, it is seen that in squat there is no such significant difference in muscle activity is found among four muscles that is vastus medialis, gluteus maximus, biceps femoris and gastrocnemius but there is a significant difference in kinematics which is done by X-SENSE 3D motion analysis and it is seen that all lumbar, knee and ankle components (p= 0.041, p= 0, p= 0.006), here knee component shows highly significant and lumbar and ankle component is significant. In jump task, vastus medialis, vastus lateralis, gastrocnemius and biceps femoris where vastus medialis and vastus lateralis shows significant difference(p=) where in kinematics lumbar and ankle components (p=0.078, p=0.006) .shows a significant difference.

STRENGTH AND WEAKNESS

1-There is still no evidence in 3D motion analysis on foot morphologies on platform based. So, it will be easy to plan a rehabilitation protocol for athletes.

2-As we have used wired EMG it is bit difficult to take the data during jump task.

In jump(kinetics)-

Vastus Medialis - As high arches can lead to a more rigid foot structure with less natural shock absorption. This can increase the load on the knee and may cause misalignment during jump activity. Flat feet often lead to excessive pronation, causing the knee to rotate inward. In response, the vastus medialis becomes more active to help realign the knee and counteract the inward movement, aiding in stabilizing the patella and the knee joint as a whole in jump activity. So, this shows poor foot posture or instability can lead to inefficient force production and increase the load on vastus medialis(30)

Vastus lateralis- In high arch the vastus lateralis may work harder to stabilize the knee and manage the increased stress from the rigid foot. This can result in greater muscle activation to ensure effective knee extension and stability during the jump. With flatfoot, the vastus lateralis may have to increase its activity to help stabilize the knee and counteract the inward rotation caused by the foot. This additional stabilization effort helps maintain proper patellar tracking and alignment, ensuring effective knee extension during the jump(31)

Biceps femoris- Does not show any significant difference($p=0.198$)- Biceps femoris, one of the hamstring muscles, plays a role in knee flexion and hip extension and assist in stabilizing the knee and hip during the jump. so, wider stance might shift some emphasis away from the biceps femoris and increase the engagement of the glutes and adductors, it may reduce the relative activation of the hamstrings, including the biceps femoris.

Gastrocnemius- Flat feet often lead to overpronation, where the foot rolls inward excessively. This can affect the alignment and efficiency of the gastrocnemius muscle, potentially causing it to work less effectively during push-off. So, the flatfoot may not provide the same leverage or stability as a higher arch, potentially affecting the force generation and distribution through the calf muscles. High arch foot can impact how effectively the foot pushes off the ground. The rigidity associated with high arches might lead to a less efficient push-off phase, affecting the less activation of the gastrocnemius during the jump(32)

(kinematics)-

Lumbar- Does not show any significant difference (p= 0.078)- foot posture does have an indirect effect on the lumbar region (lower back) during a jump. While the lumbar spine itself isn't directly involved in the mechanics of jumping, the alignment and stability of the feet can influence the overall body mechanics, which in turn affects the lumbar region.

Knee- In Initial foot morphology does not hamper the knee biomechanics or angle as the foot posture affected there is a change in whole lower limb function including knee. So, change the alignment and movement pattern of the knee, it doesn't directly change the knee angle itself but rather affects how the knee functions during movement(34)

Ankle-shows significant difference (p= 0.006)- it is seen that the segment contribution to force production during the jump or take-off is controlled by hip , knee and ankle component(1,2). So, the initial position of foot taking the load to jump plays a major role because higher the force production higher the jump.so, all it start from the foot, change in any posture of the foot varies in performance(18).

In squat(kinetics)-

Gluteus Maximus- studies shows that in static upright stance may reduce spinal extensor activation while increasing activity of the knee extensors during the movement like running or walking(35). Flatfoot may cause excessive pelvic tilt or rotation, whereas high arches can lead to a more rigid and less stable pelvis. Both scenarios can impact how well the gluteus maximus functions(36).

Vastus medialis - The vastus medialis continues to function to stabilize the knee and extend the leg. Overpronation may change the knee's alignment or load distribution, but it does not directly change the fundamental role of the vastus medialis. In high arch foot rigidity can affect how forces are transmitted through the lower limb and may lead to compensatory changes in squat mechanics. Despite these changes, the vastus medialis remains responsible for knee extension and patellar stabilization(37).

Bicep Femoris - Variations in foot morphology might lead to changes in muscle recruitment patterns or overall squat mechanics. Individuals with different foot structures might have slight variations in how the biceps femoris is activated during the squat. However, its primary role in knee and hip function remains unchanged. As it is part of a kinematic chain involving the hip, knee, and ankle. Changes in foot morphology can affect this chain, leading to adjustments in how other muscles engage, biceps femoris still performs its primary functions, even if the way it contributes might vary slightly depending on how the rest of the body adjusts(38).

Gastrocnemius - During squatting, the muscle helps stabilize the knee and ankle, providing support and balance throughout the movement. As gastrocnemius is not the primary muscle involved in the squat (which mainly engages the quadriceps, hamstrings, and glutes), it contributes to overall stability and force generation during the squat. Flatfoot and higharch might experience different loading patterns on the calf muscles, including the gastrocnemius, but the muscle's essential functions remain the same(39).

(kinematics)-

Lumbar - As the body operates as a kinetic chain, any change or misalignment in the foot posture can altered the hip component. Foot posture can influence the lumbar joint angle (lower back angle) during a squat. A wider stance generally encourages a more forward-leaning torso to maintain balance and depth. This can increase the lumbar joint angle, making the lower back more horizontal relative to the ground.

knee- To compensate for abnormal foot posture, the knee may move that aren't ideal, affect the balance of forces across the knee by altering the way muscles in the lower leg. A wider stance can alter the knee joint angle by reducing the depth of the squat, which may shift some of the load away from the knees and onto the hips and potentially lead to improper muscle activation or stress on the knee joint.

Ankle- The foot plays a crucial role in maintaining stability, balance, and proper mechanics during a squat. Neutral foot arch helps to distribute weight evenly across the foot and maintain balance during the squat. It is seen that Wider stance can reduce the demand on ankle dorsiflexion, it can also change the dynamics of the squat and affect depth and form so, the muscle activation will be more.

LIMITATION: -

The number of samples was small. The high score flatfoot and low score flatfoot is categorized in the same flatfoot group.

The use of wired EMG is bit difficult for the jump task individuals.

FUTURE SCOPE: -

More study is needed in the younger sports athlete for better sports performance. Studies can also be done for teenagers under 18. A comparison can be done in platform based and ground based and can plan a rehab protocol.

CONCLUSION

This study concluded that, the kinetics and kinematics parameters can be altered in subjects with squat and jump individual. So, individuals should consider the present findings when selecting specific exercises aiming to improve lower limb strength in different positions. Also provides new insights about muscle activation in different squat and jump task individual.

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ANNEXURES.1

Consent Form

Consent Form

Title of the study-

Lower Limb Biomechanical Differences During Jump and Squat Tasks Among Individuals with Different Foot Morphologies: An Observational Study

I have been informed by Miss.Tulasi Rani Dash. Pursuing MPT (Sports) conducting the above-mentioned study under theguidance of Dr. Deepak Kumar Pradhan, H.O.D, Abhinav Bindra Sports Medicine and Research Institute (ABSMARI), BHUBANESWAR.

I have no objection and will be a part of that group. I also understand that the study does not have any negative implication on my health. I understand that the information procedure by the study will become a part of institute's record and will be utilized, as per confidentiality regulations of the institute. I am also aware that the data might be used for medical literature and teaching purposes, but all my personal details will be kept confidential.

I am well informed to ask as many questions as I can to Miss. Saswati Biswal either during the study or later.

I understand that my assent is voluntary and I reserve the right to withdraw or discontinue the participation from the study at any point of time during the study.

I have explained to MR/MISS/MRS the purpose of the research, the procedure required in the language he/she could understand to the best of my ability.

(Investigator) (Date)

I confirm that Miss. Tulasi Rani Dash (Investigator) has explained to me in the language I can understand, the purpose of the study and the procedure. Therefore, I agree to give my assent for the participation as a subject in this study and I will be accountable for the decisions.

(Signature) (Date)

ANNEXURES.2

ETHICAL COMMITTEE CLEARANCE

ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE,
BHUBANESWAR, ODISHA

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2023/045

Date 12/08/2023

APPROVAL LETTER
APPENDIX- VIII

MEMBERS

Dr. Smaraki Mohanty, Clinician

Dr. Satyajit Mohanty, Basic Medical Scientist

Dr. Ashok Singh Chouhan Basic Medical Scientist

Mr. Shib Shankar Mohanty Legal Expert

Ms. Annie Hans, Social Scientist

Ms. Subhashree Samal, Lay Person

Mr. Deepak Ku. Pradhan, Scientific Member

IEC-SECRETARIAT

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

ABSMARI ETHICS COMMITTEE • BHUBANESWAR • Dr.

To,

TULASI RANI DASH
ABSMARI
273, PAHAL, BHUBANEWAR-752101

Protocol Title: A Comparative Study on Lower Limb Muscle Activation and Joint Kinematics During Squat and Jump Tasks on Individuals with Different Foot Morphologies

Protocol ID.: ABS-IEC-2023-PHY-004

Subject: Approval for the conduct of the above referenced study

Dear Mr./Mrs./Dr **TULASI RANI DASH**

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

The following documents were reviewed and discussed

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

The following members were present at meeting held on 12-08-2023

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

1

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

ANNEXURES.3

ETHICAL COMMITTEE CLEARANCE

ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE, BHUBANESWAR, ODISHA

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2023/045

Date: 12/08/2023

MEMBERS

Dr. Smaraki Mohanty, Clinician

Dr. Satyajit Mohanty, Basic Medical Scientist

Dr. Ashok Singh Chouhan Basic Medical Scientist

Mr. Shib Shankar Mohanty Legal Expert

Ms. Annie Hans, Social Scientist

Ms. Subhashree Samal, Lay Person

Mr. Deepak Ku. Pradhan, Scientific Member

IEC-SECRETARIAT

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

S.N.	Name of the Member	Designation & Qualification	Representation as per NDCT 2019	Gender (M/F)	Affiliation with the Institution (Y/N)
4	Dr. Smaraki Mohanty	Asst. Prof-IMS & Sum Hospital/MBBS, MD (Community Med)	Clinician	F	N
5	Mr. Chinmaya Kumar Patra	Principal-ABSMARI, MPT	Member Secretary	M	Y
6	Mr. Shiba Sankar Mohanty	Junior Counsel-Lt. Ramachandra Sarangi's Chamber / BA LLB	Legal Expert	M	N
7	Ms. Annie Hans	Disability Inclusive Development Co-Ordinator in Humanity and Inclusion (India/Nepal/Srilanka). /MA in Social Work	Social Scientist	F	N
8	Ms. Subhashree Samal	Ret. Reader-Pol Sc.	Lay Person	F	N
9	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 trial 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 and requests to be provided 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.

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

Yours sincerely

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

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ANNEXURES.4

MASTER CHART

			FLAT FOOT				
AGE	HEIGHT	WEIGHT	BMI	**Gluteus**	**Biceps**	**Vastus Med**	**Gastro**
26	153	306	17.9	948.3	1785	996.6	870
26	165	68	25	847.3	487.6	653	655.6
24	162	63	24	664.6	741.3	613.6	637.6
24	152	48	20.7	995	1160	581	692
24	183	89	27.2	612.3	459	573.3	471.6
23	195	119	31.3	889.6	755.6	622.6	616.6
25	178	71	22.2	561.3	726	604.6	663.3
24	171	65	26.6	394.6	697	482.3	486.3
24	152	49	18.7	715	684	674	598.6
19	161	69	26.6	750	498	530	610
23.9	167.2	94.7	24.02				
1.969207	13.739	73.04937	4.182981				
			HIGH ARCH				
AGE	HEIGHT	WEIGHT	BMI	**Gluteus**	**Biceps**	**Vastus Med**	**Gastro**
24	172	70	22.4	598	1066	537.6	517.6
24	161	54	22.2	871	568	790	832
21	161	45	21.2	830	512.3	645	722.3
24	178	62	20.8	612.5	705	634.2	702
26	150	68	23.7	556.7	578	792	623.5
25	166	55	20.8	685.3	487.3	582	694
25	179	71	17.4	323	737	453.4	488
20	155	45	20.2	563.5	698.3	480	438
19	152	79	24.5	843	482	650.4	640.5
18	178	71	17.3	578	745.6	625.8	693
22.6	165.2	62	21.05				
2.836273	11.10355	11.74734	2.364671				
			NORMAL				
AGE	HEIGHT	WEIGHT	BMI	**Gluteus**	**Biceps**	**Vastus Med**	**Gastro**
18	154	48	19.6	552	687	463.2	664.2
19	169	70	30.2	992	458	538	412.7
25	159	56	30.2	938	876	586	757
20	181	65	22.2	889	430	520	629
26	167	69	34.2	532.2	412.7	682	835.5
27	163	55	22.4	812.9	534.2	634	712.3
26	151	62	19.8	823	710	712	587
19	146	53	24.7	634	471	512.3	653.4
26	168	73	24.9	550.2	610.4	756.1	745.3
19	165	47	25.9	873.4	543.7	789.3	913.6
22.5	162.3	59.8	25.41				
3.749074	10.16585	9.319037	4.81605				

ANNEXURES.5

MASTER CHART

			FLATFOOT					
AGE	HEIGHT	WEIGHT	BMI	**vastus. L**	**vastus.M**	**gastro**	**bicep femoris**	
26	153	306	17.9	1100.67	789.6	667	1558.9	
26	165	68	25	796.73	955.8	712.7	671.6	
24	162	63	24	899.67	1765.8	478.9	1478.2	
24	152	48	20.7	855.7	777.9	645.4	654.9	
24	183	89	27.2	988.9	782.3	732.8	1559.8	
23	195	119	31.3	809.8	866.3	612.8	665.8	
25	178	71	22.2	1189.9	799.3	734.6	779.9	
24	171	65	26.6	867.8	732.6	652.4	1665.8	
24	152	49	18.7	1244.8	759.9	712.9	1662.5	
19	161	69	26.6	966.8	832.5	645.2	882.6	
23.9	167.2	94.7	24.02	**791.487**	**799.8**	**697.43**	**947.2**	**RMS**
1.969207	13.739	73.04937	4.182981					
			HIGHARCH					
AGE	HEIGHT	WEIGHT	BMI	**vastus. L**	**vastus.M**	**gastro**	**bicep femoris**	
24	172	70	22.4	986.7	1003.6	599.7	2006.8	
24	161	54	22.2	799.8	1123.6	732.7	1134.7	
21	161	45	21.2	765.9	1299.5	548.9	1988.8	
24	178	62	20.8	898.9	1001.6	832.6	1004.6	
26	150	68	23.7	754.8	1156.7	555.9	2089.9	
25	166	55	20.8	923.6	1256.9	786.1	1888.1	
25	179	71	17.4	956.8	1399.7	611.5	1229.1	
20	155	45	20.2	788.9	1129.7	614.8	1589.9	
19	152	79	24.5	896.9	1009.7	623.7	2389.5	
18	178	71	17.3	787.8	1045.8	654.6	2213.9	
22.6	165.2	62	21.05	**691.73**	**764.8**	**606.65**	**732.78**	**RMS**
2.836273	11.10355	11.74734	2.364671					
			NORMAL					
AGE	HEIGHT	WEIGHT	BMI	**vastus. L**	**vastus.M**	**gastro**	**bicep femoris**	
18	154	48	19.6	823.7	1399.7	898.7	1235.7	
19	169	70	30.2	934.8	1276.4	768.3	1389.4	
25	159	56	30.2	999.9	1341.8	856.2	1134.6	
20	181	65	22.2	844.7	1226.2	889.4	1267.2	
26	167	69	34.2	1161.7	1281.7	989.4	1289.6	
27	163	55	22.4	991.7	1287.9	787.2	1278.8	
26	151	62	19.8	1161.9	1322.9	813.4	1134.7	
19	146	53	24.7	1008.8	1189.6	792.6	1333.8	
26	168	73	24.9	934.6	1267.8	798.4	389.9	
19	165	47	25.9	988.9	1345.8	861.3	1299.8	
22.5	162.3	59.8	25.41	**749.78**	**712.56**	**765.76**	**711.67**	**RMS**
3.749074	10.16585	9.319037	4.81605					