



An Analysis of Soleus Muscle Tightness and Intrinsic Foot Muscle Weakness in Individuals with Flatfoot – A Cross Sectional Study

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WebLog Open Access Publications

Article ID : wjptr.2026.b0710
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OPEN ACCESS

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Received Date: 22 Jan 2026

Accepted Date: 05 Feb 2026

Published Date: 07 Feb 2026

Citation:

Muneeshwaran A, Nizarudeen M. An
Analysis of Soleus Muscle Tightness
and Intrinsic Foot Muscle Weakness
in Individuals with Flatfoot – A Cross
Sectional Study. WebLog J Phys Ther
Rehabil. wjptr.2026.b0710. [https://doi.
org/10.5281/zenodo.18779238](https://doi.org/10.5281/zenodo.18779238)

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Abstract

Background: Flat foot is related with modified foot biomechanics, where intrinsic foot muscle weakness and calf muscle tightness, particularly of the soleus muscle are deemed assisting factors. Understanding the relationship between these variables may aid in better assessment and rehabilitation strategies for individuals with flatfoot.

Objective: To analyze the relationship between intrinsic foot muscle strength, soleus muscle tightness in individuals with flatfoot.

Methods: A cross – sectional study was conducted in individuals assessed with flatfoot. Intrinsic foot muscle by using toe curl endurance test, soleus tightness by knee to wall test and flatfoot by feiss line. Pearson's correlation coefficient was used to analyze the relationship between these variables. Statistical significance was set up at $p < 0.05$.

Results: Pearson correlation analysis showed a very weak positive correlation between the knee to wall test and toe curl endurance test ($r=0.013$, $p=0.945$). A weak negative correlation was observed between the knee to wall test and feiss line measurement ($r=-0.283$, $p=0.130$). Additionally, a weak positive correlation was found between toe curl endurance test and feiss line value ($r=0.121$, $p=0.523$). None of the correlations were statistically significant.

Conclusion: The study concludes that there is no statistically significant relationship between soleus muscle tightness, intrinsic foot muscle strength in individuals with flatfoot. These show that intrinsic muscle weakness and soleus tightness act in this population, the factors may act separately instead of being directly linked. Further studies with larger sample sizes are recommended to explore this relationship more extensively.

Keywords: Flatfoot; Intrinsic Foot Muscles; Soleus Muscle Tightness; Knee to Wall Test; Toe Curl Endurance; Feiss Line

Introduction

The human body consists of a complex structure especially the foot that helps the body to stand, walk, run and maintain balance. It offers support, allows movement and absorbs shock during locomotion. The foot plays an important role in weight bearing and in shifting forces between the body and the ground. If there is any change in structure or function of the foot can affect lower limb biomechanics and lead to musculoskeletal problems.

The foot complex is made up of bones, ligaments, joints, muscle. It acts as a shock absorber, adapts to different surfaces of the floor and provides stability during movement. In this generation, one of the most common foot conditions is FLATFOOT, also known as PES PLANUS. Flatfoot is defined as where the medial longitudinal arch is reduced or absent during stability or weight bearing.

In flatfoot, it is classified into two types: flexible flatfoot and rigid flatfoot. In flexible flatfoot, the arch appears normal in sitting and lying and disappears while standing. And in rigid flatfoot, the arch is always absent. Flexible flatfoot is always seen in children, adolescents and young adults including college students and in rigid flatfoot is rare.

Although flatfoot is often considered a normal variation, many studies have concluded that it can affect foot function like altered foot mechanics, muscle imbalance and reduced functional

performance. People with flatfoot frequently show excessive foot pronation, heel eversion and poor foot stability during walking and standing. The abnormal foot mechanics can increase stress on the ankle, knee, hip and even lower back.

Medial longitudinal arch and Foot stability: The medial longitudinal arch is important structure of the foot formed by the calcaneus, talus, navicular, cuneiform bones and the first three metatarsals. This arch act as a shock absorber and helps the foot alter to different loads during standing and walking. The stability of the medial arch is maintained by passive structures such as ligament and the plantar fascia as well as by active muscle support and neural control. Both active and passive elements work together to maintain proper foot alignment. Among the active supports, intrinsic foot muscles play a major role in maintaining the medial arch. These muscles are located entirely within the foot and include the abductor hallucis, flexor digitorum brevis, flexor hallucis brevis, lumbricals and interossei muscles. these may help to raising arch, controlling pronation and providing stability during activities.

When intrinsic muscle strength is decreasing the foot cannot support the arch efficiently. this may lead to excessive pronation and increase collapse of the medial arch. In recent years the concept of the FOOT CORE SYSTEM has emphasize the important of intrinsic foot muscle in maintaining foot stability and movement control.

Flatfoot and intrinsic foot muscle weakness: Several studies concluded that the people with flatfoot who have changes in intrinsic foot muscle structure and function. these students frequently reduce muscle weakness smaller muscle size and poor muscle activation when compare to normal arches.

Intrinsic muscle weakness is also associated to poor balance, reduced postural control and decreased endurance during activities such as walking and running. As flatfoot becomes more severe, intrinsic muscle leads to stretched position for a long time, which more weakened them. This creates a cycle where arch collapse leads to muscle weakness and muscle weakness which extended arch collapse. Assessing intrinsic foot muscle strength can be difficult in clinical practice. However, simple test such as toe curl endurance test is used and suitable for this study.

Role of the soleus muscle in foot and ankle function: In relation to intrinsic foot muscles, extrinsic muscles of the lower leg also impact foot posture and movement. The triceps surae muscle group which includes gastrocnemius, soleus muscles play a major role in ankle movement during walking. The soleus muscle acts only at the ankle joint which is active during standing and walking. It helps in maintaining posture, shock absorber and controlling forward movement of the tibia over the foot during the stance phase of the gait. Good soleus flexibility is important for normal ankle dorsiflexion.

If the soleus muscle is tight, it leads to limited in ankle dorsiflexion. It causes the foot to alter by increase pronation at the subtalar joint. As a result, increased stress is positioned on medial longitudinal arch.

Soleus tightness and flatfoot: Many studies reported that calf muscle tightness is more common people with flatfoot. Even though gastrocnemius tightness is often noted, soleus tightness also plays an important role especially during weight bearing activities. Soleus muscle tightness may not be identified if ankle dorsiflexion is measured only with knee straight. Therefore, it is necessary to assess ankle dorsiflexion with the knee bent to particularly soleus flexibility.

The knee to wall test is commonly used weight bearing test to measure ankle dorsiflexion. Decreased knee to wall distance indicates soleus tightness and has been attached to increase in pronation and abnormal gait patterns. These results suggest that soleus tightness may increase the severity of flatfoot.

Relationship between intrinsic foot muscle weakness and soleus tightness: Even though intrinsic muscle weakness and soleus tightness have been studied isolated, very few studies have analyzed both factors together. From a biomechanical part these two factors are closely related. Soleus tightness limits ankle dorsiflexion which increases pronation and places more stress on intrinsic foot muscles. gradually, this increased need can cause fatigue and weakness of intrinsic muscles and reducing arch support.

Alternatively, intrinsic muscle weakness allows the arch to collapse more during weight bearing. This changes ankle mechanics and increase the workload on the calf muscles, which lead to tightening of the soleus muscle. Understanding these two relationships is important for proper assessment and treatment of flatfoot.

Fiess line as a measure of arch: The medial longitudinal arch of the foot is an important structure that provides support, shock absorber, and helps in balance and gait. Assessment of the arch is essential in understanding flatfoot severity. One commonly used clinical method is fiess line which is simple, reliable and non-invasive tool for assessing both clinical, practical and research and it provides valuable information about arch integrity.

Understanding the relationship between intrinsic foot muscle weakness, soleus tightness and arch collapse can help in developing better assessment and rehabilitation strategies. Therefore, this cross-sectional study aims to analyze intrinsic muscle weakness and soleus tightness in individuals with flatfoot and to analyze their association with medial longitudinal arch collapse.

Aim of the Study

The aim of the study is to investigate intrinsic foot muscle weakness and soleus muscle tightness in students with flatfoot and to analyze their relationship with medial longitudinal arch collapse by using fiess line”.

Need of Thestudy

The study needed to

- Assess intrinsic foot muscle weakness and soleus muscle tightness together in flatfoot students
- To analyze their association with medial longitudinal arch collapse using clinical measures
- Provide evidence for physiotherapist and clinician to design successful intervention program aim at improving arch stability and preventing progression of flatfoot.

Statement of the Study

The study on “An Analysis of intrinsic foot muscle weakness and soleus muscle tightness in individual with flatfoot – A cross sectional study”.

Objective of the Study

Primary objective:

- To analyze intrinsic foot muscle weakness and soleus muscle tightness in individual with flatfoot.

Secondary objectives:

- To measure medial longitudinal arch collapse using the feiss line.
- To identify the relationship between intrinsic foot muscle strength and soleus muscle tightness.
- To analyze the relationship between intrinsic muscle weakness and soleus tightness with severity of flatfoot individual.

Hypothesis

Null Hypothesis: There is no significant relationship between intrinsic foot muscle weakness and soleus muscle tightness and medial longitudinal arch collapse in individual with flatfoot.

Alternate Hypothesis: There is a significant relationship between intrinsic foot muscle weakness and soleus muscle tightness and medial longitudinal arch collapse in individual with flatfoot

Review of Literature**Morphological and mechanical characteristics of the intrinsic and extrinsic foot muscles under loading in individuals with flatfoot**

2024

Takumi Kobayashi et al.,

This cross-sectional study examined the morphological and mechanical characteristics of intrinsic and mechanical characteristics of intrinsic and extrinsic foot muscles underweight bearing conditions in individuals with flatfeet. Sixty young adults with flexible flatfoot were assessed using the feiss line for foot morphology, toe curl endurance test for intrinsic muscle performance and the knee to wall test for extrinsic muscle flexibility. Result showed that increasing flatfoot severity was associated with reduced intrinsic muscle endurance and decreased ankle dorsiflexion under loading. Significant negative correlations were observed between flatfoot severity and toe curl endurance test ($r \approx -0.58$, $p < 0.01$) and between flatfoot severity and Knee to wall test ($r \approx -0.61$, $p < 0.01$).

Prevalence of calf muscle tightness in asymptomatic flatfoot subjects

2022

Mohamed S.H.Kamel et al.,

This cross-sectional study assessed the prevalence of calf muscle tightness in asymptomatic individuals with flatfoot. Eighty young adults with clinically identified flatfoot were identified using the feiss line for arch assessment and the knee to wall test to measure calf muscle tightness underweight bearing conditions. The result showed that approximately 62 % of asymptomatic flatfoot subjects demonstrated reduced ankle dorsiflexion, indicating calf muscle tightness with higher prevalence observed in flatfoot. these findings suggest that calf muscle tightness is common even in asymptomatic flatfoot and may act as an early biomechanical risk factor for further foot dysfunction.

Comparison of biomechanical factors between normal, flatfoot and high arched foot in university students

2024

Kajal Chouhan et al.,

This cross-sectional study compared biomedical factors among

university students with normal, flatfoot and high arched feet. Flatfoot students showed reduced intrinsic foot muscle endurance and limited ankle dorsiflexion, indicating muscle weakness and calf tightness, while high arched feet demonstrated increased foot stiffness and reduced shock absorption. Students with normal foot posture displayed balanced muscle function and ankle mobility. These findings highlight distinct biomechanical differences across foot types that may influence injury risk.

Effects of short foot training on foot posture in patients with flatfeet: a systemic review and meta-analysis

2024

Jingling Cheng et al.,

This systematic review and meta-analysis examined the effectiveness of short foot training on foot posture in individuals with flatfeet. Analysis of controlled trials showed that short foot exercises performed for 4–12 weeks significantly improved foot posture by reducing navicular drop and foot posture index scores, reflecting better medial arch support. These findings indicate that short foot training is an effective conservative approach for improving foot posture and intrinsic foot muscle function in flatfoot patients.

Ankle equines

2024

Naraghi R et al.,

Ankle equines is a condition characterized by limited ankle dorsiflexion, most commonly due to tightness of the gastrocnemius–soleus complex, and is frequently observed in both symptomatic and asymptomatic individuals. This restriction alters normal lower-limb biomechanics, leading to compensatory movements such as excessive foot pronation, early heel rise, and increased stress on the midfoot and forefoot during gait. Ankle equinus has been strongly associated with foot deformities including flatfoot, plantar fasciitis, and Achilles tendinopathy, as reduced dorsiflexion increases load on the medial longitudinal arch. Clinical assessment is commonly performed using weight-bearing tests such as the knee-to-wall test, and management typically focuses on calf stretching, strengthening, and corrective exercises to restore ankle mobility and prevent secondary musculoskeletal complications.

Are Their Relationships Between Calf Muscle Lengths and Static and Dynamic Balance Control?

2025

Marciodos santos et al.,

The study by dos santoet.al examined the relationship between calf muscle length and both static and dynamic balance control in 47 healthy adults. Outcome measures are goniometry to measure gastrocnemius and soleus length; Static balance by balance error scoring system BESS and dynamic balance by star excursion balance test SEBT. Result showed that a moderate positive correlation between gastrocnemius length and BESS error ($r=0.45$, $p<0.001$); greater flexibility poorer static balance with better dynamic performance. The author concluded that moderate calf stiffness may enhance postural stability and increase flexibility can decrease neuromuscular control during balance task.

The Effects of Intrinsic Foot Muscle Strengthening Intervention for Adult Over Age 65: A Randomized Control Trail

2025

Futrell E, Habegger et al.,

This study explores that how targeted intrinsic foot muscle exercise influence balance mobility and fall risk among older adults. 60 participants are included above the age of 65-80 years by experimental study. Outcome measure includes dynamometry and ultrasound cross sectional area, balance performance by Y balance test and time up and go test. ANOVA showed significant improvement in the intervention group for IFM strength p (0.001), medial longitudinal arch height p (0.02), dynamic balance reach distance ($p < 0.01$) 23% reduction in fall risk score compared with control. The study concluded that strengthening IMF increase sensory feedback and postural stability in older adults, better dynamic balance and fall prevention.

Effect of Intrinsic Foot Muscle Training Combined with the Lower Extremity Resistance Training on Postural Stability in Older Adults

Sep 29, 2025

Zhangqi Lai et al.,

This randomized control trail study aimed that combining intrinsic foot muscle training with lower extremity resistance training which improves postural instability in older adults. The older adult was designed to combined training group which is intrinsic foot muscle exercises and lower limb resistance exercises and other one is resistance group. Postural stability evaluated by using static and dynamic balance measurement and functional mobility test. The combined group showed greater improvements in balance, decreased swaying and good dynamic stability compared to resistance training group. The study concluded that combined giving of both intrinsic foot muscle exercise and resistance training is an effective approach to enhance postural stability and reduce the risk of fall.

Effects of Isolated Gastrocnemius Tightness on Foot Posture, Strength Function and Balance in Children Aged 6-7 Years: A Case Control Study

2012

Evans et al.,

This case study examined the impact of isolated gastrocnemius tightness on foot posture, muscle strength, functional ability and balance in children aged 6-7 years. children with gastrocnemius tightness assessed by silfversklold test, foot posture were assessed by foot posture index and navicular drop test, while strength, functional performance and balance were evaluated through clinical test and single leg stance measures. The study concluded that isolated gastrocnemius tightness affects foot mechanics and balance in early childhood.

Effect of Isolated Gastrocnemius Tightness on Foot Posture, Strength, Function and Balance in Children Aged 7-16: A Case Control Study

2025

Deniz Tuncer et al.,

The study evaluated the effect of plantar fascia tightness on foot posture, muscle strength, functional ability and balance in children

aged 7-16 years by comparing both clinically in fascia tightness to age, sex – match control with normal flexibility. Foot posture is assessed by foot posture index and arch height while foot muscle strength measured by functional strength test. Functional performance is assessed by pediatric foot function questionnaires and balance assessed by dynamic and static balance. The result showed that the plantar fascia tightness in children altered in pronated foot posture, decreased in foot muscle strength and reduced balance performance compared with controls.

Ankle Dorsiflexion Range of Motion is Associated with Compression Stiffness of Gastrocnemius and Soleus Muscle, Foot Structure and Hallus Extension Range of Motion

2025

Koshino et al.,

The author compared between ankle dorsiflexion range of motion, calf muscle stiffness, foot posture and great toe extension in healthy adults measured by using 3D scanner, foot posture index and stiffness is assessed by ultrasonic and my tonometer technique. He concluded that, the ankle dorsiflexion assessed in non-weight bearing with knee extended related to lateral gastrocnemius tightness and arch height while dorsiflexion with knee flexed related to foot posture scores, halls extension range of motion. In weight bearing condition, ankle dorsiflexion linked to foot posture index score and soleus tightness. These findings demonstrate that calf muscle stiffness, foot posture and halls mobility are primary factor contributing ankle dorsiflexion movement.

Correlation of Intrinsic Muscle Strength with Forefoot and Hindfoot Posture in Patient with Flatfoot

2023

Shruti Sungari et al.,

This study evaluated that the relationship between intrinsic muscle strength and forefoot and hindfoot posture in patients with flatfoot. Participants assessed for intrinsic foot muscle strength by using functional tasks while foot posture assessed by foot posture index and rearfoot angle. They concluded that the intrinsic foot muscle strength plays an important role in maintaining normal foot posture and weakness of muscle leads to flatfoot.

Examining the Relationship Between Pes Planus Degree, Balance and Jump Performance in Athletes

2019

Fatma Nese Sahin et al.,

This study evaluated the relationship between the degree of pes planus, balance and jump performance in athletes. The severity of pes planus was measured by using foot posture measures while balance was assessed by static and dynamic and jump performance measured by vertical and horizontal jump tests. These findings suggest the degree of pes planus can affect the balance and athletic performance.

Procedure

Ethical approval and consent

The study procedure was explained to all participants.

Written informed consent was given.

Participant preparation

Participants were assessed for flatfoot using.

- Measurement of soleus tightness.
- Measurement of intrinsic foot muscle weakness.

Height, weight, age, dominant limb, leg length was recorded. During testing, participants were comfortable, clothing and were barefoot. A warm up was allowed before assessment for 5 minutes.

Flatfoot confirmation test

Fiess line:

Procedure:

Ask the patient to stands in relaxed position.

Draw an imaginary line from medial malleolus to head of first metatarsal.

Observe the position of the navicular tuberosity relative to this line.

Scoring:

Mild – slightly below the line 1-5mm=mild flatfoot.

Moderate – clearly below the line pes planus 6 – 10 mm=moderate flatfoot.

Severe – far below the line with visible arch collapse > 10 mm=severe flatfoot.

Measurement of soleus tightness

Knee to wall test:

Equipment needed:

Wall, measuring tape or ruler, marker/chalk.

Test position:

Patient stands facing a wall.

Test foot flat on the floor, toes pointing straight.

Heels must remain on the ground.

Knee aligned over 2nd toe.

Procedure:

Place the big toe close to the wall.

Ask the patient to bend the knee forward touch the wall without lifting the heel.

If successful, move the foot slightly backward.

Repeat until the maximum distance where the knee can still touch the wall.

Measure the maximum distance where the knee can still touch the wall.

Measure the distance from the big toe to the wall.

Repeat 2-3 times and record the best value.

Test both sides for comparison.

Normal value:

>10-12 cm → normal ankle dorsiflexion.

<10 cm → restricted dorsiflexion.

Side to side difference >2 cm → clinically significant.

Ankle dorsiflexion range of motion

Position:

Seated with the leg hanging off the table or lying supine with knee bent to relax the calf muscle.

Goniometer placement:

Axis – place over the lateral malleoli.

Stationary arm – align with the shaft of the fibula.

Moving arm – align with the base of the fifth metatarsal.

Starting position:

The ankle is at 90 degrees.

Movement:

Ask the patient to bring their toes up towards the ceiling as far as possible.

Normal degree – 20.

Measurement of intrinsic foot muscle strength

Toe curl test:

Test position:

Patient in sitting or standing.

Place the barefoot on the floor.

Ankle in neutral position.

Procedure:

Ask the patient to curl toes downward.

Heel remains on the ground.

No excessive ankle plantarflexion.

Ask the patient to curl toes around a towel or paper.

Observe toe movement, arch response and compensation movements.

Therapist should ON the timer and recorded the seconds in data sheet.

Scoring:

>60 sec – excellent endurance.

40 - 60 sec – good endurance.

20-39 sec – fair endurance.

<20 sec – poor endurance.

Rest intervals and safety

30 – 60 seconds rest was given between test.

Testing stopping if pain, fatigue or dizziness occurred.

All measurements were taken by the same examiner to reduce bias.

Data recording:

Data was recorded.

Table 1: Descriptive Statistics.

Descriptive statistics	KNEE TO WALL TEST	TOE CURL ENDURANCE TEST	FEISS LINE
Valid	30	30	30
Missing	0	0	0
Mean	8.303	32.87	12.55
Std. Deviation	1.181	5.680	2.098
Shapiro-Wilk	0.942	0.947	0.937
P-value of Shapiro-Wilk	.101	.142	.073
Minimum	6.000	24.00	9.600
Maximum	9.900	44.00	16.40

Table 2: Correlation.

Pearson's Correlations			Pearson's r	P
KNEE TO WALL TEST	-	TOE CURL ENDURANCE TEST	0.013	0.946
KNEE TO WALL TEST	-	FEISS LINE	-0.283	0.130
TOE CURL ENDURANCE TEST	-	FEISS LINE	0.121	0.523

Mean values were entered in assessment sheet.

Statistical Analysis

An analysis of soleus muscle tightness, intrinsic foot muscle weakness in individual with flatfoot. – A Cross Sectional Study.

Sample size: n = 30

Test used: Pearson correlation

Software: JASP

Descriptive Statistics

See Table 1.

Q-Q Plots

See Figures 1-3 and Table 2.

Scatter plots

See Figures 4-6.

Result

Pearson correlation analysis revealed no statically significant relationship between soleus muscle tightness, intrinsic foot muscle endurance, and flatfoot severity in individuals with flatfoot ($p > 0.05$). The analysis showed no significant correlation between knee to wall test and toe curl endurance test ($r = 0.013$, $p = 0.946$). A weak negative, non – significant correlation was observed between knee to wall test and feiss line ($r = -0.283$, $p = 0.130$). The correlation between toe curl endurance test and feiss line was also weak and non- significant ($r = 0.121$, $p = 0.523$).

Conclusion

The present study displayed that intrinsic foot muscle weakness and soleus muscle tightness are considerably associated with flatfoot severity in young adults. participants with reduced intrinsic muscle strength demonstrated greater medial longitudinal arch collapse indicating that weakened intrinsic muscle reduce active support of the arch and assist excessive pronation. In the same way, participant with tight soleus muscle showed limited ankle dorsiflexion and

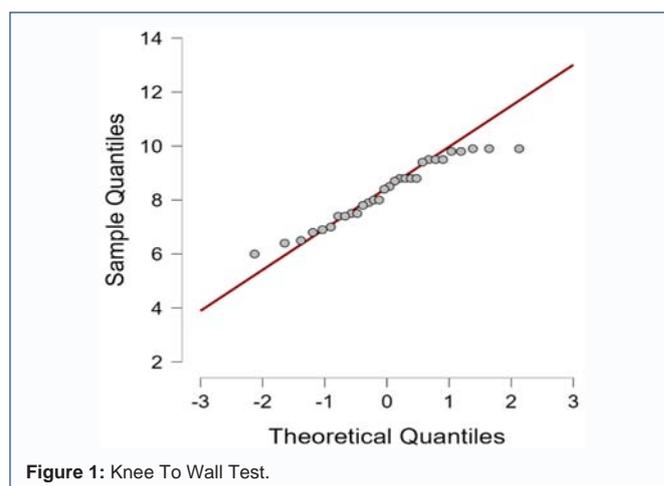


Figure 1: Knee To Wall Test.

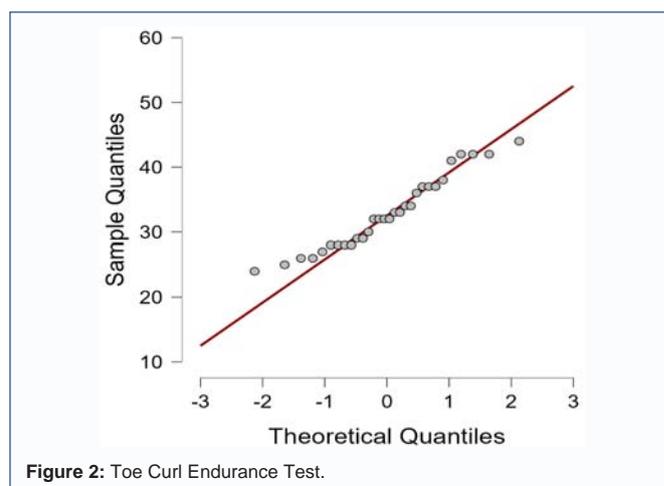


Figure 2: Toe Curl Endurance Test.

increased navicular drop, indicating that limited calf flexibility modifies foot biomechanics and increases stress on passive structure. the combination of intrinsic muscle weakness and soleus muscle

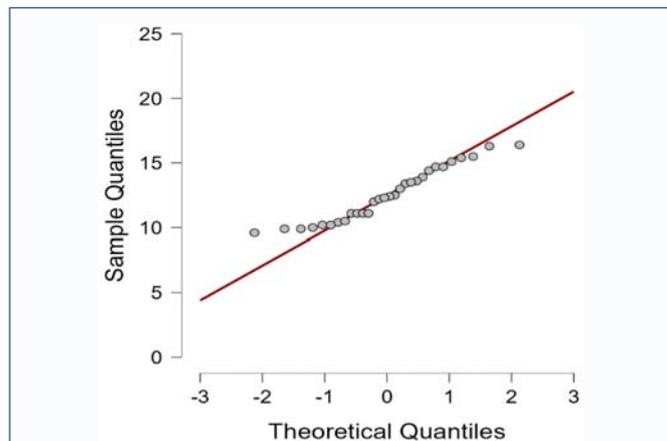


Figure 3: Feiss Line.

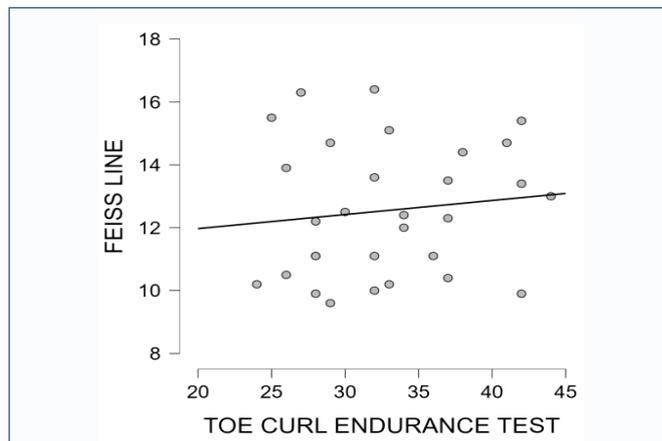


Figure 6: Toe Curl Endurance Test vs. Feiss Line.

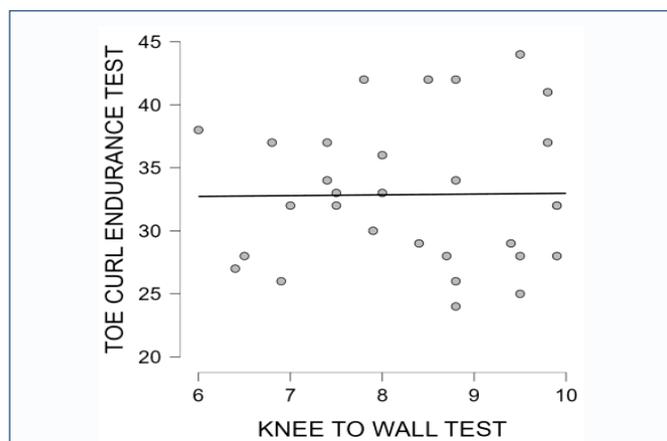


Figure 4: Knee to Wall Test vs. Toe Curl Endurance Test.

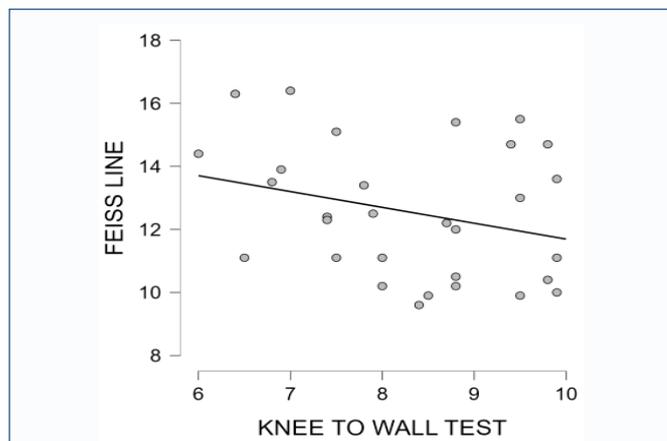


Figure 5: Knee to Wall Test vs. Feiss Line.

tightness is observed to create biomechanical imbalance, aggravating arch collapse and functional limitation. This finding highlights the importance of early assessment using simple clinical tools such as toe curl endurance test, knee to wall test, ankle range of motion measurement and feiss line evaluation. overall, the study emphasis the need for targeted intervention is focusing on both intrinsic muscle strengthening and soleus flexibility to improve arch stability, prevent progression of flatfoot deformity and improve overall function.

Limitations of the Study

Cross sectional design

The study observes the participant at a single point in a time, so it cannot initiate a cause and effective relationship between intrinsic muscle weakness, soleus tightness and arch collapse.

Sample size and sampling method

Using convince sampling from a limited population.

Assessment tools limitations

Tests like toe curl endurance test and knee to wall test are practical and dependent but provide indirect measures of muscle strength and flexibility. They may not record sight structural or functional deficits compared to advanced imaging or dynamometry.

Participant variability

Differences in activity levels, body weight or lifestyle factors among participants may affect muscle strength, flexibility and foot posture.

Short term observation

Functional adaptations or improvements over time cannot be observed in a cross-sectional study.

Potential bias

Observer bias during measurement and self-selection bias in voluntary participation may affect results.

Discussion

The present cross-sectional study was conducted to analyze the relationship between intrinsic foot muscle weakness, soleus muscle tightness and flatfoot severity in individual with pes planus using clinical outcome measure such as Toe Curl Endurance Test, Knee to Wall Test and ankle ROM assessment and feiss line. The findings of this study suggests that individuals with flatfoot shown reduced intrinsic foot muscle strength, limited ankle dorsiflexion and increased medial longitudinal arch collapse. A notable association was observed between intrinsic muscle weakness and increased arch collapse suggesting that intrinsic foot muscles as dynamic stabilizers of the arch and support the concept of the foot core system.

Decreased performance in the toe curls endurance test among flatfoot individuals indicates decreased endurance and strength of intrinsic muscle such as abductor hallucis, flexor digitorum brevis.

Chronic pronation and arch decreasing in flatfoot lead to lengthen position of the muscle, reducing their mechanical efficiency and leading to functional weakness. This weakness may lead to progressive arch collapse during weight bearing activity.

The knee to wall test result demonstrates ankle dorsiflexion indicating soleus muscle tightness in flatfoot. Soleus tightness restricts forward tibial progression during stance phase, resulting in compensatory subtalar joint pronation. this compensatory mechanism increases stress on medial longitudinal arch and leads to feiss line deviation.

The feiss line assessment showed an increased degree of navicular tuberosity displacement in people with reduce intrinsic muscle strength and soleus tightness. this supports the hypothesis that both muscular factors play a role in severity of flatfoot deformity. the combined presence of both factors creates a bio mechanical imbalance leads to inadequate active arch support and limited range of motion together increased arch collapse.

Overall, the results of the study highlight that flatfoot is not just a structural deformity but also a condition impacted by muscle strength and flexibility deficit. the inter relationship between intrinsic foot muscle weakness and soleus muscle tightness emphasis the importance of complete assessment and management strategies. rehabilitation program focusing on intrinsic muscle strengthening and soleus stretching May help to improve arch stability, ankle mobility, and functional performance in flatfoot individuals.

Recommendations

Early screening and assessment

Individuals, especially college students should be screened early for flatfoot using simple clinical tools such as feiss line, knee to wall test and toe curl endurance test to identify intrinsic muscle weakness and solus tightness.

Intrinsic foot muscle strengthening

Exercise program should include intrinsic foot muscle strengthening exercises such as short foot exercises, toe curl exercises to improve medial longitudinal arch stability.

Soleus muscle stretching

Regular soleus stretching exercises should be incorporated to improve ankle dorsiflexion and reduce compensatory pronation associated with flatfoot.

Use of simple clinical tools

Clinicians are encouraged to use cost- effective and easy to administer assessment methods such as the knee to wall test and toe curl endurance test for routine evaluation of flatfoot related muscular deficits.

Future research directions

Future studies should include lager and more populations to improve the generalizability of findings.

Education and awareness

Awareness programs should be conducted to educate students and athlete about proper foot care, footwear selection and preventive exercise to reduce the progression of flatfoot deformity.

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