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Prevalence of Calf muscle tightness in asymptomatic flat foot subjects

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Abstract:

Objective: To determine the prevalence of calf muscle tightness in asymptomatic flat foot subjects.

Methods: One hundred and seventy five asymptomatic flat foot subjects (male and female) their age ranging from 20-40 years participated in the study. Gastrocnemius and Soleus muscle tightness was assessed through measuring ankle dorsiflexion range of motion by using fluid-filled bubble inclinometer from two positions sitting straight knee for gastrocnemius muscle testing and prone bent knee for soleus muscle testing.

Results: The prevalence of gastrocnemius tightness was 76.6% with 95% CI of 69.76- 82.23%. The prevalence of soleus tightness was 15.42% with 95% CI of 10.82- 21.51%. The prevalence of gastrocnemius and soleus tightness in female subjects was significantly higher compared with males ($p < 0.01$).

Conclusion: Asymptomatic flat foot deformity is associated with gastrocnemius muscle tightness and a higher prevalence of gastrocnemius and soleus tightness was found in female subjects compared with males.

Keywords: Flat foot, calf muscle, tightness, gastrocnemius, dorsiflexion.

1. Introduction:

Flat foot deformity is considered a common chronic foot and ankle condition characterized by loss of the medial longitudinal arch (MLA), valgus of the rear foot and abduction of the mid foot on the hind foot (1).

The most common patho-mechanical problem associated with flat foot is excessive pronation during standing and walking (2).

A flat foot is known to be associated with high incidence of lower extremity injuries in the population. The cause of this could be altered foot kinetics or poor postural stability due to abnormal foot mechanics (3).

Flat foot could be present as symptomatic or asymptomatic (4). Moreover, it could be present as flexible or rigid flat foot (5).

Symptoms of flexible flat foot include a sensation of discomfort such as early tiredness

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or difficulties during prolonged standing or walking, and pain located in the plantar aspect of the foot and the medial aspect of the hind foot **(**6**)**.

The causes of flexible flat foot are tibialis posterior dysfunction, ligament loosening, Achilles tendon shortening, and weakness of the intrinsic foot muscles. These deformations cause plantar flexion and adduction of the talus bone and valgus of the calcaneus bone **(**7**).**

Van Boerum and Sangeorzan (2003) (8**)** mentioned that in case of weakness or laxity of the soft tissue supporting structures of the arch, the normal triceps surae could become more tight or short to accommodate the plantar flexed position of the talus and calcaneus. And if the triceps surae is too tight or short so this increase in force through the normal supporting structures of the arch will weaken and the mid foot will become lax and begin to collapse. In both cases, the final condition is that the arch collapses and the triceps surae complex becomes shorter and tighter.

Most of the researchers dealing with flat foot deformity have suggested that this deformity is associated with tightness of the gastrocnemius or Achilles shortening **(**9:12**).**

However, up to our knowledge, till now there is no objective quantitative measurement for the gastrocnemius and soleus muscle tightness in cases of asymptomatic flat foot.

The aim of the current study is to determine the prevalence of calf muscle tightness in asymptomatic flat foot subjects and to explore the association of gastrocnemius and soleus muscle tightness and patients' characteristics (age, sex, body mass index).

2. Materials and Methods:

This study was conducted at the outpatient clinic of the faculty of Physical Therapy at Badr University in Cairo and the Outpatient Clinic of the faculty of Physical Therapy, Cairo University. The study extended from March 2020 to January 2021. Ethical approval of the research was obtained from the Ethical Committee of the Faculty of Physical Therapy, Cairo University, Egypt.

Study design:

A cross sectional, observational study design.

Participants:

713 subjects were screened for flat foot (employees, students) then 175 subjects with flat foot deformity participated in the study aged from 20 to 40 years. All subjects were consecutively recruited among volunteers in faculty of physical therapy.

Inclusion and Exclusion Criteria:

Subjects included in this study were necessary to have flexible flat foot; having navicular drop (ND) of more than 10 mm; and Body Mass Index from 18.5 kg/m^2 to 29.9 kg/m^2.

Participants therefore were excluded if they reported any of the following conditions: a history of foot and ankle surgery, trauma, fracture or dislocation, having congenital deformities in the ankle and foot, having systemic or neurologic diseases that could affect lower extremity biomechanics.

Procedures:

Participants signed informed consent document after clear demonstration of study objectives, procedures, privacy and use of personal data. Demographic data were collected from all subjects concerning age, sex, weight, height and BMI. All subjects were evaluated by a single investigator with more than 5 years of clinical practice.

Subjects were screened for flat foot by visual observation of the MLA lowering. Then test for flexible flat foot either by standing on tip toes or by passively dorsiflexing the hallux of the weight bearing foot if the medial arch reappears, so it is positive Jack's test **(**13**).**

Navicular Drop Test was done by asking the subjects to sit on a chair with their knee and ankle in 90° and the navicular tubercle of their foot was palpated and marked on its greatest prominence. The examiner then determined the neutral position of the subtalar joint and this position was used for measurement. Then, a card was used to measure and mark the vertical height of the navicular bone in the non-weight bearing position. The height of the navicular bone was measured again in a full weight bearing position and marked on the same card. The difference between the initial and the second heights of this bone was labeled as the "Navicular Drop" index **(**14**)**.

Dorsiflexion measurements were taken from two positions by using bubble inclinometer (Baseline® Bubble Inclinometer, Fabrication Enterprises INC, White Plains, New York 10602, USA).The measurement positions are sitting straight knee for gastrocnemius muscle testing and prone bent knee (90° flexion) for soleus muscle testing. The sitting straight knee measurement was taken with the knee joint positioned in terminal extension, with the subject seated on the examining table and the lower leg over the edge of the table. The measurements were taken with the Velcro strap secured around the foot of the subject and the inclinometer adhered to the strap facing in a lateral direction, then the subject was asked to relax while the examiner passively dorsiflexed the talocrural joint until he met the restriction which was indicated by a firm end point. Then the angle of dorsiflexion was recorded **(**15**)**.

The prone bent knee measurement was performed with the subject lying prone, with the knee flexed to 90°. The measurements were taken by the same procedure as the sitting straight knee measurements. Then the angle of dorsiflexion was recorded **(**15).

Dorsiflexion measurements were repeated and recorded three times in each position, and then the mean of the three measurements was calculated.

Statistical analysis:

Descriptive statistics of the mean, standard deviation, frequencies, percentages and confidence interval (CI) were utilized in presenting the subjects demographic and measured data. Quantitative variables were summarized by using mean and standard deviation while categorical variables were summarized by using frequencies and percentage. Chi-square statistics was utilized to examine associations between calf muscle tightness and subject characteristics. The level of significance for all statistical tests was set at $p < 0.05$. All statistical measures were performed through the statistical package for social studies (SPSS) version 25 for windows.

3. Results:

Subjects characteristics:

One hundred and seventy-five subjects with asymptomatic flat foot participated in the current study. The mean ± SD age of the study group was 26.25 ± 3.81 years with minimum of 20 years and maximum of 40 years. The mean ± SD BMI of the study group was 25.93 ± 2.57 kg/m² with minimum of 18.7 kg/m² and maximum of 29.9 kg/m². The general characteristics of the subjects participated in the current work are presented in (**Table 1**).

Table 1: Participants' characteristics

Age classes	n	%
From 20 to 24 years	71	40.6%
From 25 to 29 years	77	44%
From 30 to 40 years	27	15.4%
BMI classes		
Normal weight (From 18.5 to 24.9 kg/m²)	57	32.6%
Overweight (From 25.0 to 29.9 kg/m²)	118	67.4%
Sex		
Females	110	62.9%
Males	65	37.10%

Screening for asymptomatic flatfoot:

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The mean ± SD of ND of the right side was 13.28 ± 1.94 mm and that of left side was 13.2 ± 1.91 mm with a minimum value of 11 mm and maximum value of 19 mm.

Prevalence of calf muscle tightness among participants:

The prevalence of gastrocnemius tightness in the study group was 76.6% (134 out of 175) with 95% CI of 69.76- 82.23%. The prevalence of soleus tightness in the study group was 15.42% (27 out of 175) with 95% CI of 10.82- 21.51% (**Table 2**).

The prevalence of bilateral gastrocnemius tightness in the study group was 34.28% (60) with 95% CI of 27.65- 41.58%. and that of unilateral gastrocnemius tightness was 42.28% (74) with 95% CI of 35.2- 49.69%. The prevalence of bilateral soleus tightness was 5.14% (9) with 95% CI of 2.72- 9.48% and that of unilateral soleus tightness was 10.28% (18) with 95% CI of 6.6- 15.67% (**Table 2**).

Table 2. Prevalence of calf muscle tightness of the study group.

	Prevalence of tightness	95% CI
Gastrocnemius tightness	134 (76.6%)	69.76-82.23%
Soleus tightness	27 (15.42%)	10.82-21.51%
Bilateral gastrocnemius tightness	60 (34.28%)	27.65-41.58%
Unilateral gastrocnemius tightness	74 (42.28%)	35.2-49.69%
Bilateral soleus tightness	9 (5.14%)	2.72-9.48%
Unilateral soleus tightness	18 (10.28%)	6.6-15.67%

CI: Confidence interval

Association between calf muscle tightness and subjects characteristics:

There was no significant association between gastrocnemius and soleus tightness with age (p > 0.05) and BMI (p > 0.05). There was a higher prevalence of gastrocnemius and soleus tightness in female subjects compared with males (p < 0.01) (**Table 3-4**).

Table 3. The frequency distribution of gastrocnemius tightness and association with subject characteristics:

	Gastrocnemius tightness		χ2 value	p - value
	Yes	**No**		
Age classes				
From 20 to 24 years	58 (81.7%)	13 (18.3%)	1.76	0.41
From 25 to 29 years	56 (72.7%)	21 (27.3%)		
From 30 to 40 years	20 (74.1%)	7 (25.9%)		
BMI classes				
Normal weight	42 (73.7%)	15 (26.3%)	0.39	0.53
Overweight	92 (78%)	26 (22%)		
Sex				
Females	94 (85.5%)	16 (14.5%)	13.02	0.001
Males	40 (61.5%)	25 (38.5%)		

χ2: Chi squared value, p value: Probability value

Table 4: The frequency distribution of soleus tightness and association with subjects characteristics.

	Soleus tightness		χ^2 value	p - value
	Yes	**No**		
Age classes				
From 20 to 24 years	14 (19.7%)	57 (80.3%)	2.41	0.3
From 25 to 29 years	11 (14.3%)	66 (85.7%)		
From 30 to 40 years	2 (7.4%)	25 (92.6%)		
BMI classes				
Normal weight	11 (19.3%)	46 (80.7%)	0.97	0.32
Overweight	16 (13.6%)	102 (86.4%)		
Sex				
Females	23 (20.9%)	87 (79.1%)	6.81	0.009
Males	4 (6.2%)	61 (93.8%)		

The number of subjects who had both gastrocnemius and soleus tightness was 27 subjects (15.42%). The number of subjects who had only gastrocnemius was 107 subjects (61.15%). All subjects who had soleus tightness also had gastrocnemius tightness. There was a significant association between gastrocnemius and soleus tightness (p = 0.002) (**table 5**).

Table 5. Association between gastrocnemius and soleus tightness:

		Soleus tightness		$\chi2$ value	p -value
		Tight (N= 27)	**Free (N= 148)**		
Gastrocnemius tightness	**Tight (N=134)**	27 (15.42%)	107 (61.15%)		
	Free (N= 41)	0 (0%)	41 (23.43%)	9.76	0.002

χ2: Chi squared value, p value: Probability value

4. Discussion:

The aim of the current study was to determine the prevalence of calf muscle tightness in asymptomatic flat foot subjects and to explore the association of gastrocnemius and soleus muscle tightness and patients' characteristics (age, sex, body mass index). The major finding was the high prevalence of gastrocnemius tightness (76.6%) and the low prevalence of soleus tightness (15.42%) in asymptomatic flat foot subjects. Furthermore, a significant increase in the prevalence of gastrocnemius and soleus tightness was found in female subjects compared with males.

Up to our knowledge, till now there is no objective quantitative measurement for the gastrocnemius and soleus muscle tightness in cases of asymptomatic flat foot. However, the findings of the current study agreed with the suggestions of the previous studies (9:12) that flat foot is associated with tightness of calf muscle.

The result of the present study agreed with **McCormack (2001)** (11) who suggested that tightness of the triceps surae is among the causes of acquired flat foot.

Also, the present study agrees with a previous study that suggested that flexible flat foot can be associated with shortening of the gastrocnemius muscle or the Achilles tendon that leads to valgus deformity of the hind foot to compensate for the lack of dorsiflexion in the ankle joint (9). Furthermore, **Blackman and his colleagues (2009)**(10) mentioned that flatfoot deformity is characterized by flattening of the medial longitudinal arch, forefoot abduction, hind foot eversion, and often Achilles tendon contracture.

Also, this study agrees with the findings of **Digiovanni et al., (2002)** (16) who supported the existence of isolated gastrocnemius contracture in the development of forefoot or mid foot pathology in otherwise healthy people. They measured maximal ankle dorsiflexion range of motion and assessed gastrocnemius tightness with use of an electro goniometer in two groups, one group had metatarsalgia diagnosis or related mid foot or forefoot symptoms and a control group with no foot or ankle symptoms. They concluded that patients with forefoot or mid foot symptoms had less maximum ankle dorsiflexion with extended knee than did a control group. With knee flexion 90° to relax the gastrocnemius, this difference did not exist.

Controversy is still present about whether primary calf muscle tightness exists as a cause of acquired flat foot deformity or it is an effect. In a previous study it was mentioned that long-standing hind foot valgus makes the Achilles tendon assumes a position lateral to the subtalar joint and that leads to shortening of the gastrocnemius and soleus muscle group over time (12).

5. Conclusion:

Based on the study findings, it is concluded that asymptomatic flat foot deformity is associated with calf muscle tightness particularly gastrocnemius muscle and a significant increase in the prevalence of gastrocnemius and soleus tightness was found in female subjects compared with males. There was a significant association between gastrocnemius and soleus tightness but there was no significant association between gastrocnemius and soleus tightness with age and BMI. The findings of this study should increase the awareness of the existence of tightness of the calf muscles, particularly the gastrocnemius muscle in asymptomatic flat foot subjects.

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Also, it may have clinical implications in the treatment of those subjects by adding therapeutic stretching techniques for the calf muscle in the program of treatment besides other evidence based techniques. Further researches are needed to compare tightness of the calf muscle in flat foot group with a normal arch control group and to include the dominancy of the lower limb and its relation to the degree of tightness.

Conflict of Interests

The authors declare no conflict of interest.

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