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Effect of gender and footedness on Achilles tendon flexibility in typically developed children

Omnia M Eissa[1*], Walaa E Heneidy[2], Marwa M Ismaeel[3], Khaled A Olama L[3]
[1] M. Sc, PT, Department of Physical Therapy, Tanta University Hospitals, El-Gharbia, Egypt
[2] Ph. D, PT, Department of Physical Therapy for Pediatrics and Its Surgery, Faculty of Physical Therapy, Delta University for Science and Technology, Gamasa, Egypt
[3] Ph. D, PT, Department of Physical Therapy for Pediatrics, Faculty of Physical Therapy, Cairo University, Egypt

Abstract
Background: Reduced range of motion can affect the person's ability to carry out everyday activities and can lead to secondary problems such as strain, discomfort, contractures and deformities. The calf muscle considered one of the anti-gravity muscles. Isolated gastrocnemius equines contracture has been associated with several foot and ankle pathologies
Aim of the study: this study aimed to assess the flexibility of calf muscle (gastrocnemius and soleus), detect the difference in muscle flexibility between boys and girls and identify differences in calf muscle flexibility between dominant and non-dominant lower limbs.
Methods: For this purpose, 60 normally developed children participated in this study, they were divided into two groups, group A (30 boys) and group B (30 girls). They all assessed by footedness tasks (foot preference) to identify dominant and non-dominant lower, manual assessment of gastrocnemius and soleus flexibility by Silfverskio¨ test and electro goniometer used to record the angles of gastrocnemius and soleus for both groups
Results: The study findings, revealed a statistically non-significant differences in muscle flexibility between group (A) and group (B). Significant differences in muscle flexibility between dominant and non-dominant ($p < .05$).

Keywords: flexibility, silfverskio¨ test, and electro-goniometer

Introduction

The calf muscle is the largest muscle of the posterior area of the leg, composed of gastrocnemius and soleus, which are responsible for the plantar flexion of the ankle and are engaged in activities such as running and jumping [2].
The gastrocnemius is white muscle fiber and stronger than soleus, but the soleus is an aerobic muscle, it is responsible for walking if it is the main physical effort [2].
The calf muscle is considered one of the "anti-gravity" muscles, the gastrocnemius is biarticular two-joint muscle as its attachment in the posterior knee compartment which does knee flexion and planter flexion but unable to exert full power at both joints simultaneously [3].
Gastrocnemius is two joint muscles that can lead to overuse while functioning [4]. This can lead to problems with the muscle as several foot and ankle pathologies, including plantar fasciitis, Achilles tendonitis, hallux valgus, metatarsalgia, and adult-acquired flat foot deformity [5].
Footedness or foot preference is a very active process affected by both genetic and environmental factors [6], as an asymmetric neural architecture between lateralized circuitry involved in movement coordination [7].
Ankle range of motion (ROM) is necessary for performing daily physical activities, so the ROM assessment is important to prove the absence or presence of functional affection in the normal mobility of body joints and the effect of treatment plan [10], the normal ROM for dorsiflexion (20.5° ± 6.1°) [11].
Silfverskio¨ is a clinical test used to identify and isolate equines contractures of the gastrocnemius, it is two parts 1st with knee is fully extended to assess gastrocnemius and the 2nd with knee is 90 flexion to assess soleus [12], it done with two-handed technique to neutralize the foot by isolating tibiotalar motion [13]. It is considered positive there is an increase in ankle dorsiflexion with knee flexion position [4].
The common devices for ROM assessment are universal goniometers, inclinometers, digital goniometers and electro-goniometers [15].
The electro goniometer, the protractor used in a traditional goniometer is replaced by a potentiometer positioned over the center of rotation of the joint being monitored also lightweight, portable, easily applied, do not restrict movements and not affected by environmental factors [16]. It is considered a reliable tool for clinical measurements as its great intra-rater and inter-rater reliability [17].
There were no sufficient studies that detected the difference in muscle flexibility in children, the difference between boys and girls, and the difference between dominant and non-dominant leg.
Therefore, the findings of this study clarify the difference in muscle flexibility between boys and girls and the difference between dominant and non-dominant.

Participants

Sixty children of both sexes who follow a normal sequence of development participated in this study; they were divided according to gender into two groups with equal size (30 participants for each). 30 boys were assigned to group (A) and 30 girls were assigned to group (B). Their age ranged from 8 to 10 years, recruited from the governmental Egyptian schools at El-Gharbia governorate. They followed the normal growth indices concerning weight and height and followed normal BMI in relation to their age.

Any participant who has a history of lower limb surgery, congenital deformity in the lower extremities or trunk, visual or hearing problems, neurological or musculoskeletal problems affecting lower extremities, previous surgical procedures lower extremities in the previous 6 months, foot deformity (clubfoot, flatfoot), recreational or competitive athletic child they were all excluded.

Ethical consideration: the current study protocol obtained approval of the Research Ethical Committee at the Faculty of Physical Therapy, Cairo University. (Approval number: P.T.REC/012/003286)

Evaluation procedures

Footedness identification: The foot preference tasks were used to determine the dominant and non-dominant leg for each participant by 1- kicking a foam ball on target 2m away, 2- Using one foot, tapping the rhythm that clapped by the therapist, 3- forward jumping performed by one leg) [9], the preferred leg that performed those tasks was considered as the dominant leg.

Manual assessment of calf muscle flexibility was carried out by Silfverskio¨ test: the test was done for dominant and non-dominant for each participant in both groups A (boys) and group B (girls), from a supine position with the knee fully extended, ankle was passively dorsiflexed to assess gastrocnemius, then repeated as previous with knee 90-degree flexion to assess soleus muscle.

The electro goniometer was used to measure the range of motion of both gastrocnemius and soleus muscles for each participant in both groups, it was composed of two inertial measurement units (IMU) and a data management platform [18], the IMU1 fixed by straps midway between the base of the prominent part of the fifth metatarsal head and the projected part of the heel and the IMU2 fixed by straps between the head of the fibula and the lateral malleolus

Statistical analysis

The normal distribution of data was checked using the Shapiro-Wilk test. Levene's test for homogeneity of variances was conducted to test the homogeneity between groups unpaired t test was conducted for comparison of gastrocnemius and soleus flexibility between girls and boys**.** Paired t-test was conducted for comparison of between dominant and non-dominant legs**.** The level of significance for all statistical tests was set at $p < 0.05$. All statistical analysis was conducted through the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

Results

Subject characteristics

Sixty typically developed children participated in this study group. Their mean value ± SD of age was 9.16 ± 0.84 years. Table (1) showed the subject characteristics of study groups.

Table 1: Basic characteristics of participants.

	Mean ± SD	
Age (years)	**9.16 ± 0.84**	
	N	%
Sex distribution		
Girls	30	50
Boys	30	50
Dominant side		
Right	50	83.3
Left	10	16.7

SD, standard deviation

Comparison of flexibility between girls and boys

There was no significant difference in gastrocnemius flexibility of dominant and non-dominant legs between girls and boys ($p > 0.05$).

There was no significant difference in soleus flexibility of dominant and non-dominant legs between girls and boys ($p > 0.05$). (Table 2).

Comparison of flexibility between dominant and non-dominant legs

There was a significant increase in gastrocnemius flexibility of the non-dominant leg compared with that of the dominant leg in girls and boys ($p < 0.001$).

There was a significant increase in soleus flexibility of the non-dominant leg compared with that of the dominant leg in girls ($p < 0.001$) and boys ($p < 0.05$). (Table 2)

Table 2: Mean gastrocnemius and soleus flexibility of dominant and non-dominant legs in girls and boys

Flexibility (degrees)	**Girls**	**Boys**			
	Mean ± SD	**Mean ± SD**	**MD**	**t- value**	**p-value**
Gastrocnemius					
Dominant leg	24.16 ± 1.41	24.03 ± 1.52	0.13	0.35	0.72
Non dominant leg	26.1 ± 1.24	25.93 ± 1.57	0.17	0.45	0.65
MD	-1.94	-1.9			
t- value	-11.67	-11.76			
	p = 0.001	p = 0.001			
Soleus					
Dominant leg	33.16 ± 1.12	33.13 ± 1.33	0.03	0.1	0.91
Non dominant leg	34.33 ± 1.02	34.07 ± 1.91	0.26	0.67	0.5
MD	-1.17	-0.94			
t- value	-7.66	-2.19			
	p = 0.001	p = 0.03			

SD: standard deviation; MD: mean difference; p-value: level of significance

Discussion

The current study was conducted to determine the difference between gastrocnemius and soleus flexibility between boys and girls, the difference between dominant and non-dominant side flexibility, and the change in flexibility in relation to age. Sixty children from both genders were included in this study. Their age ranged from 8-10 years old as children's motor skills harmoniously developed with stable coordination patterns, this is called the golden age of skill motor development, by age of 7 the normal gait pattern becomes as adults and before the puppetry and its related muscular changes, [8, 19, 20].

This study showed that there was a non-significant difference ($p > 0.05$) in gastrocnemius flexibility between girls and boys nor difference in soleus flexibility of legs between girls and boys, there was a significant increase in gastrocnemius and soleus flexibility of non-dominant leg compared with that of dominant leg in girls and boys and the difference was more prominent in girls group.

The findings of this study were consistent with studies that reported the normal range of dorsiflexion at age of six to twelve years old is (20.5° ± 6.1°) [11], the difference between boys and girls becomes apparent by 13 to 15 years of age that increased with age from the early childhood and the adolescent age groups [21, 22].

The findings of this study were consistent with the results of several studies that demonstrated the difference between dominant and non-dominant legs depending on increased muscle action, angular velocity, and muscle peak torque in dominant than non-dominant [23, 24]. The difference was a little bit more prominent in girls group as girls were more flexible than boys but boys are superior to girls in aerobic fitness that as a lot of factors such as muscle volume, dynamic properties of tendon tissues, body fat, and the cardiac size and oxygen-carrying capacity [25, 26, 27, 28, 29].

Glossary of abbreviations

ROM: range of motion.

BMI: body mass index.

IMU: inertial measurement units

Conclusion

There was no significant difference in muscle flexibility between boys and girls at this age group but there was significant difference in muscle flexibility between dominant and non-dominant.

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This study had not received any financial support.

Conflict of interests

The authors declared that there is no conflict of interest.

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