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Original Article

Relationship between Flat Foot and Lower Limb Muscle Activation among 12 Years Old Children

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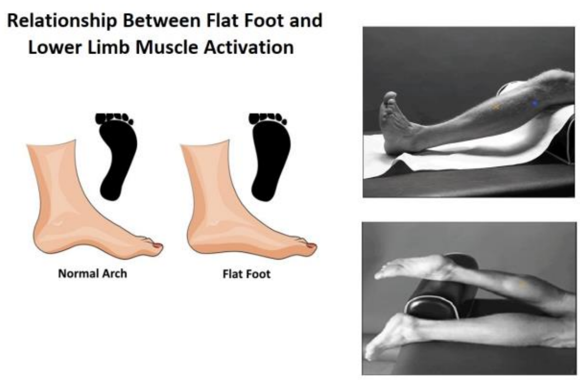
ABSTRACT

Optimal leg muscle activity is one of the essential factors to maintain body stability. The condition of the pedis arch could affect the musculoskeletal structure and biomechanics of the body. Furthermore, age and sex also affect the formations of the pedis arch. The objective is to determine the relationship between the degree of flat foot and the activation of the lower leg muscles in children aged 12 years old. The study was conducted using the correlational method with a Cross-Sectional approach. The sample of the study included 15 girls aged 12 years old. The independent variable was measured by the wet footprint test with Clarke's angle category method and the dependent variable was measured by sEMG. The results showed that there was no relationship between flat foot and lower leg muscle activation in children aged 12 years old (p>0.05) with p-value of 0.58, 0.462, and 0.642 for the activation of anterior tibial muscle, the medial gastrocnemius muscle, and the lateral gastrocnemius muscle, respectively. There was no relationship between the flat foot and the activation of lower leg muscles in children aged 12 years.

GRAPHICAL ABSTRACT



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Introduction

One of the problems that occur in the lower limb is the abnormal shape of the feet. A flat foot is a medical condition where there is an emphasis on the subtalar joint, which results in internal rotation of the tibia so that the entire foot is directly in contact with the ground [1,1–5]. Research has shown that tendon specimens from individuals suffering from flat feet obtained by adults show signs of increased proteolytic enzyme activity. The constituents of the tendons involved can be broken down by these enzymes and cause the foot arch to collapse. Those enzymes could become targets for new drug therapies in the future. By examining the patient standing or just looking at them, many medical professionals may diagnose a flat foot. The deformity can be corrected when moving up to tip toe when this is a flexible flat foot in a child with loose joints. In adults with a rigid flat foot, the correction is not seen. The wet footprint test, achieved by wetting the feet in water and then standing on a flat level surface such as smooth concrete or thin cardboard or heavy paper, is a simple and conventional home diagnosis. Typically, the flatter the foot, the greater the sole of the foot that makes contact, leaving a footprint. The prevalence of children who have flat feet with an age range of 6 to 10 years in girls is more than the boys. The number of girls who have flat feet reaches 53.4% , while for boys, about 46.6% [6]. The growth of flat feet in children stops when the child reaches ten years of age. Otherwise, it is called a pathological condition. Medial Longitudinal Arch (MLA) grows significantly at age six years, then slows down at ten years old [7,8]. Pathological changes in the formation of the MLA and changes in the shape and length and width of the legs in women occur at the age of 3 to 12 years old, while for men at the age of 15 years [9].

In flat foot conditions, the position of the feet changes towards pronation, with changes in the shape of the feet that will affect the muscles in the knee and leg areas. The intrinsic muscles and extrinsic muscles of the feet work harder and together to maintain posture stability [10]. Posture changes in flat foot conditions can cause problems related to changes in muscle activity, such as stiffness of the lower leg muscles or weakness of the leg muscles [11–13]. The long-term effect of flat foot is a pain in the feet and ankles as well as instability and disorders of the lower back to the lower extremities, which directly or indirectly affect the quality of life [14]. Examination of muscle activity can use a tool, namely surface electromyography (sEMG), which is a tool used to compare muscle activity during contraction [15].

According to research [16–18], the tibialis anterior muscle experienced hyperactivity as measured using surface electromyography (sEMG) in flat foot conditions compared with normal foot conditions. Therefore, we became interested in researching the relationship between flat foot and lower leg muscle activation in children aged 12 years.

Material and methods

Ethical Clearance

This study had received approval from the Health Research Ethics Commission of the Faculty of Medicine, Universitas Muhammadiyah Surakarta.

Research Method

This research was a correlational study with a cross-sectional approach [19,20]. It aimed to determine the relationship between the degree of flat foot and lower leg muscle activation in children aged 12 years old. This research was conducted in the Boarding of Islamic Junior High School Al-Abidin Banyuanyar Surakarta with a population of 40 children and the sample was 15 children with female subjects who met the inclusion criteria.

The criteria for sampling the participants included 1). The subject was a 12-year-old female, 2) she had a flat foot shape, and 3). The participant was willing to take part in a lower leg muscle activation check program. Those with the following characteristics were excluded from the study: 1) A female participant who was not willing to participate in the research, 2) the one who had high Arcus, 3) the one with normal foot, and 3). The participant who had experienced injuries in posture.

Arkus Pedis Examination

Examination of the pedic arch using the wet footprint test method was carried out by placing the soles of the feet moistened with ink or paint on HVS paper. Then, the pedic arch was measured using Clarke's angle category. Calculation of Clarke's angle was done by measuring the angle of two lines, the first line connects the medial edge of the first metatarsal head with the heel (points A and B), and the second line connects the first metatarsal head and the center of the longitudinal arch of the inner medial side of the arch (Points A and C) after measuring the angles [21].

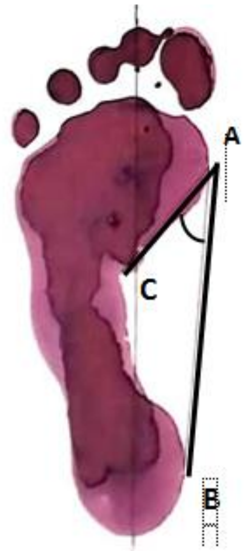

Figure 1: Clarke's Angle

Clarke's Angle value categories are as follows:

1) Normal Foot: 31^{o}- $<45^{o}$
2) Flat Foot: $<31^{o}$
3) High Arcus:> 45^{o}

Measurement of Lower Limb Muscle Activation

Measurement of lower leg muscle activation was done using surface electromyography (sEMG) under the Noraxon metrics brand using microvolt (μV) units which are represented in the form of numbers. The placement of the sEMG electrode based on SENIAM was as follows:

a) The anterior tibialis muscles: The location of the electrode placement on the tibialis anterior muscle is placed in 1/3 of the line between the tip of the fibula and the tip of the medial malleolus. The maximum size of the electrode used is in the same direction as the muscle fiber, which is 10 mm; the electrode distance is 20 mm, as shown in Figure 2.

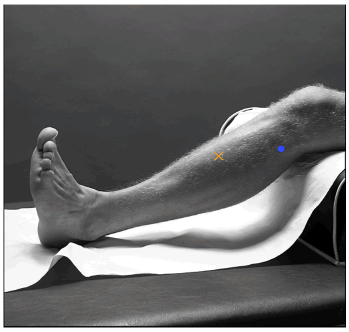

Figure 2: EMG placement on the tibialis anterior muscle

b) The medial gastrocnemius muscles: The location for placing the electrodes on the medial gastrocnemius muscle was placed on the most prominent muscle protrusion. The maximum size of the electrode used was in the same direction as the muscle fiber, which is 10 mm, the electrode distance is 20 mm, as shown in Figure 3.

Figure 3: EMG placement on the medial gastrocnemius muscle

c) Gastrocnemius lateral muscle: The location of the electrode placement on the lateral gastrocnemius muscle was placed on 1/3 of the line between the head of the fibula and the heel. The maximum size of the electrode used was in the same direction as the muscle fiber, which is 10 mm; the electrode distance was 20 mm, as shown in Figure 4.

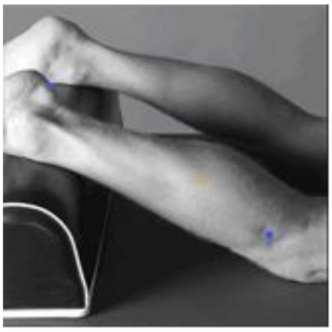

Figure 4: EMG placement on the lateral gastrocnemius muscle

Result and Dissection

Respondents were all females aged 12 years old. The following distribution of respondents was based on the pedis arc.

Table 1: Arcus pedis respondents

Pedis Arc	Respondent	Percentage
Normal Foot	18	45%
Flat Foot	15	37.5%
High Arcus	7	17.5%
Total	**40**	**100%**

Based on Table 1, 40 girls included the sample. There were 45% samples with normal foot conditions, 37.5% with flat foot conditions, and 17.5% with high arcus conditions. This study focused on respondents with flat foot conditions.

The normality test used is the Shapiro Wilk test. Data was shown to be normally distributed if it was known that p> 0.05 and p <0.05 for data that are not normally distributed.

Table 2: Normality test results with Shapiro Wilk

	Uji Normalitas *Shapiro Wilk*			
	Statistik	Df	Sig.	Kesimpulan
Flat Foot	0.906	15	0.119	Normal
Tibialis Anterior	0.796	15	0.003	abnormal
Gastrocnemius Medialis	0.653	15	0.000	abnormal
Gastrocnemius Lateralis	0.638	15	0.000	abnormal

Based on table 2, the normality test using the Shapiro Wilk test shows that the flat foot with the lower leg muscles, namely the tibialis anterior muscle, was 0.003, the gastrocnemius medialis muscle was 0.000, and the lateral gastrocnemius muscle was 0.000, so it was concluded that the p-value <0.05 showed the data was not normally distributed.

Based on the normality test, it was known that the flat foot and lower leg muscle data were not normally distributed, which was stated with a p-value <0.05; the correlation test used in this study was the Spearman rho test.

Table 3: The results of the flat foot correlation test with the lower limb muscle activation

	Spearman Correlation	Sig.	Illation
Flat Foot	0.05	0.058	hypothesis rejected
M Tibialis Anterior	0.05	0.058	hypothesis rejected
Flat foot	0.206	0.462	hypothesis rejected
M. Gastrocnemius medialis	0.206	0.462	hypothesis rejected
Flat Foot	0.131	0.642	hypothesis rejected
M. Gastrocnemius Lateralis	0.131	0.642	hypothesis rejected

In Table 3, it was known that the results obtained from the correlation test between the flat foot and tibialis anterior muscle activation have a significance value of 0.058, which means that there was no correlation between the flat foot and anterior tibial muscle activation because the p-value > 0.05. Therefore, it was known that the results obtained from the correlation test between the flat foot and the activation of the medial gastrocnemius muscle have a significance value of 0.462, which means there was no correlation between the flat foot and the activation of the medial gastrocnemius muscle because the p-value > 0.05. Moreover, it was known that the results obtained from the correlation test between the flat foot and gastrocnemius lateral muscle activation have a significance value of 0.642, which means there was no correlation between the flat foot and activation of the lateral gastrocnemius muscle because the p-value > 0.05. Based on the correlation test using the Spearman rho test, it can be seen that flat foot data with activation of the lower leg muscles, namely the tibialis anterior muscle, medial gastrocnemius muscle, and lateral gastrocnemius muscle had a coefficient value of p> 0.05, indicating there was no relationship between flat foot and muscle activation. Lower leg and data would be correlated if there was a coefficient value of p <0.05.

Sam Khamis and Ziva Yizhar [22] focused on "Effect of Feet Hyperpronation on Pelvic Alignment in a Standing Position" to determine the effect of foot hyperpronation on the pelvic shape to the feet when standing. 35 subjects participated in the study, which showed that the feet were deformed. Towards hyperpronation could cause changes in muscle activity in the legs.

Gender and age are among the factors that can affect the flat foot [23–25]. Women have a different body shape from men. This can cause different physical conditions between women and men. Research [9] has shown that pathological changes in arch formation, changes in leg shape, leg length, and width in women occur at the age of 3 to 12 years, while it happens for men at the age of 15 years. Ezema et al. [6] showed that those who experienced flat foot were more women than men by 53.4% versus that of men by 46.6%.

Based on the analysis conducted by researchers in this study, it was found that there was no relationship between flat foot (X) and lower leg muscle activation (Y) with a significance value of 0.058 on the correlation between the flat foot and anterior tibial muscle activation, a significance value of 0.462 in the results. There was a correlation between the flat foot and medial gastrocnemius muscle activation, and the significance value of 0.642 on the correlation between the flat foot and lateral gastrocnemius muscle activation, so there was no relationship where the value of p> 0.005. Several factors can affect muscle activation, including physical activity, muscle fatigue, measurement of Maximum Voluntary Isometric Contraction (MVIC), and sample motivation factors. Muscles are very responsive to physical activity, if the muscles are often trained or regularly exercised, the muscle strength will be even greater, but if the muscles are never trained, it will cause muscle atrophy [26]. Muscle fatigue or what is often called muscle fatigue, can affect postural control so that it can interfere with muscle activity and muscle imbalance [27]. In addition, researchers did not measure Maximum Voluntary Isometric Contraction (MVIC) where MVIC can affect lower leg muscle activity, activation of the lower leg muscles is different from the size of the base of support (BOS) and the height of the center of gravity (COG), meaning that posture is closely related to muscle movement [28]. The sample motivation factor at the time of conducting the study had a major effect on the activation of muscle strength. There is a difference between those with high motivation and those of low motivation low motivation. For samples with high motivation, the resulting muscle strength activation is better than samples with low motivation. Motivation encourages efforts to achieve achievement [29].

Conclusion

Based on the research results, it can be concluded that there was no relationship between flat foot and lower leg muscle activation in children aged 12 years. Different theories account for the factors influencing the activation of the lower leg muscles. Therefore, it is hoped that further research could consider other factors that can affect the activation of the lower leg muscles. This study has limitations, including not controlling previous activities where previous activities can affect the activation of muscles and not measuring MVIC.

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Authors' contributions

All authors contributed toward data analysis, drafting and revising the paper and agreed to be responsible for all the aspects of this work.

Conflict of Interest

We have no conflicts of interest to disclose.

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