KnE Medicine

ICMEDH
2nd International Conference on Medical Health Science
Volume 2023

Knowledge E
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Research Article

Comparative Analysis of the Components of a Child's Gait Pattern with Flat Foot Disorder

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Abstract.
Flat foot is a condition that generally occurs in children. Flat-foot is a condition where the entire foot is on the ground. The condition of a flat foot often does not show symptoms because in pre-school children, this condition remains a physiological condition. However, this condition will become pathological if it continues with age. The gait pattern is a structured movement carried out by a person to move and have a step distance, speed, and footprints. This study aimed to determine the gait pattern of normal-foot children and flat-foot children between the ages of 4-6 years at PAUD Sahabat Ananda Dau. The method used is a case-control two-group test on 23 children who have met the inclusion and exclusion criteria at PAUD Sahabat Ananda Dau in March 2022. Measurements of the wet footprint test, Clarke's angle, and gait parameters were out after obtaining approval from the respondents. \ It was found that respondents with flat-foot were 57%. Based on the T2 Sample Independent Test, the results obtained on stride was p=0.263, step right was p=0.235, step left was p=0.69, cadence p=0.7, and speed p=0.311(p<0,05). It was discovered that there is no difference in gait pattern in normal foot and flat foot children aged 4-6 years at PAUD Sahabat Ananda Dau.

Keywords: normal arch, flat foot, Gait pattern, Gait parameter, pre school children

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Published 8 March 2023

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the ICMEDH Conference Committee.

1. INTRODUCTION

In the human body anatomically, the foot is formed by several structures, one of which is the arch. Arkus is a segmented structural building that has a function and forms a concert (1). According to Flores (2), the arch is divided into three parts, namely the lateral longitudinal arch, the medial longitudinal arch, and the transverse arch in the medial tarsal bone. The arch of the foot is useful for helping the efficient function of the foot (3). Besides, normal arcus is useful for supports the whole body well and helps in mobilizing motion when walking or running (3,4). Abnormal arch conditions can cause balance disorders and get tired easily when walking for a long time (5). This causes a person to experience changes in walking patterns when they are tired of walking for too long.

Pathologically, the abnormal arch shape is divided into two, namely, pes cavus (high medial longitudinal arch) and pes planus (lower medial longitudinal arch) (6). pes planus or the condition where the height of the medial longitudinal arch is low is also known as the flat foot condition (7). Pes planovalgus or flat foot deformity is the most common foot deformity that is difficult to identify (8). Flat foot is a condition where part or all of the sole of the foot is in contact with the ground (9). Of these, flat foot is where there is a deformity of the foot with a very low medial longitudinal arch height and the condition of the entire sole of the foot on the ground.

One of the symptoms that often arise due to flat foot cases is a disturbance in walking patterns(10). When the normal arch has not appeared or disappeared, the walking pattern will change medially and the foot will lean to one side of the footing (11). In one study it was proven that there was a slight difference in Range of Motion (ROM) during the pre-swing phase in the walking pattern of flat foot patients (6).Abnormal walking patterns can interfere with daily activities, exercise, and social activities (12).

The prevalence that occurs in Turkey, states that flat foot is the most common congenital abnormality found in school children with the number is 22.8% while in Tehran, Iran it is 35.6% (13). In Indonesia itself, the number of flat foot conditions is not clearly recorded every year. Research conducted also varies according to various factors, such as age and research methods. In Sukajadi District, 40% of children have flat foot conditions (9).

Several studies have shown that flat feet have an impact on a person's growth. In research (5), it is stated that flat foot conditions can make a difference to the results of blood pressure and heart that affect physical fitness. In another study, if the flat foot condition itself can mention statistical balance that occurs in children aged 9-12 years where the results obtained in maintaining balance are very significant (14,15). The results of the study by (6),stated that in the case of pes planus, there was a decrease in Range of Motion (ROM) in the midfoot during the pre-swing phase.

Some changes in road patterns that may change include aspects of the road pattern in the form of walking speed, stride length, the number of steps, to the length of the stride. In a study by (16) it was stated that there was a change in stride length and right and left foot stride although it was not significant. On the other hand, research shows that the values of cadence, stride, step length, and speed have greater values in normal children's feet than in flat foot and cavus foot children (17). This is supported by the research of Githa et al., (18) which proves that there are differences in gait parameters of the normal foot, flat foot, and cavus pedis type.

Results Based on what was obtained from a preliminary study conducted by researchers on students aged 4 to 6 years at PAUD Sahabat Ananda Dau, it was said that 10 of the 30 students had flat foot conditions. This makes researchers more confident in conducting research, seeing the number of cases of flat foot in children which may have an impact on children's physical development. Thus, the researcher will conduct research to analyze the differences in walking patterns in normal-footed and flat-footed children aged 4-6 years at PAUD Sahabat Ananda Dau.

2. MATERIALS AND METHODS

The research conducted by this researcher is a case control study where the design used is a two group test. This study aims to determine the comparison of walking patterns in normal foot children and flat foot children aged 4-5 years. In this research, the population is all PAUD Sahabat Ananda Dau students. The considerations that have been made by researchers are by determining several inclusion criteria and exclusion criteria as follows:

2.1. Inclusion Criteria

1. Children aged 4-6 years.
2. The child is a student of PAUD Sahabat Ananda Dau, Malang, East Java.
3. Children who have flat foot conditions based on the results of the wet foot print test and the degree of curvature of the medial arch with Clarke's angle.
4. Children who have normal foot conditions based on the results of the wet foot print test and the degree of curvature of the medial arch of Clarke's angle.

2.2. Exclusion Criteria

1. Children who do not get permission from their parents/guardians.
2. Children who have leg injuries during the examination.

3. RESULTS

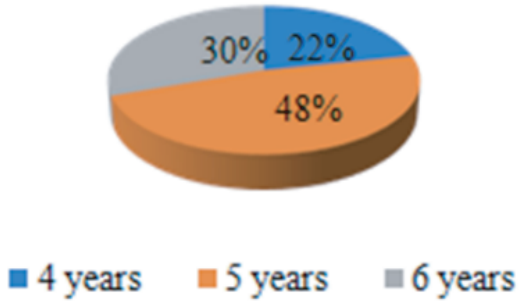

Figure 1: Characteristics of Respondents Based on Age.

3.1. Charactheristics of Sample

Based on the diagram above, most of the PAUD Sahabat Ananda Dau children who participated in this study were in the pre-school age range. The average age of 5 years is dominant with a total of 11 people from a total sample of 23 people, then followed by a 6 year old with a total of 7 people, and followed by the last 4 years with a total of 5 people.

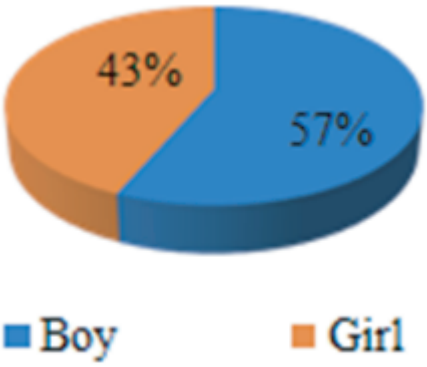

Figure 2: Characteristics of Respondents Based on Gender.

Based on the diagram above, the researchers used male and female respondents. On average, the female sex was dominant with a total presentation of 13 people, followed by the male gender with a presentation of 10 people from a total sample of 23.

Based on the diagram above, most of the PAUD Sahabat Ananda Dau children who participated in this study had a degree of the medial longitudinal arch with a dominant flat foot with a presentation of 13 people from a total sample of 23 people, then for those who had a normal degree of the medial longitudinal arch arch as many as 10 people. .

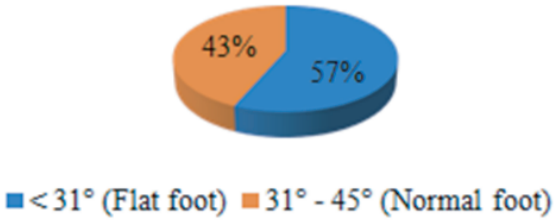

Figure 3: Characteristics of Respondents Based on Archus.

3.2. Result

3.2.1. Description of Gait Parameter

Stride

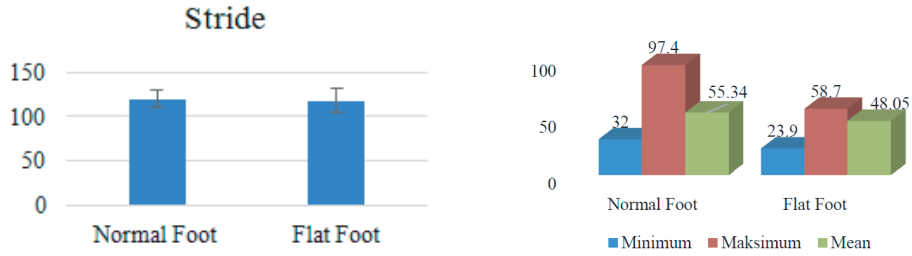

Figure 4: Result Gait Parameter Stride.

The picture above illustrates that there is a significant difference in the maximum value for normal-footed and flat-footed children. Where the maximum value for normal foot children is 97.4 cm, while the maximum value for flat foot children is 58.7 cm. with a difference in the length of the stride as far as 38.7 cm. Meanwhile, for the minimum and mean values in children, normal foot and flat foot have a difference in stride length of less than 10 cm.

Step Right

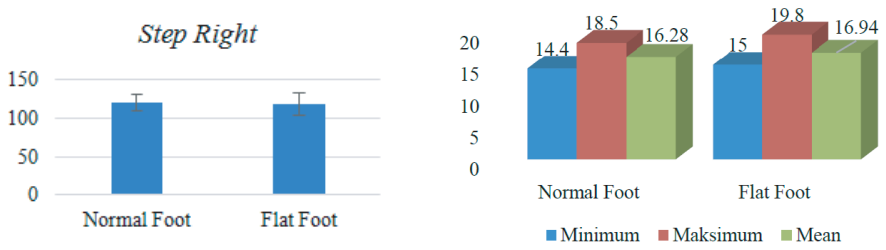

Figure 5: Result Gait Parameter Step Right.

The figure above illustrates that the minimum, maximum, and mean value of the step right measurement in normal foot children and flat foot children have insignificant differences. Where the difference in the step right measurement is less than 1.5 cm.

Step Left

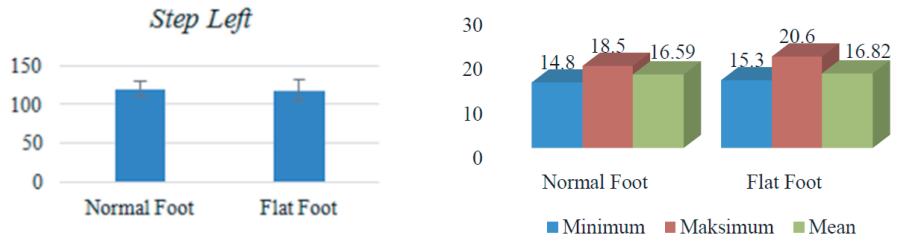

Figure 6: Result Gait Parameter Step Left.

The picture above illustrates that the minimum, maximum, and mean value of the step left measurement in normal foot children and flat foot children have insignificant differences. Where the difference in the step right measurement is less than 1.5 cm.

Cadence

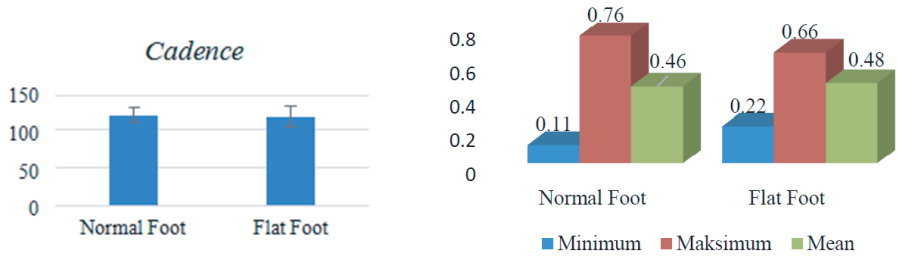

Figure 7: Result Gait Parameter Cadence.

The picture above illustrates that there is the same pattern in the minimum, maximum, and mean results in the measurement of cadence in normal foot children and flat foot children.

Speed

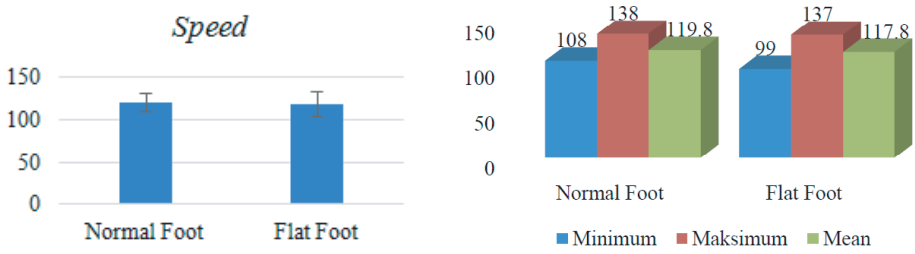

Figure 8: Result Gait Parameter Speed.

The picture above illustrates that there is the same pattern in the results of the minimum, maximum, and mean speed measurements in normal foot children and flat foot children.

3.2.2. Result

Table 1: Result of Normality Test.

Gait Parameter	V	N	m ± s.d	p
Stride	X1	10	55,3 ± 19,6	0,270
	X2	13	48,1 ± 10,3	0,081
	X1	10	16,3 ± 1,3	0,804
Step Right				
	X2	13	16,9 ± 1,3	0,592
	X1	10	16,6 ± 1,3	0,634
Step Left				
	X2	13	16,9 ± 1,4	0,031
	X1	10	119,8 ± 10,1	0,480
Cadence				
	X2	13	117,8 ± 13,8	0,247
	X1	10	0,56 ± 0,23	0,128
Speed				
	X2	13	0,48 ± 0,12	0,901

Based on the results of the normality test that has been carried out, the results of the normality test data for gait parameter examinations in each examination in children with normal foot conditions and children with flat foot conditions have a significance value of more than 0.05. Thus, the data on gait parameter checks are normally distributed.

Table 2: Tabel of Comparison Test.

Gait Parameter	n	p	α
Stride		0,263	
Step Right		0,235	
Step Left	23	0,690	0,05
Cadence		0,700	
Speed		0,311	

Based on the results of the T2 Sample Independent Test comparison on the gait parameter measurement data, it was found that the significance value was > 0.05. Thus, for the results of the gait measurement data, the H0 parameter is accepted. From the analysis of the data above, it can be concluded that there is no difference in walking patterns in normal foot children and flat foot children aged 4-6 years.

4. DISCUSSION

4.1. Analysis based on the degree of curvature of the medial arch

The medial longitudinal arch itself has a function to support body weight and maintain proper posture when standing or running so that it can affect gait patterns (19). In this study, the characteristics of the condition of the medial longitudinal arch were distinguished by using the wet foot print test and measured using Clarke's angle. Classification by Pita (20), if the measurement results for flat foot conditions have results <31˚, for normal foot results have a range of 31˚-45˚, and for cavus foot conditions have results >45˚.

4.2. Analysis Based on Gait Parameter

The anatomical structure of a stable foot can help and support posture which, if there is pathology, will cause developmental delays. Developmental delays themselves can be caused by several factors, including environmental factors, family socio-economic status, education level, interaction among family members, to the facilities provided in child development (19). Based on the results of the study, it was found that there was no difference in walking patterns in flat foot and normal foot children. However, there are differences in the results of gait parameter measurements.

Stride

The results of the stride data (step length) given show that the stride value in normal foot children is higher than in flat foot children. Where in this study the mean of the stride value for normal foot children is 55.3, while in flat foot children it is 48.1. This proves that there is a difference in stride size in children with normal foot and flat foot, although it is not significant. Several factors that can cause differences in stride include the use of certain footwear, in some types of footwear use can cause an increase in changes in movement in the hip joint so that in some cases it can increase the length of the stride. However, it is possible that this can also reduce the length of the stride (21).

Step Right

The results of the measurement data for step right (right foot steps) and step left (left foot steps) on examination in this study indicate that the value of flat foot children is higher than normal foot children. This is evidenced by the length of the step left in normal foot children has a mean of 16.6, while in flat foot children it is 16.8. This difference

in length occurs due to the compensation of m. plantar flexor so that there is a missing phase and results in a person having to maintain balance so that someone with flat feet does not fall to one side. The length of the step is one indicator of a person's walking stability (22). This will later affect a person's walking speed and cadence.

Cadence

Furthermore, on the cadence examination (number of steps) it was found that the data obtained in normal foot children were higher than in flat foot children. Where the results of this study show that the mean cadence in normal foot children is 120 steps, while in flat foot children it is 118 steps. The increase in cadence can be due to increased movement in all joints, especially the important role of the muscles that drive flexion of the hip joint. At the ankle joint if the cadence results increase due to additional compensation from m. plantar flexor (23). So, if there is a problem with m. the plantar flexor can cause a decrease in the number of cadences.

Speed

The last measurement, regarding speed, was found if the minimum and mean values for normal foot children were faster than flat foot children. It was stated in (19) that flat foot conditions can have an impact on decreasing walking speed. This is due to the high pressure distribution on the plantar, causing delays in walking and even making it difficult for someone to carry out activities. According to Badiya (21) said that fatigue is also one of the triggers for a decrease in a person's walking speed so that it can have an impact on walking patterns, this is supported by Githa (18) if someone is in a flat foot condition. will require more energy consumption than the normal foot condition so that if there is an energy deficit it can result in a decrease in a person's walking speed. In a study, short steps can be caused by reduced balance and postural control so that short steps can provide a sense of security to reduce the risk of falling (24).

According to Githa (18), the difference in gait parameters can be caused by differences in ground reaction forces (GRF). Where GRF itself is a condition when a person is in a standing or walking position to cause a force that affects the body where it is caused by a reaction from the ground. The arch type in flat foot conditions generally has a shape that tends to overpronation, this causes the ground reaction forces to shift medially during the position of the foot on the ground (stance phase). Excessive pronation of the feet, especially during the push-off phase causes the legs to become unstable because in this phase the legs are required to be in a rigid condition so that the feet cannot transmit the force during the push-off phase. This also occurs in conditions of excessive supination so that the function of the shock absorber mechanism on the foot cannot work properly. The foot tends to maintain a rigid condition, but at the same

time the foot must also be able to adapt to the surface structure such as when the heel strike phase goes to flat foot. This inability has an impact on decreasing balance. In more detail, the ankle in humans is an example of a type II lever so that the foot requires an appropriate distance between the fulcrum and the force. Rigid legs are prepared to accept the pressure associated with the push-off phase. In addition to the activation of the intrinsic and extrinsic muscles of the foot, the foot is also stabilized as a result of increased tension, known as the windlass effect. In flat feet, the lever arm shortens due to forefoot abduction, heel valgus, the lever's hardness decreases, and the windlass effect does not work. This shortening of the lever causes the muscle to experience hyperactivation. The greatest hyperactivation of muscles in flat foot patients occurs in the vastus medialis and abductor hallucis muscles. In addition to these muscles, when the heel is raised, the peroneus longus and posterior tibialis muscles also contract. These two muscles work to neutralize each other like a sling in supporting the medial longitudinal arch and the transverse arch. The tendon attachments of this muscle serve to support the medial longitudinal arch. Appropriate exercises for strengthening intrinsic muscles can help change the distribution of plantar pressure and reduce pain in patients with flat foot.

5. CONCLUSION

Based on the results of the data analysis test, it was found that there was no significant difference in the walking pattern of children with normal foot conditions and children with flat foot conditions at the age of 4-6 years at PAUD Sahabat Ananda Dau, Malang. This can be caused by external factors.

Research related to walking patterns in flat foot children in Indonesia is still very minimal so further research is needed regarding other factors that influence the differences and the factors that cause them.

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