Correlation Between Body Mass Index and Medial Longitudinal Arch of The Foot in Children Aged 5–6 Years

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Abstract: The medial longitudinal arch of the foot has clinical significance because it functions to absorb shocks to the feet and protect the feet from injury. The objective of this study was to look for a correlation between body mass index (BMI) and the medial longitudinal arch of the foot in children aged 5–6 years. Data were collected from 31 students of Khairunas Nurul Hayat Kindergarten, Surabaya, and a cross-sectional analytic observational study was undertaken using total sampling. BMI measurements were performed by weighing weight and height using a ruler The medial longitudinal angle was measured by using a footprint angle with a pegograph from Clarke. Data were analyzed using Spearman correlation analysis with SPSS. The data indicated that the participants' weight was 16.42 ± 3.93 kg and their height was 109.16 ± 5.20 cm. The mean of BMI was 13.56 ± 2.29 with a distribution of 90.32% within normal BMI range, while the rest was not normal. The angle of the medial longitudinal arch was 15.32 ± 9.10°, with a distribution of 35.48% of students with flat feet and 64.52% with a normal foot arch. The result of a Wilcoxon–Mann–Whitney comparative test for the flat-feet group and the normal group was p=0.951. The result of a Spearman's correlation test for BMI and medial longitudinal arch was p=0.355. There was no difference in BMI between flat feet and normal feet; and there was no correlation between BMI and medial longitudinal arch. In the future, research could be carried out using a larger number of research subjects, because the results suggested that the bigger the participant's BMI, the smaller their medial longitudinal arch.

1 INTRODUCTION

The foot is used as a lever to move the body forward when walking and running. It is also used for weight bearing. Humans are born with three arches of the foot, namely the medial longitudinal arch, the lateral longitudinal arch, and the transversal arch (Snell, 2006). The most clinically important foot arch is the medial longitudinal arch, which is used to absorb shocks to the foot and to protect it from injury (Xiong, 2010). Based on the structure of the medial longitudinal arch, the foot arch is classified into three types: normal foot arch, flat foot arch (pes planus), and high foot arch (pes cavus). A flat foot arch and a high foot arch can increase a person's risk of injury.

Pes planus (flat foot) is a disorder of the foot where the inner leg curve (medial longitudinal arch) does not form or disappears in the standing position (Matthew, Buchanan et al., 2016). About 20–30% of children in the world have flat feet (Evans, 2008); the survey results in SDN Coblong 2 Bandung indicated that about 6 of 33 children have flat feet (Wardanie, 2013). The prevalence of flat feet is 54% in 3-year-old children and 24% in 6-year-old children. Most children will show normal development of the sole completely at 10 years old (Rodriguez, 1999). A foot arch that has not grown normally causes balance impairment, fatigue when walking for a long time, the heel of the shoe to wear off quickly, excessive injury, and pain (Ferry, 2006).

In previous research, there was a negative correlation between BMI and the arch of the left foot and a very strong correlation between BMI and the arch of the right foot at college age (Herick Alvenus et al., 2016). A study with 17- to 21-year-old subjects found that 89% had a normal foot arch, 7% had a high foot arch, and 4% had a low foot arch (Wicaksono, 2013). However, research on the medial longitudinal arch in children, especially kindergarten students, is still rare in Indonesia, and the correlation between BMI and a tendency to have flat feet is still not clear.

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To obtain information about the correlation between BMI and medial longitudinal arch in 5- to 6-year-old children, the arch of the foot of students of Khairunas Nurul Hayat Kindergarten in Surabaya was measured. The hypothesis of this research was that BMI has a negative correlation with medial longitudinal arch and that there is a difference in BMI between children with flat feet and those with a normal arch.

2 METHODS

This research used cross-sectional observational analysis. The collected data were age, body weight, body height, BMI, and medial longitudinal arch measurement. The research was conducted in Khairunas Nurul Hayat Kindergarten in Surabaya on October 2nd, 2017. The sampling method was total sampling, which was 31 male and female students of the kindergarten.

Body weight was measured using weighing scales with minimal clothes attached to the body, and body height was measured using a ruler, with the child standing on the floor barefoot, with no hat or head covering, and with their back to the measuring instrument and their head upright. BMI was calculated by dividing body weight by the square of the height (kg/m^2).

Examination of the medial longitudinal arch in this research used a wet footprint test to observe the medial border of the foot. In the wet footprint test, the arch of the foot is formed by making the foot wet with ink and then placing it on a piece of paper so it will leave a footprint (Miller, 2010). According to the subjects' medial longitudinal arch, the condition of flat feet was divided into three grades:
Grade 1: Foot still has a little arch
Grade 2: Foot does not have an arch at all
Grade 3: Foot does not have an arch, angle in the middle of the foot leads outside

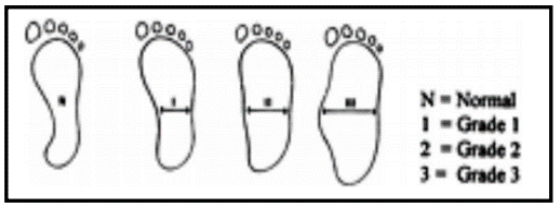

Figure 1: Medial longitudinal arch classification (Nilsson et al., 2012).

In addition to the above classification, the grade of flat-footedness can be measured using Clarke's angle, with the following procedures:

Table 1: Clarke's angle procedure.

Parameter:	Clarke Index
Obtained from:	Footprint
Instruments	Conventional podoscope, ink footprint and photopodogram
Definition	Objective method for measuring internal longitudinal arch
Methodology	Angle between line A, which joins the more internal point of the forefoot and the more internal point of the rear foot, with line B, which joins the more internal point of the forefoot with the deeper part of the footprint
Criteria	•Clarke angle < 31°: Tendency to flatness and/or pronation •Clarke angle 31°–45°: Normality range •Clarke angle > 45°: Tendency to cavus foot
Image	

3 RESULTS

There were 31 research subjects, of whom 20 were male students and 11 were female students. Their general characteristics are shown in table 2.

Table 2: General characteristics of research subjects.

Character	Mean±SD	Min	Max
Age (year)	5.74±0.54	5m03	6.78
Body weight (kg)	16.42±3.93	11.00	34.00
Height (cm)	109.16 ±5.20	97.00	123.00

The distribution of students based on BMI and a normal foot arch or flat feet can be seen in figure 2. Subjects are categorized as flat-footed when the medial longitudinal arch is less than 31°.

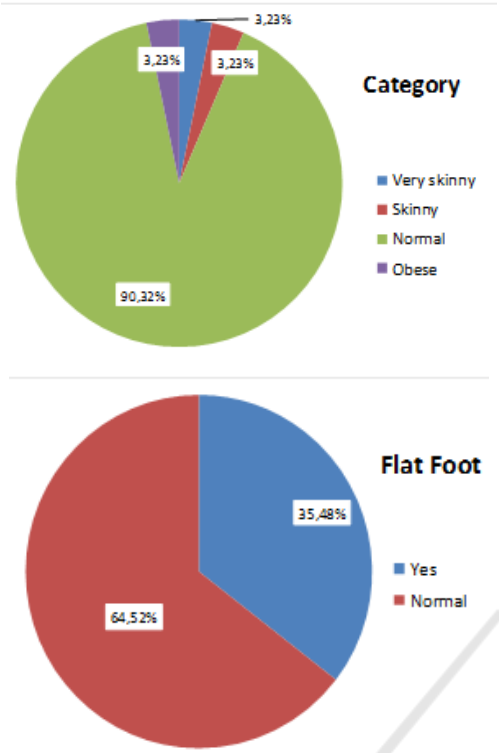

Figure 1: Medial longitudinal arch classification (Nilsson et al., 2012).

Comparison of BMI in subjects with flat feet and normal feet was performed using a Wilcoxon–Mann–Whitney comparative test. The results are presented in table 3.

Tabel 3: The result of statistical analysis.

Group	n	BMI (Mean±SD)	p
Flat feet	11	13.56±2.29	p=0.951
Normal	20	13.81±2.65	

The correlation between BMI and the measurement of the medial longitudinal arch using a Spearman test had a p-value of 0.355 and a correlation coefficient of -0.172.

4 DISCUSSION

Based on the cause, flat feet (pes planus) is classified as a pathological or a physiological condition. Pathological flat-footedness has a wide variety of etiologies. It can cause pain and disability and usually requires treatment. Physiological flat-footedness is associated with development and is often seen in children in their first decade (Sacco et al., 2007). Factors affecting its manifestations include ligamentous laxity and overweight (Mosca, 2010).

In this study, more than one third of the student population was classified as flat-footed. This result is almost equivalent to a survey in Surakarta, which found that from a total sample of 1089 students, 299 students had flat feet and 790 students had a normal arch (Wardanie, 2013). In the global population, about 20–30% of children have flat feet (Evans, 2008). Flat–footedness is a concern because, over a long time, it will cause pain in the soles of the feet, the ankles, and the knees. It will also cause recurrent acute trauma and deformity in the legs (Harris et al., 2004).

In this study there was no difference in BMI between subjects with flat feet and those with normal feet; and there was no correlation between BMI and medial longitudinal arch. This is different from the theory that is most widely embraced by experts, which is based on the occurrence of flat-footedness. One of the pathophysiologies of flat feet is the ligament weakness (ligament laxity) theory. With increasing BMI, the pressure on the sole of the foot gets bigger and makes the medial longitudinal arch become collapsed or disappear when standing (Mosca, 2010). Previous research has shown there is a link between obesity and flat feet in boys and girls aged 12–15 years (Hasan et al., 2009), and that foot arch in overweight and obese children is lower than in normal BMI children aged 9–16.5 years (Villaroya et al., 2008).

In this study, there were no differences and no correlation between BMI and medial longitudinal arch. This could have been because of the small number of research subjects and the fact that the distribution of research subjects who had normal BMI was 90.32%, which meant that deeper information could not be extracted. However, if it looked from negative correlation between BMI and medial longitudinal arch, then in the future, research needs to be carried out with a greater number of study subjects, more diverse BMI variation, and measurements and analysis of both feet.

5 CONCLUSION

There was no difference in BMI between participants with flat feet and those with normal feet; and there was no correlation between BMI and medial longitudinal arch in students of Khairunas Nurul Hayat Kindergarten in Surabaya.

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